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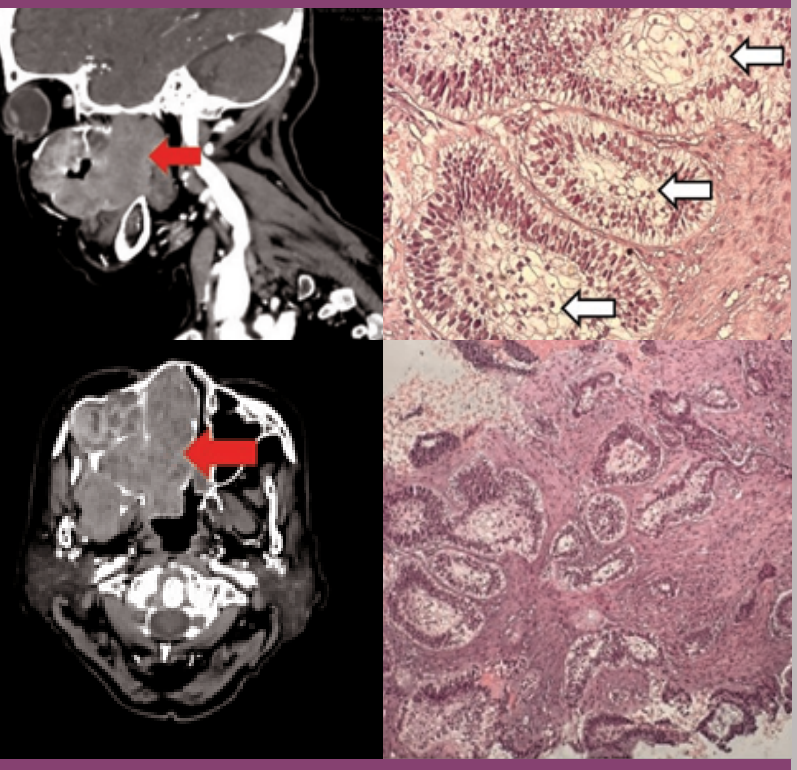

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IIUM Journal of Orofacial and Health Sciences (IJOHS) is a peer-reviewed biannual international journal dedicated to publishing high-quality scientific research in the field of orofacial sciences, health sciences and interdisciplinary fields, including basic, applied and clinical research. The journal welcomes review articles, original research, case reports and letters to the editor. Areas that are covered include, but are not limited to, dental sciences, oral microbiology and immunology, oral maxillofacial and craniofacial surgery and imaging, dental stem cells and regenerative medicine, dental biomaterials, oral maxillofacial genetic and craniofacial deformities, dental public health and health sciences.

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EDITORIAL Open Access

Artificial intelligence and the future of oral health equity

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Introduction

Artificial intelligence (AI) is reshaping oral healthcare through advances in diagnostics, clinical decision support, predictive analytics, teledentistry, and digital health systems. Its growing capacity to improve disease detection, treatment planning, and service efficiency has positioned AI as an important component of contemporary dentistry (Khurshid *et al.*, 2025; Xu *et al.*, 2025). AI-enabled remote assessment and decision-support systems may also help extend oral healthcare to populations facing geographic or workforce-related barriers (Beltrán Varas *et al.*, 2025; Glassman *et al.*, 2024).

Nevertheless, technological progress does not automatically produce equitable outcomes. Oral health inequalities remain deeply influenced by socioeconomic disadvantage, unequal access to services, geographic isolation, and wider structural determinants (Bastos *et al.*, 2023). Yet much of the dental AI literature continues to prioritise technical performance over whether implementation reduces or inadvertently reinforces these disparities. This editorial argues that AI should be judged not only by how accurately it performs, but by how effectively it advances oral health equity.

Embedding equity in artificial intelligence

AI is only as equitable as the data, systems, and assumptions on which it is built. Models developed primarily from data obtained in high-income countries or specialist settings may perform less reliably when applied to populations with different demographic characteristics, disease patterns, or healthcare environments. Without representative datasets and subgroup evaluation, even technically accurate algorithms may reproduce existing inequalities (Khoury *et al.*, 2024; Rojas *et al.*, 2022).

Equity must therefore be embedded throughout the AI lifecycle from data collection and model development to validation, implementation, and evaluation. The central question should move beyond whether an algorithm works to ask: *for whom does it work, under what circumstances, and who may be excluded from its benefits?* Fairness-oriented evaluation,

transparent development, and meaningful engagement with underserved communities should become essential requirements rather than optional additions.

Equitable implementation also depends on the strength of the health systems into which AI is introduced. AI cannot compensate for workforce shortages, fragmented services, financial barriers, weak digital infrastructure, or inadequate primary oral healthcare. If these structural limitations are ignored, AI may disproportionately benefit populations already well served while leaving those with the greatest needs further behind. AI should therefore be integrated within broader reforms involving universal health coverage, primary oral healthcare, digital health infrastructure, and population-based planning. Ultimately, AI will contribute to oral health equity only if technological innovation is matched by strong health systems capable of delivering equitable, accessible, and person-centred care.

From innovation to action

A prepared workforce is essential for translating technological innovation into equitable care. AI should augment, rather than replace, professional judgement. Dental professionals must be able to critically evaluate AI-generated recommendations, recognise their limitations, communicate their use transparently, and interpret them within each patient's clinical and social circumstances. This requires AI literacy alongside critical thinking, ethical reasoning, communication, and an understanding of health equity (Sharab *et al.*, 2024). Excessive reliance on AI, particularly among less experienced clinicians, may weaken independent clinical judgement and compromise patient-centred decision-making (Glick *et al.*, 2022).

Governance must also evolve alongside innovation. Current uncertainties surrounding transparency, accountability, data protection, algorithmic fairness, and professional responsibility may undermine trust and widen inequalities if AI is scaled prematurely (McGrath *et al.*, 2025). Governance frameworks should extend beyond technical validation to evaluate whether AI performs fairly across populations, improves access, and produces meaningful real-world benefit.

Collective leadership is therefore required. Researchers should prioritise representative evidence and equity-oriented evaluation; educators should prepare clinicians for responsible AI use; professional organisations should establish practice standards; and policymakers should promote transparency, accountability, public trust, and equitable access. Governance should not be regarded as a barrier to innovation, but as the mechanism through which innovation becomes safe, legitimate, and socially responsible.

Conclusion

The question is no longer whether AI will transform oral healthcare, but whether it will transform it equitably. Achieving oral health equity requires an equity-centred approach in which fairness is embedded throughout AI design, health system implementation, workforce preparation, and governance. The future contribution of AI will depend not on increasingly intelligent algorithms alone, but on collective decisions that ensure innovation serves all populations, particularly those who have historically faced the greatest barriers to oral healthcare.

Declaration on the Use of Generative Artificial Intelligence and AI-Assisted Technologies

During the preparation of this work, the author used artificial intelligence–assisted technology (ChatGPT) in order to support language refinement and editing of the manuscript. After using this tool/service, the author reviewed and edited the content as needed and takes full responsibility for the content of the published article.

References

American Academy of Pediatric Dentistry (2024). Behavior guidance for the pediatric dental patient. The Reference Manual of Pediatric Dentistry. Chicago, III: 358-378.

Che Lah, N. A., Badrul Hisham, A. R., Zakaria, N. S., Mohamad Jurimi, N. H., Mohd Fathil, N. H., Mohamad, F. N., & Leong, K. J. (2024). Perception of behaviour management techniques for paediatric patients among dental officers. *Compendium of Oral Science*, 11(1), 11–22. https://doi.org/10.24191/cos.v11i1.26033

Malaysian Dental Council. (2022). Code of Professional Conduct. Retrieved 15 May 2025, from https://hq.moh.gov.my/ohp/mdc/index.php/?id=24

Ministry of Health Malaysia (2015). National Oral Health Survey of Preschool Children 2015. In: *Oral Health Status and Caries Treatment Needs of 5-Year-Old Children*; Ministry of Health Malaysia, Volume 1, pp. 3–58.

Yuan, S., Humphris, G., MacPherson, L. M. D., Ross, A. L., & Freeman, R. (2021). Communicating with parents and preschool children: a qualitative exploration of dental professional-parent-child interactions during paediatric dental consultations to prevent early childhood caries. *Frontiers in Public Health*, 9, 669395. https://doi.org/10.3389/fpubh.2021.669395

ORIGINAL ARTICLE Open Access

Periodontitis prevalence based on the current classification system among patients attending Dental Clinic Hospital Pakar Universiti Sains Malaysia

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Abstract

Periodontal disease is among the most prevalent oral health issues globally. This condition compromises the supportive structures of teeth and is influenced by both local and systemic factors. The 2017 Diagnosis and Classification of Periodontal Diseases and Conditions characterized the severity and progression of periodontitis by staging (I to IV) and grading (A, B, C), respectively. Although this classification scheme has been gradually adopted in local settings since its introduction in 2018, data on the prevalence of periodontitis using this framework remain limited. This study intended to determine the prevalence of periodontitis and its associated factors based on the current classification system among patients attending Hospital Pakar USM (HPUSM). This is a retrospective record review study that utilized the retrieval of patients' records, spanning 2018 to 2024. Data on sociodemographic and periodontal diagnosis were collected. Data were analysed by using descriptive statistics, chi-squared tests, and an independent t-test. Of 300 records retrieved, 262 had complete periodontal records. The mean age of patients was 42.48 years (SD14.32), with 91.2% being Malays. The overall prevalence of periodontitis was 50.8%, with generalized periodontitis stage III grade C being the most reported (31.4%). Significant associations were found between periodontitis and age ($p<0.001$), systemic diseases ($p< 0.001$), medication taken ($p= 0.001$), and smoking habits ($p<0.001$). Within study limitations, periodontitis stage III grade C was prevalent among the study population. Age, systemic diseases, medications, and smoking habits are the possible risk factors for periodontitis.

Keywords: *periodontitis, periodontal classification system, risk factors, staging and grading*

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Introduction

Periodontal disease is a chronic inflammatory disease affecting the supportive structures of the teeth, encompassing gingival tissue, alveolar bone, cementum, and periodontal ligament (Gasner & Schure, 2023). Periodontal disease can generally be classified into gingivitis and periodontitis. These conditions may stem from developmental, inflammatory, traumatic, neoplastic, genetic, or metabolic causes, either inherited or acquired (Jordan, 2004). Gingivitis is the mildest form of periodontal disease confined to inflammation of the gingiva and can be found in most of the population (Pihlstrom *et al*., 2005). Periodontitis is a severe form of periodontal disease that involves the destruction of tooth-supporting tissues. If left untreated, it progresses to deeper

tissues, disrupting bone homeostasis and ultimately resulting in tooth loss (Petersen & Baehni, 2012). As per the Global Burden of Disease Study in 2016, severe periodontal disease ranked as the 11th most prevalent condition globally (Nazir *et al*., 2020). According to National Oral Health Survey of Adults in year 2020, 38.2% of Malaysian population suffered from periodontitis, where 23.7% of them having shallow periodontal pocket and 14.5% of them having deep periodontal pocket (NOHSA, 2020).

Previous diagnosis of periodontal diseases was based on American Academy of Periodontology 1999 Classification of Periodontal Diseases. However, this classification was perceived to pose challenges for dental student education and implementation in clinical practice (Das, 2015). For years, periodontitis was classified using outdated methods that overlooked key risk factors, leading to inconsistencies in diagnosis and prevalence estimates. With the introduction of a 2017 Classification of Periodontal and Peri-Implant Diseases and Conditions, it provides a more refined way to diagnose and categorize periodontitis, reshaping our understanding of its true prevalence. The diagnosis of periodontal diseases based on this classification characterized disease in staging and grading that were not defined in previous classification. The current classification is based on the case definition (Tonetti *et al*., 2018; Eke *et al*., 2020) that presently being employed globally as the standard guideline in determining the prevalence of periodontitis. The 2017 classification introduced a more accurate approach, focusing on staging and grading to better reflect disease severity and risk.

In Malaysia, there is a lack of local studies reported, applying this new classification to real-world patient populations. This gap hinders a comprehensive understanding of disease patterns and risk profiles. Hence to address this gap, this study was conducted, aimed to determine the prevalence of periodontitis and its associated factors consistent with the current classification systems among local populations.

Materials and Methods

This is a retrospective record review study of patients attending dental clinic Hospital Pakar Universiti Sains Malaysia (HPUSM). The inclusion criteria specified patients aged 18 years old and above, newly diagnosed with periodontal disease within the study period and clearly stated periodontal staging and grading. Meanwhile those presented with gingival enlargement or pregnancy, and incomplete periodontal records were excluded. Based on the sample size calculation using a single proportion formula with anticipated population proportion (P)= 92.7% (Ranganathan *et al*., 2007) and by anticipating for a potential 10% dropout rate, 138 records required for analysis. The study protocol had been approved by Human Research Ethics Committee USM (*Jawatankuasa Etika Penyelidikan Manusia USM*) (USM/JEPeM/KK/24040309). Utilizing a convenience sampling method, all records of patients from year 2018 until 2024 were screened and reviewed for eligibility.

Data collection involved extracting sociodemographic information such as age, gender, ethnicity, smoking habits, systemic diseases, and medications taken. Oral hygiene status and diagnosis of periodontal disease including its staging and grading was retrieved from the periodontal records. The periodontal examinations were performed by trained undergraduate dental students under the direct supervision and approval of a periodontist. All clinical findings, including staging and grading, were reviewed and verified to ensure consistency and diagnostic accuracy.

The data collected were entered into Statistical Package for Social Science (SPSS Statistics for Windows, Version 27.0, Armonk, NY: IBM Corp) for analysis. Descriptive statistics for categorical variables are presented as frequency and percentage (%) whereas mean and standard deviation (SD) or median and interquartile range (IQR) are presented for continuous variables. Chi-square tests, Fishers exact tests and independent t-test were used to

determine factors associated with periodontitis. Significant level was set at $p<0.05$ with 95% confidence intervals (CI).

Results

A total of 262 patients out of 300 records has fulfilled the criteria, comprising mostly data of female subjects (56.9%). The remaining 38 cases were excluded due to insufficient clinical data required for accurate diagnosis including probing pocket depth, clinical attachment loss, bleeding on probing, and radiographic assessment of bone loss. The mean (SD) age was 42.5 (14.3) years with Malay ethnicity, accounting for 91.2%, followed by Chinese (7.3%) and Indian (1.5%). The demographic characteristics of study subjects is summarized in Table 1. Of the total subjects, 32 (12.2%) were diagnosed with diabetes mellitus, 23 (8.8%) had hypertension, and 14 (5.3%) had hyperlipidaemia. A combination of diabetes mellitus and hypertension was present in 26 patients (9.9%). Other systemic diseases, which included conditions such as history of breast cancer, bronchial asthma and allergic rhinitis, were observed in 28 patients (10.7%). Among the total patients, 116 (44.3%) taking medications for their medical problem. About 18% were smokers and most of the patients (85.5%) exhibited poor oral hygiene. The prevalence of periodontitis among patients attending HPUSM was 133 (50.8%) as shown in Table 2.

Table 1. Sociodemographic profile of study subjects (n=262).

Variables	n (%)	Mean (SD)
Age		42.5 (14.3)
Gender		
Male	115 (43.9)	
Female	147 (56.1)	
Ethnic		
Malay	239 (91.2)	
Chinese	19 (7.3)	
Indian	4 (1.5)	
Systemic diseases		
Diabetes Mellitus	32 (12.2)	
Hypertension	23 (8.8)	
Hyperlipidaemia	14 (5.3)	
Combined DM + HPT	26 (9.9)	
Others	28 (10.7)	
None	139 (53.1)	
Medication taken		
Yes	116 (44.3)	
No	146 (55.7)	
Smoking habits		
Yes	47 (17.9)	
No	215 (82.1)	
Oral hygiene		
Good	38 (14.5)	
Poor	224 (85.5)	

Table 2. Prevalence of periodontitis based on the 2017 Classification of Periodontal Diseases and Conditions 2017 (n=262).

Variables	n(%)
Gingivitis	129 (49.2)
Periodontitis	133 (50.8)

Regarding the severity and extent of periodontitis based on staging and grading (Table 3), the most common diagnosis was generalized periodontitis stage III grade C, identified in 33 patients (31.4%). This was followed by generalized periodontitis stage III grade B (24.8%), generalized periodontitis stage II grade B (13.3%) and generalized periodontitis stage IV grade C (11.4%).

Table 3. Severity and extent of periodontitis based on staging and grading (n=133).

Variables	n(%)		
	Grade A	Grade B	Grade C
Localised Periodontitis			
Stage I	4 (14.3)	6 (21.4)	0 (0)
Stage II	3 (10.7)	5 (17.9)	1 (3.6)
Stage III	0 (0)	6 (21.4)	0 (0)
Stage IV	1 (3.6)	1 (3.6)	1 (3.6)
Generalised Periodontitis			
Stage I	2 (1.9)	2 (1.9)	1 (1.0)
Stage II	4 (3.8)	14 (13.3)	2 (1.9)
Stage III	5 (4.8)	26 (24.8)	33 (31.4)
Stage IV	1 (1.0)	3 (2.9)	12 (11.4)

Age was significantly associated with periodontitis ($p<0.01$), with a mean age of 49.2 years (SD11.3). Similarly, systemic diseases were also found to be significantly associated with periodontitis ($p<0.01$), with 77 (57.9%) patients having systemic conditions such as hypertension, hyperlipidaemia, diabetes mellitus, or a combination of diabetes mellitus and hypertension. Additionally, a significant association was also observed between periodontitis and medication, as well as smoking habits ($p<0.01$). There was no significant association between periodontitis and gender, ethnicity and oral hygiene status (Table 4).

Table 4. Factors associated with the periodontitis (n=262).

Variables	Gingivitis n (%)	Periodontitis n (%)	x^2 (df)	P-value
Age (mean, SD)	35.53 (13.8)	49.2 (11.3)	-8.8 (246.9)	< 0.01[a]
Gender				
Male	54 (41.9)	61 (45.9)	0.4 (1)	0.51[b]
Female	75 (58.1)	72 (54.1)		
Ethnic				
Malay	115 (89.1)	124 (93.2)	1.7	0.42[c]
Chinese	11 (8.5)	8 (6.0)		
Indian	3 (2.3)	1 (0.8)		
Systemic diseases				
Yes	44 (34.1)	77 (57.9)	14.9 (1)	< 0.01[b]
No	85 (65.9)	56 (42.1)		
Medication				
Yes	44 (34.1)	72 (54.1)	10.6 (1)	0.00[b]
No	85 (65.9)	61 (45.9)		
Smoking habits				
Yes	9 (7.0)	38 (28.6)	20.7 (1)	< 0.01[b]
No	120 (93.0)	95 (71.4)		
Oral hygiene				
Good	19 (14.7)	19 (14.3)	0.0 (1)	0.92[b]
Poor	110 (85.3)	114 (85.7)		

[a]Independent T-test, [b]Pearson Chi-square Test, [c]Fisher's Exact Test; Significant at p<0.05

Discussion

Periodontitis is a significant public health concern, with a notable impact on oral health and overall well-being. Considering the current classification system of periodontal disease 2017 (Tonetti *et al.*, 2018), this study aims to determine the prevalence of periodontitis and its associated factors among patients attending HPUSM since the application of this new classification scheme in our setting in 2018.

The prevalence of periodontal disease in Malaysia is notably high, affecting 94% of adults aged 15 years and older. Among these, 48.5% have been diagnosed with periodontitis, with 18.2% suffering from its severe form—a rate significantly higher than the global average (Anuwar *et al.*, 2024). This present study shows a similar pattern

emerges in which 50.8% of cases were diagnosed with periodontitis, among all subjects with the rest were having gingivitis. This distribution reflects a balanced yet concerning trend, as gingivitis, if left untreated, can progress to periodontitis, increasing the risk of tooth loss. In comparison, the NOHSA 2020 reported a national prevalence of 38.2%, with 14.5% of the population having deep periodontal pockets (NOHSA, 2020). Globally, pooled data from 2011 to 2020 showed a 62% prevalence among dentate adults (Trindade *et al*., 2023), while high-income countries reported a prevalence of 43.7% (Nazir *et al*., 2020). The higher prevalence of periodontitis at HPUSM compared to national and global figures may reflect regional risk factors, patient demographics, or differences in healthcare-seeking behaviour.

Generalized periodontitis stage III grade C was the most prevalent in this study, accounting for 31.4% of cases. According to the 2017 classification system for periodontal diseases, in which stage III is characterized by interdental clinical attachment loss greater than 5 mm and radiographic bone loss extending to the middle third of the root and beyond, and grade C denotes a rapid rate of disease progression. In a study conducted by Carmen & Hong (2024), reported among their study subjects, stage IV periodontitis was more common (54.2%) than stage III periodontitis (45.8%). Furthermore, a large proportion of patients showed rapid periodontitis progression and were categorized under grade C (78.9%). Generalized periodontitis was predominant in their study, accounting for 85.9% of cases (Carmen & Hong, 2024). Our study observed a slightly lower prevalence of generalized periodontitis stage III grade C, with a difference of 14.4%. Periodontitis affects a significant portion of the global population, and the current classification system provides a universal framework for assessing its prevalence. This aligns with other studies reporting high proportions of advanced stages (17.6%–54%) (Germen *et al*., 2021; Stødle *et al*., 2021) and rapid progression under grade C, reaching up to 78.9% (Carmen & Hong, 2024). Variations in the prevalence of periodontitis classifications can occur due to differences in study populations and clinical settings. The slightly lower prevalence observed in our study may reflect differences in the severity of cases presenting at our clinic or regional disparities in oral health practices and risk factors. Additionally, demographic characteristics such as age distribution, socioeconomic status, and access to dental care may also contribute to these findings.
While dental biofilm and calculus accumulation are the main causes of periodontal diseases, other risk factors such as age, gender, ethnicity, systemic conditions, medication, smoking habits and oral hygiene play a significant role in influencing the development and progression of periodontitis. Understanding this complex interplay is essential for the effective prevention, diagnosis, and management of the disease.

The mean age of patients diagnosed with periodontitis in this study was 49.2 years, with an age range of 18–75 years. Similarly, another study reported a mean age of 43.4 years for their periodontitis patients, within the same age range of 18–75 years (Carmen & Hong, 2024). In this study, we found that there was a significant association between mean age and periodontitis ($p < 0.01$). A study conducted by Arshad *et al*. (2024), found that individuals aged 45–64 and those of Malay ethnicity have a significantly higher risk of severe periodontitis compared to other age groups and ethnicities, respectively (Arshad *et al*., 2024). Huang *et al*. (2024) reported that higher biological age was associated with an increased risk of periodontitis ($p = 0.03$) (Huang *et al*., 2024). Similarly, Germen *et al.* found a significant association between periodontitis and individuals aged 45–64 years ($p = 0.001$) (Germen *et al*., 2021). Additionally, Huang *et al.* (2024) also identified age as a risk factor for the development of periodontitis, particularly among middle-aged and elderly patients ($p < 0.05$) (Huang & Dong, 2022). This current study found a significant association between age and periodontitis, with older individuals more likely to experience severe forms of the disease. This

finding aligns with other studies, which also report increased prevalence and severity among middle-aged and elderly adults. The association may be attributed to the cumulative effects of plaque accumulation and age-related changes in immune function and tissue regeneration, reinforcing age as a key factor in the progression of periodontitis.

With regard to gender, periodontitis was more common in female (54.1%) than in male (45.9%). Similar observations were noted in a local study where 63.8% of periodontitis patients were female (Taib *et al*., 2013). This could be attributed to several factors, including greater health-seeking behaviour and awareness of oral health issues among women compared to men. Additionally, hormonal changes associated with pregnancy, menopause, and the menstrual cycle may increase females' susceptibility to periodontal diseases (Reeves, 2025). These highlight the need for targeted prevention and education efforts that address gender-specific risk factors and behaviours. However, we found that there was no significant association between gender and periodontitis ($p = 0.51$). Another local study by Singh *et al.* (2019), reported that sex was not significantly associated with periodontitis in the adjusted analysis. This finding is consistent with our study even though few studies reported the prevalence of periodontitis is greater in males than females (Desvarieux *et al*., 2004; Ababneh *et. al*., 2012).

We found that ethnicity was not statistically significant with periodontitis ($p = 0.42$), with the highest prevalence observed among Malay patients (93.2%), followed by Chinese (6.0%) and Indian (0.8%). However, a study conducted by Arshad *et al.* (2024) found that ethnicity was significantly associated with periodontitis severity ($p = 0.003$). Malay individuals exhibited a higher prevalence of both mild (36.0%) and severe (4.7%) periodontitis compared to other ethnic groups, which reported rates of 4.8% and 0%, respectively (Arshad et al., 2024). Majority of patients attending HPUSM were Malay, which may have skewed the ethnic distribution and limited the ability to detect statistical differences between groups. Moreover, ethnicity itself does not inherently determine susceptibility to periodontitis; rather, the development and progression of the disease result from a complex interplay of modifiable and non-modifiable risk factors. When differences are observed across ethnic groups, they are more likely to reflect underlying socio-economic conditions, disparities in access to care, and health-related behaviours, rather than ethnicity as an independent determinant.

In the present study, 57.9% of patients with periodontitis also had systemic diseases, and was significantly associated ($p < 0.01$). This finding is consistent with previous local study that reported a significant association between periodontitis and systemic conditions such as diabetes mellitus ($p = 0.01$), hypertension ($p < 0.01$), and the combination of both ($p = 0.004$) (Taib *et al.,* 2013). Similarly, Gatarayiha *et al.* in 2024 found that systemic conditions significantly influence the development and progression of periodontitis (Gatarayiha *et al*., 2024). Larvin *et al*. (2023) further reported that individuals with moderate-to-severe periodontitis have a higher risk of developing diabetes (Larvin et al., 2023). These findings are consistent with growing evidence that highlights the bidirectional relationship between systemic diseases and periodontal health (Preshaw *et al*., 2012). Conditions like diabetes mellitus and hypertension are known to exacerbate periodontal disease due to their effects on immune function, inflammatory pathways, and tissue repair. For instance, diabetes impairs the body's ability to fight infections and promotes a chronic inflammatory state, while hypertension can compromise blood flow and hinder tissue regeneration within the periodontium (Genco and Borgnakke, 2013). Collectively, these studies reinforce the importance of considering systemic health in the management and prevention of periodontitis.

Our findings demonstrated a strong association between medication use and periodontitis ($p =0.00$), with more than half of the participants (54.1%) reporting

current medication use. This aligns with previous evidence indicating that several drug categories, including bisphosphonates, proton pump inhibitors, antidepressants, anticoagulants, statins, and ACE inhibitors, may adversely influence periodontal health (Chatzopoulos *et al*., 2023). Other study also found that systemic medications used to manage diabetes mellitus were significantly associated with the severity and progression rate of periodontal disease ($p < 0.05$) (Batista-Cárdenas *et al*., 2024). This aligns with our findings, as many of these medications are known to influence oral and periodontal health. For instance, bisphosphonates and proton pump inhibitors can affect bone metabolism and healing, while anticoagulants may exacerbate gum bleeding, a hallmark of periodontitis. Additionally, medications like antidepressants and statins can alter inflammatory pathways, potentially impacting periodontal disease progression (Wang *et al*., 2020).

We also found that periodontitis is significantly associated with smoking habit ($p < 0.001$). The role of smoking as a risk factor for periodontal disease is well-documented in the literatures (Baharuddin, 2008). They found that 71.8% of the participants were current smokers, with periodontitis affecting 21.8% of their examined sextants. In another study, conducted by Razali *et al*. in 2005, confirmed that smokers exhibited more severe periodontal disease compared to non-smokers (Razali *et al*., 2005). Smoking raises the incidence of periodontitis by 85% (Alwithanani, 2023). Tobacco smoking may lead to an increase in both local and systemic levels of pro-inflammatory cytokines, reactive oxygen species, collagenase, and serine proteases, which contribute to the accelerated destruction of periodontal tissues (Johannsen *et al*., 2014). Long-term smoking is strongly associated with poor periodontal health, as it influences the progression of periodontitis by impairing both immune response and vascular function (Batista-Cárdenas *et al*., 2024).

Our study revealed that the majority of periodontitis patients (85.7%) had poor oral hygiene. However, there was no significant association between oral hygiene status and periodontitis ($p = 0.92$). A meta-analysis by Lertpimonchai *et al*. (2017), observed a dose-response relationship between oral hygiene and periodontal disease, showing that fair to poor oral hygiene increases the risk of developing periodontitis by 2 to 5 times (Lertpimonchai *et al*., 2017). This is inconsistent with our result could be due to differences in study design, population characteristics, or sample size. For instance, our study population may have included other confounding factors, such as systemic health conditions, or medication used, which could mask the impact of oral hygiene. Additionally, variations in the assessment methods for oral hygiene and periodontitis severity may have contributed to the inconsistency. Oral hygiene practices vary worldwide and are often shaped by factors such as socioeconomic status, level of education, and home environment (Vano *et al*., 2015).

This study has several limitations. First, its retrospective design posed challenges, including incomplete records and variability in the quality of documented information. As with most record review studies, the lack of control over data quality may affect the reliability of the findings. Furthermore, information bias could arise if diagnoses or exposures were inaccurately recorded, potentially leading to misclassification. Nevertheless, the insights gained from this review can serve as a foundation for designing cross-sectional or prospective studies with more rigorous control over data collection and variable measurement.

Second, the use of convenience sampling for participant recruitment limits the generalizability of our findings, as the sample may not accurately represent the broader population and is subject to selection bias. Next, lack of standardized diagnostic criteria due to variations in the definition and classification of periodontitis among different studies can pose challenges when comparing findings. For instance, while some studies may use the 2017 classification system (staging and grading) for periodontitis, others might follow older

or alternative diagnostic criteria. These differences can lead to inconsistencies in prevalence rates, severity assessment, or disease progression metrics. As a result, drawing direct comparisons or integrating findings with other research may become difficult, potentially affecting the study's ability to contribute to a broader understanding of periodontitis.

Lastly, the reliance on self-reported data for systemic conditions and smoking habits introduces the potential for reporting bias, which may affect the accuracy of the results. Patients may underreport or overreport their health conditions or smoking behaviours due to forgetfulness, social desirability bias, or a lack of awareness about their actual health status. This reliance on subjective accounts could lead to misclassification, resulting in an underestimation or overestimation of the associations between these factors and periodontitis.

Despite its limitations, our study had several notable strengths. The periodontitis was diagnosed based on the 2017 classification system for periodontal and peri-implant diseases and conditions. This ensures that the data from our study can be directly compared with other studies employing this updated classification system. Additionally, as this classification is now widely adopted by periodontal specialists, our findings align with current clinical standards, enhancing their relevance and applicability in local clinical practice. Other than that, our study highlighted significant findings on few risk factors associated with periodontitis such as age, systemic diseases, medication used, and smoking. The study identifies potential gaps and inconsistencies, paving the way for future research to explore these areas further.

Conclusion

Within the study's limitations, it was found that severe periodontitis (stage III grade C) was prevalent among patients attending HPUSM, based on 2017 classification of periodontal disease, indicating a rising incidence in local region. Age, systemic diseases, medication used, and smoking habits, all of which may influence the development and progression of periodontitis. These findings underscore the critical role of risk factors in determining the rate of periodontal disease progression, emphasizing the need for targeted prevention and management strategies for periodontitis.

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References

Ababneh, K.T., Abu Hwaij, Z.M.F. & Khader, Y.S. (2012). Prevalence and risk indicators of gingivitis and periodontitis in a multi-centre study in North Jordan: a cross sectional study. *BMC Oral Health*, 12(1). https://doi.org/10.1186/1472-6831-12-1

Alwithanani, N. (2023). Periodontal disease and smoking: systematic review. *Journal of Pharmacy and Bioallied Sciences*, 15(Suppl 1), S64-S71. https://doi:10.4103/jpbs.jpbs_516_22

Anuwar, A.H.K., Ng, C.W., Safii, S.H., Saub, R., Ab-Murat, N. (2024). Modelling the national economic burden of non-surgical periodontal management in specialist clinics in Malaysia using a markov model. *BMC Oral Health*, 24(1). https://doi:10.1186/s12903-024-04094-z

Arshad, S., Awang, R.A., Rahman, N.A., Hassan, A., Ahmad, W.M.A.W., Mohamed, R.N., *et al.* (2024). Assessing the impact of systemic conditions on periodontal health in Malaysian population: a retrospective study. *BMC Oral Health*, 24(1), 1330. https://doi:10.1186/s12903-024-05102-y

Baharuddin, N.A. & AI-Bayaty, F.H. (2008). The relationship between smoking and periodontal status. *Annals of Dentistry University of Malaya*, 15(2), 59-66.

Batista-Cárdenas, D., Araya-Castillo, A., Arias-Campos, M.P., Solís-Rivera, A.P., Jiménez-Matarrita, J., Piedra-Hernández, L., *et al*. (2024). Association of the severity and progression rate of periodontitis with systemic medication intake. *Frontiers in Oral Health*, 5, 1447019. https://doi:10.3389/froh.2024.1447019

Carmen, K., Hong, A.K.B. (2024). The prevalence of systemic diseases and its association with periodontal disease among patients referred to a government periodontal specialist clinic in Melaka, Malaysia. *Malaysian Dental Journal*, 47(1), 20–26. https://doi:10.4103/mdj.mdj_1_24

Chatzopoulos, G.S., Jiang, Z., Marka, N., Wolff, L.F. (2023). Relationship of medication intake and systemic conditions with periodontitis: a

retrospective study. *Journal of Personalized Medicine*, 13(10), 1480. https://doi:10.3390/jpm13101480

Das, S.S. (2015). American Academy of Periodontology Task Force report on the update to the 1999 classification of periodontal diseases and conditions. *Journal of Periodontology*, 86(7), 835-838. https://doi.org/10.1902/jop.2015.157001

Desvarieux, M., Schwahn, C., Völzke, H., Demmer, R.T., Lüdemann, J., Kessler, C., *et al*. (2004). Gender differences in the relationship between periodontal disease, tooth loss, and atherosclerosis. *Stroke*, 35(9), 2029–2035. https://doi:10.1161/01.STR.0000136767.71518.36

Eke, P.I., Borgnakke, W.S., Genco, R.J. (2020). Recent epidemiologic trends in periodontitis in the USA. *Periodontology 2000*, 82(1), 257-267. https://doi:10.1111/prd.12323

Fu, H., Li, X., Zhang, R. *et al.* (2025). Global burden of periodontal diseases among the working-age population from 1990–2021: results from the Global Burden of Disease Study 2021. *BMC Public Health*, 25, 1316. https://doi.org/10.1186/s12889-025-22566-x

Gasner, N.S. & Schure, R.S. (2023). Periodontal disease. In StatPearls [Internet]. StatPearls Publishing.

Gatarayiha, A., Brookes, Z., Rulisa, S., Andegiorgish, A.K., Mutesa, L. (2024). Association between periodontitis and hypertension among adult population in Rwanda. *Journal of Clinical Medicine*, 13(16), 4722. https://doi:10.3390/jcm13164722

Genco, R.J., Borgnakke, W.S. (2013). Risk factors for periodontal disease. *Periodontology 2000*, 62(1), 59–94. https://doi:10.1111/j.1600-0757.2012.00457.x

Germen, M., Baser, U., Lacin, C.C., Fıratlı, E., İşsever, H. and Yalcin, F. (2021). Periodontitis prevalence, severity, and risk factors: a comparison of the AAP/CDC case definition and the EFP/AAP classification. *International Journal of Environmental Research and Public Health*, 18(7), 3459. https://doi:10.3390/ijerph18073459

Huang, Q., Dong, X. (2022). Prevalence of periodontal disease in middle-aged and elderly patients and its influencing factors. *American Journal of Translational Research*, 14(8), 5677-5684.

Huang, Z., Peng, S., Cen, T., Wang, X., Ma, L., Cao, Z. (2024). Association between biological ageing and periodontitis: Evidence from a cross-sectional survey and multi-omics Mendelian randomization analysis. *Journal of Clinical Periodontology*, 51(10), 1369–1383. https://doi:10.1111/jcpe.14040

Johannsen, A., Susin, C., Gustafsson, A. (2014). Smoking and inflammation: evidence for a synergistic role in chronic disease. *Periodontology 2000*, 64(1), 111–126. https://doi:10.1111/j.1600-0757.2012.00456.x

Jordan, R.C.K. (2004). Diagnosis of periodontal manifestations of systemic diseases. *Periodontology 2000*. https://doi:10.1046/j.0906-6713.2002.003433.x

Larvin, H., Kang, J., Aggarwal, V.R., Pavitt, S., Wu, J. (2023). Periodontitis and risk of immune-mediated systemic conditions: a systematic review and meta-analysis. *Community Dentistry and Oral Epidemiology*, 51(5), 705-17. https://doi:10.1111/cdoe.12812

Lertpimonchai, A., Rattanasiri, S., Vallibhakara, S.A.O., Attia, J., Thakkinstian, A. (2017). The association between oral hygiene and periodontitis: a systematic review and meta-analysis. *International Dental Journal*, 67(6), 332-43. https://doi:10.1111/idj.12317

Nazir, M., Al-Ansari, A., Al-Khalifa, K., Alhareky, M., Gaffar, B. and Almas, K. (2020). Global prevalence of periodontal disease and lack of its surveillance. *The Scientific World Journal*, 2020(1), 2146160. https://doi:10.1155/2020/2146160

Oral Health Programme, Ministry of Health Malaysia. National Health and Morbidity Survey 2020: National Oral Health Survey of Adults (NOHSA) 2020 key findings. (2020). https://hq.moh.gov.my/ohp/images/pdf/4.-penyelidikan-kesihatan-pergigian/key-findings-nohsa-2020.pdf.

Petersen, P.E., Baehni, P.C. (2012). Periodontal health and global public health. *Periodontology 2000*, 60(1), 7–14. https://doi:10.1111/j.1600-0757.2012.00452.x

Pihlstrom, B.L., Michalowicz, B.S., Johnson, N.W., 2005. Periodontal diseases. *The Lancet*, 366(9499), 1809-1820.

Preshaw, P.M., Alba, A.L., Herrera, D., Jepsen, S., Konstantinidis, A., Makrilakis, K., *et al.* (2012). Periodontitis and diabetes: a two-way relationship. *Diabetologia*, 55(1), 21–31. https://doi:10.1007/s00125-011-2342-y

Ranganathan, K., Magesh, K., Kumarasamy, N., Solomon, S., Viswanathan, R., Johnson, N. (2007). Greater severity and extent of periodontal breakdown in 136 South Indian human immunodeficiency virus seropositive patients than in normal controls: a comparative study using community periodontal index of treatment needs. *Indian Journal of Dental Research*, 18(2), 55-59. https://doi:10.4103/0970-9290.32420

Razali, M., Palmer, R.M., Coward, P., Wilson, R.F. (2005). A retrospective study of periodontal disease severity in smokers and non-smokers. *British Dental Journal*, 198(8), 495–498. https://doi:10.1038/sj.bdj.4812253

Reeves, J. (2025). The impact of female hormones on the periodontium-a narrative review. *International Journal of Dental Hygiene*. https://doi:10.1111/idh.12908

Singh, V.P., Gan, J.Y., Liew, W.L., Soe, H.H.K., Nettem, S., Nettemu, S.K. (2019). Association between quality of sleep and chronic periodontitis: a case–control study in Malaysian population. *Dental Research Journal*, 16(1), 29-35.

Stødle, I.H., Verket, A., Høvik, H., Sen, A., Koldslan, O.C. (2021). Prevalence of periodontitis based on the 2017 classification in a Norwegian population: the HUNT study. *Journal of Clinical Periodontology*, 48(9), 1189–1199. https://doi:10.1111/jcpe.13507

Tonetti, M.S., Greenwell, H., Kornman, K.S. (2018). Staging and grading of periodontitis: Framework and proposal of a new classification and case definition. *Journal of Periodontology*, 89, S159–S172. https://doi:10.1002/JPER.18-0006

Trindade, D., Carvalho, R., Machado, V., Chambrone, L., Mendes, J.J., Botelho, J. (2023). Prevalence of periodontitis in dentate people between 2011 and 2020: a systematic review and meta-analysis of epidemiological studies. *Journal of Clinical Periodontology*, 50(5), 604-626. https://doi:10.1111/jcpe.13769

Vano, M., Gennai, S., Karapetsa, D., Miceli, M., Giuca, M.R., Gabriele, M., *et al.* (2015). The influence of educational level and oral hygiene behaviours on DMFT index and CPITN index in an adult Italian population: an epidemiological study. *International Journal of Dental Hygiene*, 13(2), 151–157. https://doi:10.1111/idh.12098

Wang, I., Askar, H., Ghassib, I., Wang, C., Wang, H. (2020). Association between periodontitis and systemic medication intake: A case-control study. *Journal of Periodontology*, 91(10), 1245–1255. https://doi:10.1002/JPER.19-0593

Zainoddin, N.M.N., Taib, H., Awang, R.A.R., Hassan, A., Alam, M.K. (2013). Systemic conditions in patients with periodontal disease. *International Medical Journal,* 20(3), 363-366.

ORIGINAL ARTICLE Open Access

Perceptions and utilization of the Index of Orthodontic Treatment Need (IOTN) among final year dental students: a qualitative study

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Abstract

The Index of Orthodontic Treatment Need (IOTN) is widely used to assess malocclusion severity and prioritize orthodontic treatment. However, its perception and utilization among undergraduate dental students remain unclear. This qualitative study aimed to explore the perceptions and utilization of the IOTN among 13 final-year dental students at AIMST University, Malaysia. Participants were recruited using convenience sampling, and data were collected through semi-structured interviews conducted via Zoom. The interviews were transcribed verbatim and analysed using thematic analysis until data saturation was achieved. Five main themes emerged: subjectivity in perception of criteria, neglect of patients' psychological well-being, time-consuming application, lack of training and exposure, and potential facilitators for improvement. Although the participants acknowledged the IOTN as a valuable standardized tool, its consistent application in clinical practice was perceived to be limited by variability in interpretation and practical constraints. These findings highlight the need for improved undergraduate training, greater standardization, and the incorporation of digital technologies to enhance the reliability and clinical applicability of the IOTN. Strengthening these aspects may better prepare future dental practitioners for effective orthodontic assessment and treatment prioritization. Future research should consider multi-centre studies involving both public and private universities to improve generalisability and to better understand variations in training exposure, curriculum structure, and clinical experience across institutions.

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Introduction

Efficient administration of the public healthcare system necessitates evaluating both demand and the requirement for orthodontic treatment. It is crucial to prioritize patients, ensuring that treatment is allocated to those with the most pressing needs, particularly in nations facing constraints in manpower and financial resources (Salzmann, 1968).

Therefore, Index of Orthodontic Treatment Need (IOTN) by (Brook & Shaw, 1989) in the 1989 marks an important milestone in orthodontic index development. The IOTN aimed to provide a standardized method for assessing malocclusions and determining the need for orthodontic treatment based on both dental health and aesthetic considerations. It consisted of two components: the Dental Health Component (DHC) and the Aesthetic Component (AC), which together provided a comprehensive evaluation of orthodontic treatment need (Järvinen, 2001).

The IOTN stands out for its holistic approach, encompassing clinical and patient-centered factors. This system has been embraced and recommended for integration into orthodontic education programs for undergraduate dental students in various countries as a standard for epidemiological and clinical research. Clinical decision-making may be significantly influenced by IOTN due to its substantial correlation with orthodontic treatment necessity.

Despite being recommended for inclusion in dental education programs, there is insufficient data to confirm its reliability in routine clinical settings (Ferguson, 2006). As a result, there is uncertainty about its utility and impact on treatment decisions among dentists. Over the past several decades, orthodontic research has shown that dentists often hold inconsistent views when assessing the need for orthodontic treatment. Concerns have been raised that dental school training may not adequately equip graduates to diagnose malocclusion or to appropriately refer patients who may require orthodontic care (Bentele *et al.*, 2002).

Therefore, assessing the perception of final-year dental students regarding the IOTN becomes necessary to understand their views, concerns, and experiences with its use in practice. This assessment can help identify any challenges or limitations associated with the implementation of the IOTN and inform future efforts to improve its application in dental practice.

Previously published data on IOTN has mostly centred on establishing the index's reliability, reproducibility, validity, and accuracy. In a study on the perspectives and experiences of dental practitioners in Scotland (Puri *et al.*, 2015), the IOTN was not used or applied in their dental practice for several reasons, including that it is only considered to be suitable for secondary dental care, was not included in their undergraduates training program, while some claimed that IOTN is only suitable for use after referral.

Another research conducted on UK dental students' ability in applying IOTN index (Bouskandar *et al.*, 2023), suggested that dental students demonstrated insufficient proficiency and confidence in accurately utilizing the IOTN Dental Health Component and determining the suitable referral pathway.

However, research examining the obstacles clinicians and researchers encounter in utilizing the IOTN remains limited in the literature. In private dental practices, patients frequently receive treatment from multiple dentists. The implementation of a standardized orthodontic assessment tool like IOTN facilitates the monitoring of patients' progress by various dentists and enables them to address any subsequent complications more efficiently.

Hence, it's crucial to evaluate the challenges, perspectives, and opinions of current fifth-year dental undergraduates regarding the IOTN, given its widespread use as a prioritization tool in government dental services. With limited resources available, it becomes paramount to allocate treatment priority to those with greater needs. The assessment and management of malocclusions play a significant role across various domains, including epidemiology, diagnosis, communication among clinicians, patient interactions, and the assessment of treatment efficacy. This ensures that they are equipped to effectively navigate and contribute to the orthodontic treatment landscape upon entering their professional careers.

The objective of this research is to investigate the perceptions of year 5 dental undergraduates regarding the use of the IOTN. To the best of our knowledge, no comparable study has been conducted in Malaysia. Hence, a qualitative study was conducted to explore the students' attitudes, views, and experiences in utilizing the IOTN index for orthodontic treatment need assessment within their dental practice.

By gaining insights into the students' perceptions, this research seeks to identify any barriers, challenges, or enablers that

may influence their understanding and utilization of the IOTN index. Ultimately, the findings of this study aim to contribute to the enhancement of dental education and training programs by addressing any educational gaps and improving the integration of orthodontic assessment tools like the IOTN index into the curriculum.

Materials and Methods

Study design

This qualitative study explored the perceptions of final-year dental students in Malaysia regarding the use of the IOTN. Ethical approval was obtained from the AIMST University Research Ethics Committee (Reference: AUHEC/FOD/05/08/2024/G1). In this study, final-year dental students referred to undergraduate dental students in their fifth year of training who had been exposed to the IOTN during their curriculum.

Participants' recruitment and interview process

A semi-structured interview guide was developed based on a review of existing literature (Bouskandar *et al.*, 2023, Hsu *et al.*, 2014, Shahrul AI *et al.*, 2024) and was content-validated by an experienced qualitative researcher in the faculty. Eligible participants were final-year dental students from AIMST University who had prior exposure to the IOTN. Convenience sampling was used, and potential participants were invited via email.

Participant information sheets were provided, outlining the study objectives, voluntary nature of participation, confidentiality measures, and the right to withdraw at any time prior to data publication. Students who expressed interest were enrolled in the study.

One-on-one semi-structured interviews were conducted to explore participants' experiences and perceptions of the IOTN in depth. Verbal and written consent were obtained prior to participation. Participants were given the opportunity to clarify any questions before the interviews commenced. The interviews were conducted via Zoom Video Communications Software and lasted approximately 20–30 minutes. Each session was facilitated by two researchers, with one leading the discussion and the other providing support. The facilitators had no prior relationship with the participants. All interviews were audio-recorded with consent and later transcribed verbatim for analysis.

Data analysis

All audio recordings were anonymized and transcribed verbatim. Data collection and analysis were conducted concurrently. Regular meetings were held among the research team to discuss emerging patterns and themes. Data collection was discontinued when all researchers agreed that no new themes were identified, indicating that data saturation had been achieved.

Data were gathered from interviews and meticulously transcribed into a password-secured Google Docs™ (Google LLC, Mountain View, CA, USA), solely accessible to the designated research team.

A phenomenological approach was adopted to explore participants' lived experiences with the IOTN. The data were analysed using thematic analysis as described by Braun and Clarke (2006), which is commonly applied in phenomenological research.

Initial coding was performed independently by two researchers using NVivo 12 software. The researchers identified meaningful segments of text and generated preliminary codes. Any discrepancies in coding were resolved through discussion with a third researcher.

The codes were subsequently grouped into categories, and themes were developed iteratively to reflect patterns within the data. All themes were reviewed, refined, and agreed upon by the entire research team to

ensure consistency, credibility, and trustworthiness of the findings.

Results

A total of 13 students participated in the study. Most participants were female, constituting 69.2%, while male participants accounted for 30.8% (Figure 1}. Five main themes were developed inductively through the coding process namely, subjectivity in perception of criteria, neglect of patients' psychological well-being, time-consuming application, lack of training and exposure, and potential facilitators for improvement.

Table 1 presents a comprehensive summary of the themes and subthemes derived from the qualitative analysis of participants' perceptions of the IOTN system. Each theme is accompanied by a description and illustrative quotes to provide contextual depth and support the findings.

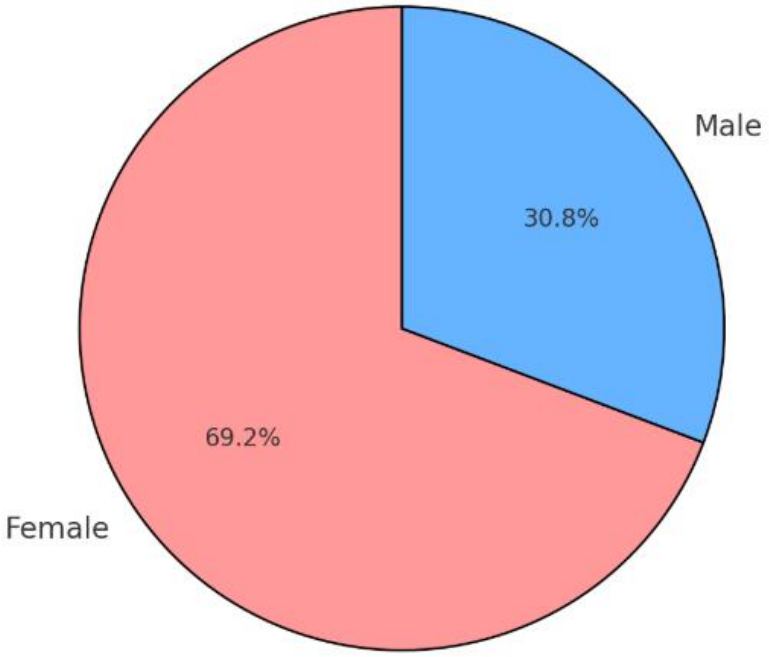

Figure 1. Gender composition of the study sample: distribution of male and female participants.

Table 1. Thematic analysis of participants' perceptions of the IOTN: themes, subthemes, and supporting quotes.

Theme	Subtheme	Description	Supporting Quotes
Theme 1: Subjectivity in perception of criteria	• Variability in clinician judgement	• Despite standardized criteria, clinicians interpret malocclusion differently, leading to inconsistent scoring.	• *"IOTN itself is quite a subjective assessment… different people have different perspectives on it."* (Participant 2)
	• Subjectivity in aesthetic component	• Aesthetic evaluation varies between clinician and patient, contributing to inconsistency.	• *"It's the subjectivity in the aesthetic component because the patient's and clinician's perceptions may be varied."* (Participant 1)
	• Patient's limited self-awareness	• Patients may not fully understand their dental condition, affecting aesthetic scoring.	• *"The esthetic component is very subjective… some patients do not know about their dental condition very well."* (Participant 3)
	• Differences in severity perception	• Clinicians differ in judging severity levels of malocclusion.	• *"Some may feel that it's more severe. Some may feel that it's less severe."* (Participant 4)
Theme 2: Neglect of patient's psychological well-being	• Lack of psychosocial consideration	• IOTN does not incorporate psychosocial or emotional factors.	• *"…the system does not incorporate patient psycho-social content…"* (Participant 1)
	• Focus on clinical over patient concerns	• Emphasis on clinical need overlooks patient-reported concerns.	• *"It doesn't fully capture functional issues or patient-reported concerns."* (Participant 6)
	• Limited reflection of patient priorities	• Patients prioritize aesthetics, but this may not align with clinician-based scoring.	• *"It does not fully consider the patient's emotional and psychological concerns…"* (Participant 7)
Theme 3: Time-consuming application	• Complexity of assessment criteria	• Multiple components and severity levels require detailed measurements.	• *"There are many things to measure."* (Participant 3)

	• Workflow constraints in practice	• Busy clinical settings limit feasibility of using IOTN.	• *"…for private practice, they don't really have the time to do all this."* (Participant 4) • *"…you have to ask the patient to open very wide for a long time. It is quite time consuming."* (Participant 13)
Theme 4: Lack of training and exposure	• Insufficient undergraduate training	• Limited formal training reduces confidence in using IOTN.	• *"The training of IOTN system is really insufficient…"* (Participant 2)
	• Limited clinical exposure	• Students encounter few and less complex cases.	• *"…we still see quite limited cases for us back in university time."* (Participant 2)
	• Difficulty mastering the index	• Limited patient numbers hinder skill development.	• *"…you can't expect yourself to master… just from seeing 10 to 11 patients."* (Participant 9)
Theme 5: Potential facilitators for improvement	• Standardization of aesthetic assessment	• Use of visual aids or reference tools can reduce subjectivity.	• *"…we can use some improved visual tools to reduce the subjectivity…"* (Participant 1)
	• Enhanced scoring system	• Refinement of aesthetic component scoring may improve reliability.	• *"…maybe we can integrate a more scoring part in aesthetic component…"* (Participant 2)
	• Use of photographic comparison	• Visual comparison methods may support patient involvement.	• *"…take a photo of the patient and let the patient compare side by side."* (Participant 3)
	• Improving reliability of assessment	• Greater standardization can enhance consistency across clinicians.	• *"…the aesthetic component should be more standardized and less subjective…"* (Participant 6)

Theme 1: subjectivity in perception of criteria.

The IOTN index provides a standardized set of criteria for the clinician to score the patient's presented malocclusion. Hence, this system that makes the criteria advocates for objectivity from the practitioner. However, every practitioner may have different perception and view every patient's malocclusion in a different way. As

a result, this breeds inconsistency in scoring despite viewing the same criteria.

Variability in clinician judgement

Participants reported that individual clinicians interpret malocclusion traits differently despite standardized guidelines. The variability introduces inconsistency in scoring and may compromise inter-examiner reliability.

Participant 1: But for the limitation of IOTN, I will say that IOTN itself is quite a subjective assessment to be honest. So different people have different perspectives on it.

Subjectivity in the aesthetic component

The aesthetic component (AC) of the IOTN was particularly identified as a course of inconsistency. Participants emphasized that aesthetic judgement are inherently subjective and influenced by both clinician bias and patient perception.

Participant 2: For the limitation, I think it's the subjectivity in the aesthetic component because the patient's and clinician's perceptions may be varied.

Patient's limited self-awareness

Another contributing factor to subjectivity is patients' limited understanding of their own dental conditions. Participants noted that patients often lack the knowledge to accurately assess their malocclusion, which can lead to underestimation or overestimation of aesthetic concerns.

Participant 3: However, the esthetic component is very subjective because it is based on how the patients see themselves and some patients do not know about their dental condition very well.

Differences in severity perception

Variations were also observed in how clinicians perceive the severity of malocclusion. Participants acknowledged that identical clinical presentations could be graded differently depending on the assessor.

Participant 4: it's actually quite subjective. Some might think that it falls in it falls indifferent stages. Some may feel that it's more severe. Some may feel that it's less severe.

Theme 2: neglect of patient's psychological well-being

The IOTN index only focuses on the dental and aesthetic components. If clinician only focuses on treating the malocclusion, they end up neglecting the patient's mental health and psychological well-being.

Lack of psychosocial consideration

A recurring observation was that the IOTN does not incorporate psychological or social factors, such as self-esteem, social confidence, or emotional distress related to dental appearance.

Participant 1: ... the system does not incorporate patient psycho-social content...

Focus on clinical over patient concerns

The findings suggest that the IOTN prioritizes objective clinical indicators over subjective patient experiences. Participants noted that functional and patient-reported concerns may be overlooked if they do not align with the index's scoring criteria.

Participant 6: However, a limitation is that it doesn't fully capture functional issues or patient- reported concerns.

Limited reflection of patient priorities

Participants highlighted a disconnect between clinician-driven assessments and patient priorities. While patients often place high importance on aesthetics and psychosocial outcomes, these factors are not fully captured within the IOTN scoring system.

Participant 7: Additionally, it does not fully consider the patient's emotional and

psychological concerns, which can be important in determining treatment necessity.

Theme 3: time-consuming application

The IOTN index comprised of various sets of criteria to be scored when evaluating the patient's malocclusion. The practitioner has to measure each component to discover its severity for the final score to be determined. For a clinician to utilise this index in a government setting or private practice can be time consuming as they are operating on a heavy workflow.

Complexity of assessment criteria

Participants described the IOTN as requiring multiple measurements and detailed evaluations, which can be cumbersome, particularly for inexperienced users. The need to assess both dental health and aesthetic components adds to the complexity and duration of the assessment.

Participant 3: The main concern is the difficulty in interpretation because there are many things to measure.

Workflow constraints in practice

In busy clinical environments, especially private practice settings, time efficiency is critical. Participants indicated that the comprehensive nature of the IOTN makes it less feasible for routine use. Unlike government funded settings where resources are limited, the IOTN serves little purpose in private practice, as the practitioner are paid and will treat cases regardless of IOTN.

Participant 4: It's just maybe time consuming, because you need to count all the displacement count overjet or maybe for private practice, they don't really have the time to do all this.

Participant 13: when you want to score something right inside the patients, you have to ask the patient to open very wide for a long time. It is quite time consuming.

Theme 4: lack of training and exposure

Many practitioners encountered difficulties when aiming to fully utilise the index in a consistent and efficient manner due to lack of exposure and training during their undergraduate programme.

Insufficient undergraduate training

Participants consistently reported that formal training in the use of IOTN was limited during their undergraduate education. This lack of structured teaching contributes to uncertainty and reduced confidence in applying the index accurately.

Participant 2: To be honest, as a year, as a graduated year 5 student and still waiting for posting, I feel that the training of IOTN system is really insufficient Then, cases that we have received in uni and those cases that they will be given to us to assess will be more likely more simple cases to be honest, instead of more severe cases. So, to be honest, I just feel that we still see quite limited cases for us back in university time.

Limited clinical exposure

Students noted that their clinical exposure to orthodontic cases was relatively limited, both in quantity and complexity. As a result, opportunities to practice and refine IOTN scoring were insufficient.

Participant 5: we only have limited ortho clinic sessions due to the need of prioritising other clinic sessions as well.

Difficulty mastering the index

Due to limited case exposure and practice opportunities, participants found it challenging to achieve proficiency in using the IOTN. Mastery of the index requires repeated application across a diverse range of cases, which many students felt was lacking in their training.

Participant 9: we started at the end of year four till year five. So within this period, we probably have seen a maximum 10 to 11 patient. So there's very limited clinical exposure, and then you can't expect yourself

to master and truly understand and truly be able to apply IOTN just from saying 10 to 11 patient.

Theme 5: potential facilitators for improvement

Despite the challenges identified, participants proposed several strategies to enhance the usability and reliability of the IOTN.

Standardization of aesthetic assessment

Participants suggested that incorporating standardized visual aids or reference tools could help reduce subjectivity in the aesthetic component. Improved calibration methods may enhance inter-examiner agreement and scoring consistency.

Participant 1: I think the aesthetic component can be refined where we can combine the patient and clinician's ratings and also maybe we can use some improved visual tools to reduce the subjectivity in aesthetic component.

Enhanced scoring system

Refinement of the scoring system, particularly within the aesthetic component, was proposed as a means to improve clarity and reliability. Participants indicated that a more detailed or structured scoring framework could reduce ambiguity.

Participant 2: …maybe we can integrate a more scoring part in aesthetic component itself. This is one of the parts that I think can improve IOTN.

Use of photographic comparison

The use of photographic records and side-by-side comparisons was identified as a practical tool to support both clinician assessment and patient understanding. This approach may also facilitate shared decision-making by involving patients more actively in the evaluation process.

Participant 3: The esthetic component should be made less subjective, maybe we can take a photo of the patient and let the patient compare and choose side by side

Improving reliability of assessment

Overall, participants emphasized the need for greater standardization and calibration in applying the IOTN. This includes improved training, clearer guidelines, and possibly digital or technological aids to enhance consistency across users.

Participant 6: I believe the aesthetic component should be more standardized and less subjective to improve its reliability.

Discussion

The aim of the present study was to explore the perceptions of the use of the IOTN among final-year dental students in Malaysia. The IOTN is widely used as an objective measure to determine the requirement for orthodontic treatment, taking into account both dental health and aesthetic factors, and serves as a guide for treatment prioritization and resource allocation within Ministry of Health facilities in Malaysia (Loke & Tan 2017) reported that the diagnostic accuracy of dental officers in the Malaysian Ministry of Health in applying the IOTN was low. They recommended training and calibration to enhance proficiency. This study highlights the underlying reasons why even graduate dentists may not have fully mastered the use of the IOTN and offers strategies to improve this competency.

To the best of the authors' knowledge, the current study is the first of its kind to investigate the perceptions of Malaysian final-year dental students regarding the use of the IOTN. The present study has established five theme barrier categories: subjectivity in perception of criteria, neglect of patients' psychological well-being, time-consuming application, lack of training and exposure, and potential facilitators for improvement. This could help improve undergraduate dental education by identifying gaps in students' understanding and application of the index. It can guide

curriculum enhancements by integrating more case-based learning, hands-on workshops, and calibration exercises to improve clinical decision-making and standardization. Additionally, it can reinforce the role of IOTN in public health policy and evidence-based practice, ensuring students are better prepared for both private and government-funded orthodontic care. Insights from the study can help refine teaching methods, making orthodontic training more practical and relevant.

The IOTN is designed to provide a standardized method for assessing malocclusion severity and treatment necessity. However, findings from this study reveal a prevailing concern among participants regarding the subjectivity of the index, particularly in its Aesthetic Component (AC). While the IOTN aims to enhance objectivity in orthodontic treatment prioritization, differences in perception and interpretation among clinicians and patients introduce variability in scoring, leading to inconsistencies in assessment. This aligns with the findings of Loke and Tan, who reported that dental officers demonstrated greater accuracy in diagnosing the Dental Health Component compared to the Aesthetic Component (Loke & Tan 2017).

Participants highlighted variability in assessing malocclusion severity using the IOTN, as different practitioners may interpret cases differently despite following the same criteria. This inconsistency stems from differences in clinical experience, personal judgment, and case interpretation, making uniform scoring particularly challenging for borderline cases. This concern is supported by (Siddiqui *et al.*, 2014), who found significant variability between orthodontists' and patients' perceptions of malocclusion severity when using the IOTN-AC, indicating inconsistencies in assessments.

The subjectivity of the IOTN is most evident in its Aesthetic Component (AC), which relies on individual perceptions of dental attractiveness. Participants noted that both patients and clinicians may have differing views on aesthetics, influenced by personal preferences and cultural factors. Previous study (Grzywacz, 2003) supports this view, stating that the AC of the IOTN moderately reflects subjective perceptions of dental aesthetics and the demand for orthodontic treatment, further highlighting its inherent subjectivity. These variations in perception can impact treatment decisions, as what is considered an aesthetic concern varies across individuals and communities.

The IOTN is a comprehensive tool used to assess malocclusion severity, encompassing various components such as missing teeth, overjet, crossbite, displacement of contact points, and overbite. Each of these elements requires precise measurement across multiple levels of severity, necessitating meticulous evaluation by practitioners. This detailed process can be particularly time-consuming in clinical settings, especially for practitioners managing heavy workloads.

In private practices, where efficiency is paramount, the extensive time required to assess each component of the IOTN may be impractical. Similarly, in government healthcare settings with limited resources, the thorough application of the IOTN can be challenging. However, despite these challenges, the IOTN remains valuable in prioritizing treatment for patients with significant orthodontic needs, thereby optimizing resource allocation.

To address the time-consuming nature of the IOTN, there is growing interest in integrating artificial intelligence (AI) into orthodontic assessments. AI has the potential to streamline the evaluation process by automating measurements and analyses, thereby reducing the time burden on practitioners. A review on the application of AI in orthodontics discusses current advancements and future perspectives, suggesting that AI could enhance efficiency in clinical assessments (Stetzel *et al.*, 2024, Liu *et al.*, 2023).

This study's findings underscore the final theme of discussion, which revolves around the key challenges faced by final-year dental students in Malaysia regarding the use of the

IOTN, namely lack of training (Loke, 2006). One of the primary concerns expressed by participants is the lack of adequate exposure and training during their undergraduate programme. The ability to consistently and efficiently utilise the IOTN relies heavily on repeated practice and familiarity with a diverse range of malocclusion cases. However, as noted by multiple participants, the clinical exposure provided during their studies was insufficient in terms of both quantity and variety.

A significant challenge is the limited number of patients seen during the orthodontic clinical sessions. Participant 9 mentioned that within the allocated training period, students were exposed to only 10 to 11 patients, which is a very small sample size to develop mastery of the IOTN. The complexity of the index, which requires an understanding of multiple severity levels and criteria, makes it difficult to memorise and apply correctly without extensive hands-on experience. This lack of exposure likely hinders students' confidence and ability to accurately use the IOTN in future clinical practice.

Furthermore, the prioritisation of other clinical sessions over orthodontic training has exacerbated the issue. As Participant 5 pointed out, the limited number of orthodontic sessions means that students do not have enough opportunities to practice applying the IOTN in real clinical settings. This reinforces the notion that while students may be introduced to the index in theory, their practical application remains inadequate due to time constraints and curriculum structure.

Another critical issue is the simplicity of cases that students encounter during their university training. Participant 2 expressed concern that most of the cases presented during training were relatively straightforward, whereas more severe and complex cases were rarely encountered. This lack of diversity in case severity prevents students from fully appreciating the breadth of the IOTN's application and limits their ability to assess and classify more challenging cases effectively. Without exposure to severe cases, students may struggle when they enter professional practice and are required to make independent orthodontic treatment decisions.

The combination of these factors suggests a need for curriculum reform and enhanced training strategies. To improve competency in IOTN application, universities could consider increasing the duration and frequency of orthodontic clinical sessions, incorporating case-based discussions with a wider range of malocclusion severity, and implementing simulation-based training or digital learning tools. Additionally, structured workshops and refresher courses could be introduced post-graduation to reinforce knowledge and practical skills before students begin clinical practice.

Possible solutions & future directions

To enhance the consistent and effective use of the IOTN, structured and comprehensive training should be formally incorporated into the final-year of undergraduate dental curricula to ensure a uniform understanding and application of the index. This training should be supported by case-based learning, hands-on workshops, and real-life patient assessments to improve students' confidence and clinical competence in using the IOTN, as previously recommended in the literature. In parallel, the establishment of clear national and institutional guidelines for IOTN utilization is essential to minimize discrepancies in assessment and interpretation, with professional bodies playing a key role in issuing standardized recommendations for treatment prioritization based on the index. Greater interdisciplinary collaboration should also be encouraged through strengthened communication between orthodontic, general dentistry, and pediatric dentistry postgraduate trainees, facilitating appropriate referrals and improved case selection; this may be supported by continuing professional development programs and structured discussion forums focusing on the clinical relevance and interpretation of the IOTN. Additionally, the

integration of digital technologies, including electronic scoring systems (Murray, 2023) and AI-assisted tools, has the potential to enhance objectivity and reduce inter-examiner variability, warranting further research into machine learning applications to improve scoring accuracy and predict treatment outcomes.

Limitations of the study

This study is subjected to several limitations that should be considered when interpreting the findings. The relatively small sample size, comprising only current Year 5 undergraduate students, may restrict the applicability and generalisability of the results to a broader population. In addition, the study was conducted within a single university, which further limits the representativeness of the findings. Institutional differences in curriculum design, clinical exposure, and teaching approaches across dental schools in Malaysia may influence students' perceptions and experiences, and these factors were not captured in the present study. Future research should incorporate multi-centre designs involving multiple universities, including both public and private universities to enable more comprehensive comparisons and contextualise these findings within the wider Malaysian dental education landscape. In addition, the study relies on self-reported data, and participants' responses may have been shaped by individual experiences, personal biases, and differing levels of exposure to orthodontic cases, introducing subjectivity and variability in interpretation. The absence of objective measures to assess knowledge gaps or competency in the use of the IOTN further constrains the strength of the conclusions.

Finally, as the study captures perceptions at a single point in time, it does not reflect how understanding and application of the IOTN may evolve with continued training and clinical experience; a longitudinal design would offer more comprehensive insights into the development of IOTN-related knowledge and its influence on clinical decision-making.

Conclusions

The study highlights significant variability in how undergraduate dental students perceive and utilize the IOTN, underscoring the necessity for improved education, standardization, and integration with modern diagnostic tools. Enhancing undergraduate training in orthodontic indices can refine clinicians' ability to prioritize treatment more effectively, while a standardized approach to IOTN usage ensures fairness in resource allocation and treatment decisions.

While the IOTN remains a valuable tool for assessing orthodontic treatment needs, its inherent subjectivity, particularly in the Aesthetic Component and borderline case classification, poses a notable limitation. Differences in perception among clinicians and patients can lead to inconsistencies in scoring, affecting treatment decisions and prioritization.

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Conflict of Interest

The authors declare that they hold no competing interests.

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References

Bentele, M.J., Vig, K.W., Shanker, S., Beck, F.M. (2002). Efficacy of training dental students in the index of orthodontic treatment need. *American Journal of Orthodontics and Dentofacial Orthopedics*, 122(5):456-462.

Bouskandar, S.Y., Al Muraikhi, L., Hodge, T.M., Barber, S.K. (2023). UK dental students' ability and confidence in applying the Index of Orthodontic

Treatment Need and determining appropriate orthodontic referral. *European Journal of Dental Education*, 27(3):489-496.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.

Brook, P.H., Shaw, W.C. (1989). The development of an index of orthodontic treatment priority. *European Journal* of *Orthodontics*, 11(3):309-320.

Ferguson, J.W. (2006). IOTN (DHC): is it supported by evidence? *Dental Update*, 33(8):478-486.

Grzywacz, I. (2003). The value of the aesthetic component of the Index of Orthodontic Treatment Need in the assessment of subjective orthodontic treatment need. *European Journal of Orthodontics*, 25(1):57-63.

Hsu, E.E.H., Myo, Y.Y., Yee, H.H., Win, S.S. (2014). A study of Index of Orthodontic Treatment Need and perception of personal dental appearance among dental students. *Myanmar Dental Journal*, 21(1),60-66.

Järvinen, S. (2001). Indexes for orthodontic treatment need. *American Journal of Orthodontics and Dentofacial Orthopedics*, 120(3):237-239.

Liu, J., Zhang, C., Shan, Z. (2023). Application of artificial intelligence in orthodontics: current state and future perspectives. *Healthcare*, 11(20):2760.

Loke, S.T. (2006). Training dental officers and nurses in the index of orthodontic treatment need (IOTN) as a screening tool in public health facilities. *Malaysian Journal of Public Health Medicine*, 6(2):49-55.

Loke, S.T., Tan, S.Y. (2017). Competency of primary care officers in referring patients for orthodontic treatment using IOTN (Index of Orthodontic Treatment Need). *Malaysian Dental Journal*, 2:1-31.

Murray, D.G., Sivamurthy, G., Mossey, P. (2023). Helping general dental practitioners use the Index of Orthodontic Treatment Need: an assessment of available educational apps. *British Dental Journal*, 1-5.

Puri, A., Ho-A-Yun, J., McGuiness, N.J. (2015). Use and knowledge of IOTN among GDPs in Scotland. *British Dental Journal*, 218,399-404.

Salzmann, J.A. (1968). Handicapping malocclusion assessment to establish treatment priority. *American Journal of Orthodontics*, 54(10):749-765.

Shahrul, AI., Pauzzi, E.R., Abas, N.D.A., Yahya N.A., Khan, K.A.M., Nor, M.M. (2024). To assess the knowledge, awareness, and perception of non-dentists offering orthodontic treatment among the Malaysian young adult population. *BMC Public Health*, 24(1):3224.

Siddiqui, T.A., Shaikh, A., Fida, M. (2014). Agreement between orthodontist and patient perception using Index of Orthodontic Treatment Need. *Saudi Dental Journal*, 26(4):156-165.

Stetzel, L., Foucher, F., Jang, S.J., Wu, T. H., Fields, H., Schumacher, F., *et al.* (2024). Artificial Intelligence for predicting the aesthetic component of the Index of Orthodontic Treatment Need. *Bioengineering*, 11(9):861.

ORIGINAL ARTICLE Open Access

The assessment of quality of life measured by General Oral Health Assessment Index (GOHAI) among complete denture patients at a public university

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Abstract

Edentulism remains a public health issue globally, especially in low to middle-income countries. To combat the associated problems with edentulism, complete dentures are prescribed to improve their function, speech, and comfort. The aim of this study is to assess the quality of life using the General Oral Health Assessment Index (GOHAI), focusing on physical function, oro-facial pain and psychosocial impact among complete denture patients in the USIM polyclinic. Patients included in this study consisted of 58% male and 42% female patients with an average age ranging from 60 to 69 years old. 98% of the patients requested new dentures to improve their chewing ability. The highest mean score was 3.34 (±1.39) for satisfaction with appearance, while the lowest mean score was 0.72 (± 1.10) for limiting themselves from contact with others. In conclusion, edentulousness greatly affects patients' oral function and complete denture treatment had a positive effect on patient's quality of life.

Keywords: *complete denture, edentulous, GOHAI, psychometric*

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Introduction

The ageing population has been the topic of interest for the past few years in dental fraternities due to the rising number of elderly populations in the world. In Japan, for example, where life expectancy has been steadily increasing, a whopping 38.8 percent of the population will be over the age of 65 by the year of 2050 owing to the improvement in modern healthcare technology and the reduction in birth rate (Jack, 2016). In recent years, life expectancy is now averaged around 71 years old and is expected to further increase in the future (Dattani *et al.*, 2024). One review found that high-income countries recorded a higher life expectancy relative to the least developed countries, where life expectancy is less than 60 years old. This is related to better health-related variables (i.e., improved sanitation, higher public health expenditure, *etc.*) in a high-income country (Karacan *et al.*, 2020).

In order to cater to the rising number of elderly, improvements to the current health care systems are crucial in order to prepare for the impending demand, and this includes geriatric patients' dental treatment.

Edentulism can be described as the total absence of teeth. Tyrovolas *et al.* (2016) stated that the current prevalence of edentulism for the global population is at 7.6% with an overall reduction in the prevalence of edentulism worldwide. Khazaei *et al.* (2012) took a deeper look revealed a regional distribution based on economic and social variations and found that the prevalence of edentulism is on a decline in the developed countries, while the opposite is seen in developing countries. The treatment for edentulism can be divided into two options, either a fixed or a removable prosthesis. The McGill consensus in 2002 posed evidence that the first line of treatment for edentulous mandibles is the 2-implant overdenture (Feine, 2003). In a developing country like Malaysia, however, this treatment option is not feasible for all patients because it will incur a high cost of implant surgery and the subsequent implant placement and prosthesis fabrication (Juhari *et al.*, 2024; Ting *et al.*, 2021).

Edentulism negatively affects patients' quality of life (QoL) in terms of psychosocial, function and comfort (Rajaraman *et al.*, 2018). World Health Organisation (WHO) defined quality of life as an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. There are numerous studies that conclude oral health is part of a factor that makes up for a patient's quality of life (Sischo & Broder, 2011). The fundamental of good oral health constitutes the ability to function properly including mastication and speech, the absence of pain and being psychosocially able to mingle well without diminished self-confidence. The disruption of any of these factors may lead to malnutrition and reduced self-confidence. A complete denture is prescribed to improve these concerns and improve oral function. However, it remains a question whether the dentures delivered by the students to their patients are satisfactory. This is necessary not only for the students to be fully equipped to become a dentist, but also a measure of complete denture teaching in general.

In order to assess the quality of life, the Geriatric/General Oral Health Assessment Index GOHAI was developed. It consists of a 12-item questionnaire to measure the oral health-related QoL. GOHAI was developed by Atchinson and Dolan (Atchison & Dolan, 1990) and has been translated into several languages, including the Malay language (Othman *et al.,* 2006). The questions evolve around three key oral health-related domains, namely physical, psychosocial and pain and discomfort. The physical domain assessed the functional aspects, such as mastication and speech, while the psychosocial domain assessed the social aspects, such as wariness, social contacts and self-consciousness. The last domain, which touched on the aspect of pain and discomfort, was used to assess patients, general wellbeing and concern (Othman *et al.,* 2006). GOHAI measures patient QoL without an intraoral examination, therefore, it is not suitable to be used as a total measure for correlation of disease-quality of life.

In this study, our interest lies in the quality of patients' lives after the introduction of new complete dentures made in USIM polyclinic. There is little evidence regarding pedagogy, particularly in complete denture management in Malaysian undergraduate dentistry programs where most of the study focuses on partial dentures and fixed prosthodontics (Ab Ghani *et al.*, 2022; Daood *et al.*, 2022). The assessment regarding outcome of the teaching is important to ensure the regulatory body requirement are followed and graduates provide high treatment quality according to the needs of their patient. The objective of the study was to assess the quality of life of the elderly population among the geriatric patients who received complete dentures from the undergraduate dental students of the Faculty of Dentistry, Universiti Sains Islam Malaysia (USIM), Kuala Lumpur.

Materials and Methods

Prior to the study, ethical approval was obtained from USIM Board of Ethics (Project approval code: USIM/JKEP/2022-195). All participants who enrolled in this study were selected using simple random sampling from the complete case list from the undergraduate students polyclinics. The number of participants required was calculated using G-Power software (Germany) with effect size 0.5, alpha 0.05 and power 0.95, a sample size of 34 participants was obtained. However, a total of 50 patients were recruited for the study. All patients that were treated with the same conventional technique by undergraduate students in USIM polyclinic were invited to the study after a three-month review. All patients must fulfill the inclusion criteria; 1) at least three months of complete denture wear, 2) fluent in Malay language and 3) no underlying systemic diseases that might affect denture wear or clinical attendance. Patients who do not wear their denture and do not understand basic Malay are excluded from the study.

Consent was obtained from the participants before the questionnaire was distributed. Participants were interviewed by a single interviewer using the Malay version of GOHAI. The questionnaire was organized into two parts, where the first part of the questionnaire relates to sociodemographic questions, among which include gender, age, education level, occupation and history of denture wearing and reasons for denture wearing. In the second part, the questionnaires go into itemized questions under the domain of physical, psychosocial and discomfort. The rating on the questionnaires utilizes a six-point Likert scale from '*always*' (5), *'very often'* (4), *'often'* (3), *'sometimes'* (2), *'seldom'* (1) or *'never'* (0) (Othman *et al.,* 2006). The score is determined by the total sum of the whole questionnaire, with a total range of 0-60 range. The higher the scores, the better oral health is perceived by the patient. In this study, item 7 was removed because all participants in this study were edentulous hence, they do not experience sensitivity to the sweet, hot and cold. The score was recalculated to a maximum of 55 and the score for high, medium and low were changed accordingly. Items three, five and nine have a positive question-rating score and the reverse for the rest of the questions so that the end score will reflect a positive score. The scores were then analyzed using an independent t-test to compare means across the variables in GOHAI scores with the significance levels set at $p< 0.05$. The data were analyzed using SPSS Statistics version 22.

Results

Table 1 shows the characteristics of all the participants in the study. From the table, the average mean score for each patient was 41.72 (SD 8.3) ranging from score 31 to 57.

The mean age was 63.88 ± 5.6, where 58% of the participants were male, while 42% of participants were female. Most of the participants received an education up to secondary education level at 64% and only 30% of them were working. Only 7% of participants never had any dentures prior to the treatment and the rest of the participants had a history of previous dentures. 98% of the respondents stated their reason to request new denture is to improve their chewing ability, followed by improved speech and aesthetic appearance, while only 20% of the participants stated a health reason.

Table 2 shows the response for GOHAI questionnaires. Item 7, related to sensitivity to hot, cold and sweet food, was eliminated because all participants are edentulous. The percentage of participants' positive response that comprises of '*sometimes*', '*often*', '*very often*' or '*always*' to the GOHAI items. The percentage of subjects responding positively to each item ranged from 6% to 70%. For items three, five and nine, which were positive rating items, two out of three items scored high positive response of more than 50%. The highest positive responses are related to aesthetic, *'pleased with the look of teeth'* at 70% and function, '*able to swallow comfortably'* at

64%. The lowest percentage for positive responses was feeling *'self-conscious of denture'* and *'uncomfortable eating in front of others'*, with the same percentage of 8%. For items with negative ratings, questions that scored a high positive response were items in the physical function domain, which were '*trouble biting and chewing'* at 38% and '*limit the kinds of food'* at 28%.

Table 1. Sociodemographic profile of participants.

Characteristics of Subjects		
GOHAI score	Mean 41.72	
Range	31-57	
Socioeconomic Profile	**N**	**%**
Gender		
Male	29	58%
Female	21	42%
Age		
>55 y/o	8	16%
55-59 years old	6	12%
60-69 years old	27	54%
70-79 tears old	6	12%
>80 years old	3	6%
Education Level		
No schooling	2	4%
Primary school	3	6%
Secondary school	32	64%
University	13	26%
Occupation		
Still working	15	30%
Not working	35	70%
History of Wearing Denture		
>1 year	8	16%
1-3 years	14	28%
3-5 years	9	18%
>5 years	12	24%
Never	7	14%
Reasons of Wearing Denture		
Chewing	49	98%
Speech	38	76%
Aesthetic	27	54%
Health	10	20%

In the physical function domain, 72% of the respondents stated that they do not limit their food intake by the use of complete denture, however, 38% of them had trouble in biting and chewing especially firm meat and apples. For the GOHAI items that describe the pain and discomfort, most of the respondents (88%) did not use any medication to relieve the pain and 36% of them were not able to eat anything without discomfort. In the psychosocial function domain, most of the respondents did not have a problem socialising with other people, while only 8% of the participants felt uncomfortable eating in front of others with their complete denture.

Table 2. Percentage of subjects responding '*sometimes*', '*often*', '*very often*' or '*always*' to each GOHAI and the mean of each of the items.

GOHAI Items	Percentage of participant responding to positive response (%)	Mean score (SD)	Never	Seldom	Sometimes	Often	Very often	Always
			Percentage (%)					
Physical Function								
1. Limit the kinds of food	28	2.02(1.42)	16	20	36	6	18	4
2. Trouble biting and chewing	38	2.26(1.36)	10	18	34	20	10	8
3. Able to swallow comfortably	64	2.96(1.41)	10	0	26	26	24	14
4. Unable to speak clearly	16	1.36(1.35)	30	34	20	6	6	4
Pain and Discomfort								
5. Able to eat without discomfort	36	2.20(1.48)	14	18	32	16	10	10
6. Used medication to relief pain	12	0.88(1.35)	60	16	12	0	12	0
7. Sensitive to hot, cold or sweet foods	-	-	-	-	-	-	-	-
Psychosocial Function								
8. Limit contact with people	6	0.72(1.10)	58	24	12	2	2	2
9. Pleased with the look of teeth	70	3.34(1.39)	2	10	18	16	30	24
10. Worried about denture	14	1.30(1.34)	34	30	22	2	10	2
11. Self-conscious of denture	8	0.90(1.21)	54	18	20	0	8	0
12. Uncomfortable eating in front of others	8	0.98(1.25)	48	24	20	0	6	2

Discussion

Measurement of therapeutic outcome is important to assess the long-term effect of a treatment in terms of quality-of-life improvement. Several assessment tools have been developed previously, specifically to measure the oral health impact on quality of life (OHQoL). Among all, two of most used instruments are Oral Health Impact Profile (OHIP) and GOHAI. OHIP is the tool used to

measure an individual's perception of the social impact of oral health while GOHAI is used to measure the oral health problems for elderly (Slade & Spencer, 1994).

In this study GOHAI (Atchison & Dolan, 1990) was chosen to measure the oral health problems after the delivery of a complete denture. GOHAI is chosen because it is more sensitive to measure the QoL, especially in terms of oral function and psychosocial impacts (Locker *et al.,* 2001). In the education field, this is especially important to assess the quality of treatment provided by undergraduate students.

As previously discussed, GOHAI questionnaire is divided into 2 types of responses, where three items were positive responses, and the rest of the items were negative responses. In terms of positive rating items, a higher percentage of positive responses could be considered as a good outcome while for negative rating items, a high percentage of positive responses could be considered as a failure of the prosthesis given. In this study, the delivered complete dentures treatment has a good aesthetic outcome and patients are able to swallow comfortably.

On the other side of the spectrum, in terms of physical function, there are some reported troubles with mastication and patients had to limit the types of food intake, especially meat and apples. This is a major concern because according to Paturu *et al.* (2011) limitations of food intake and masticatory problems are prevalent in the elderly and can lead to malnutrition. In this study, the questionnaire was given to patients who have at least three months of denture wear. As stated by Eberhard *et al.* (2018) study, the adaptation to new dentures differs significantly after one, three and six months of denture wear and this could be the factor that affects mastication for some of the patients who have worn the dentures for a shorter period. However, in terms of education, six months post treatment questionnaires might be the answer to the findings.

Other than that, the lowest mean recorded was for limiting social contact, which means most patients almost never had to limit themselves from meeting other people. Meanwhile, the highest mean score is related to the aesthetic outcome of the denture. In terms of pain and discomfort, a small number of patients had to deal with pain coming from the denture. It is imperative that a review appointment be given where reported troubles with denture usage can be evaluated and managed. This is not only important for the patient but also as a part of the learning curve for undergraduate students.

Adjustment of percentage was done according to the original GOHAI score was done since the study item 7 was excluded. Taking this into consideration of the original GOHAI score where 57-60 was considered high, 51-56 moderate and less than 50 was low, new calculation was made. In the new calculation a score of less than 47.7 was considered low and this means that the mean GOHAI score of 41.72 indicates that participants in this study are at a low level of quality of life (Aguirre *et al.*, 2020). This means an improvement to the current teaching is needed, especially for complete dentures. There are little study in different university, however a study by a university in Lahore, Pakistan reported mean score of 20.46 pre-treatment to 26.32 post-treatment (Rana *et al.*, 2019). The mean GOHAI can be interpreted as significantly lower than the result in this study, however, the result in Rana et al. (2019) study does state that there are improvements in the score before and after treatment.

A few limitations to this study are the relatively small sample size, with participants gathered only in USIM polyclinic. To make further comparisons, further studies with a larger sample size and corroborative efforts with different dental school around Malaysia could be done to assess patients' satisfaction in terms of complete denture treatment from undergraduate students. A bigger research area could only mean that schools are able to compare notes and improve the teaching of undergraduates. In the future, a

measurement for before and after treatment will be used to measure changes in quality-of-life post-treatment.

Conclusions

In conclusion, edentulousness greatly affects patients' oral function and complete denture treatment has a positive effect on their quality of life. Although complete denture helps patients in terms of physical function, psychosocial and comfort, further management, including review post treatment, is needed to help patient adapt to the new denture.

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References

Ab Ghani, S.M., Abdul Hamid, N.F., & Lim, T.W. (2022). Comparison between conventional teaching and blended learning in preclinical fixed prosthodontic training: a cross-sectional study. *European Journal of Dental Education,* 26(2), 368-376.

Aguirre, J., Barón, F., Carmona, F., Pérez, N., & Wärnberg, J. (2020). Validation of a modified versión of the Spanish Geriatric Oral Health Assessment Index (GOHAI-SP) for adults and elder people. *BMC Oral Health,* 20(1),61.

Atchison, K.A., & Dolan, T.A. (1990). Development of the geriatric oral health assessment index. *Journal of Dental Education,* 54(11), 680-687.

Feine, J.S. (2003). The McGill consensus statement on overdentures. *Quintessence International,* 34, 78-79.

Daood, U., Sidhu, P., Jamayet, N.B., Kohli, S., Ab Malik, N., Lin, S.L., et al. (2022). Current and future trends in the teaching of removable partial dentures in dental schools in Malaysia: a cross sectional study. *Journal of Dentistry,* 124,104225.

Dattani, S., Rodés-Guirao, L., Ritchie, H., Ortiz-Ospina, E., Roser, M (2023). Life expectancy. Our World in Data. Retrieved September 2024, from: https://ourworldindata.org/life-expectancy.

Eberhard, L., Oh, K., Eiffler, C., Rammelsberg, P., Kappel, S., Schindler, H.J., et al. (2018). Adaptation to new complete dentures—is the neuromuscular system outcome-oriented or effort-oriented?. *Clinical Oral Investigations,* 22(6), 2309-2317.

Jack, D. (2016). The issue of Japan's aging population. In: Law School International Immersion Program Papers; University of Chicago Law School: Chicago, IL, USA, 8.

Juhari, N.A., Sinor, M.Z., Ahmad, B., & Sanusi, S.Y. (2024). Knowledge of dental implants among adults attending Hospital Universiti Sains Malaysia. *Malaysian Journal of Medicine & Health Sciences,* 20(5).

Karacan, I., Sennaroglu, B., & Vayvay, O. (2020). Analysis of life expectancy across countries using a decision tree. *Eastern Mediterranean Health Journal,* 26(2), 143-151.

Khazaei, S., Firouzei, M.S., Sadeghpour, S., Jahangiri, P., Savabi, O., Keshteli, A.H., et al. (2012). Edentulism and tooth loss in Iran: SEPAHAN systematic review No. 6. *International Journal of Preventive Medicine,* 3(Suppl1), S42.

Locker, D., Matear, D., Stephens, M., Lawrence, H., & Payne, B. (2001). Comparison of the GOHAI and OHIP-14 as measures of the oral health-related quality of life of the elderly. *Community Dentistry and Oral Epidemiology,* 29(5), 373-381.

Othman, W.N., Muttalib, K.A., Bakri, R., Doss, J.G., Jaafar, N., Salleh, N.C., et al. (2006). Validation of the geriatric oral health assessment index (GOHAI) in the Malay language. *Journal of Public Health Dentistry,* 66(3), 199-204.

Paturu, R., Thallam Veeravalli, P., Vaidyanathan, A.K., & Grover, M. (2011). Evaluation of nutritional status and eating pattern in first and second-time denture wearers: a prospective 60 days (2 months) pilot study. *The Journal of Indian Prosthodontic Society,* 11, 156-164.

Rajaraman, V., Ariga, P., Dhanraj, M., & Jain, A.R. (2018). Effect of edentulism on general health and quality of life. *Drug Invention Today,* 10(4), 549-553.

Rana, H. (2019). Oral health related quality of life by means of functional changes in Geriatric Oral Health Assessment Index (GOHAI) before and after insertion of new conventional complete dentures in completely edentulous patients. *The Professional Medical Journal,* 26(12), 2085-2089.

Sischo, L., & Broder, H. (2011). Oral health-related quality of life: what, why, how, and future implications. *Journal of Dental Research,* 90(11), 1264-70.

Slade, G.D., & Spencer, A.J. (1994). Development and evaluation of the oral health impact profile. *Community Dental Health*, 11(1), 3-11.

Ting, S.F., Chien, K.C., Ramzi, N.H., Pau, A., & Menon, R.K. (2021). Personality traits and annual income determine the willingness to pay for a single tooth implant. *Healthcare,* 9(8), 952.

Tyrovolas, S., Koyanagi, A., Panagiotakos, DB., Haro, J.M., Kassebaum, N.J., Chrepa, V., *et al.* (2016). Population prevalence of edentulism and its association with depression and self-rated health. *Scientific Reports,* 6(1), 37083.

ORIGINAL ARTICLE Open Access

Palm mixed-carotenes promote viability and exhibit non-cytotoxic effects on human oral mucosal fibroblasts

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Abstract

Palm mixed-carotenes (PMC), a carotenoid-rich fraction obtained from crude palm oil, contain provitamin A compounds with reported antioxidant and cell-protective activities. However, limited information is available on their biological effects in oral soft tissue cells. This study evaluated the effects of PMC on the viability of human oral mucosal fibroblasts (HOMFs) under in vitro conditions. Primary HOMFs were isolated from healthy donors and exposed to PMC at concentrations of 1.56 –100 µg/mL for 72 hours. Cell viability was determined using the MTT assay. Serum-free medium containing 0.1% dimethyl sulfoxide served as the negative control, while medium supplemented with 10% fetal bovine serum was used as the positive control. Data were analyzed using SPSS version 29.0, and group comparisons were performed using one-way ANOVA followed by Tukey's post hoc test, with significance set at $p < 0.05$. PMC treatment maintained or increased HOMF viability across all tested concentrations. The greatest viability response was observed at 6.25 µg/mL, which was significantly higher than the negative control ($p = 0.005$). All PMC-treated groups showed viability values above the 70% cut-off specified by ISO 10993-5, indicating that the tested concentrations were non-cytotoxic. These findings suggest that PMC are biocompatible with HOMFs and may support cellular viability, particularly at lower to intermediate concentrations. This study provides early in vitro evidence to support further investigation of PMC in oral soft tissue research.

Keywords: *carotenes, cell viability, cytotoxicity, human oral mucosal fibroblasts, palm oil*

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Introduction

Fibroblasts are important connective tissue cells that contribute to extracellular matrix production, tissue repair, immune regulation, and interactions within the tumor microenvironment. Although fibroblasts may appear similar morphologically, their biological behavior varies according to their tissue origin (Nanci, 2013). Oral fibroblasts are derived from neural crest ectomesenchyme and differ from fibroblasts found in skin and other connective tissues (Vijayashree & Sivapathasundharam, 2022). Within the oral cavity, these cells contribute to the development and maintenance of structures such as dentin, cementum, alveolar bone, salivary glands, and the oral mucosa by producing collagen, proteoglycans, glycoproteins, matrix metalloproteinases, cytokines, and other regulatory molecules (Vijayashree & Sivapathasundharam, 2022). Oral mucosal fibroblasts (OMFs) are of particular interest in regenerative research

because of their distinctive wound-healing properties. Compared with cutaneous fibroblasts, OMFs have been reported to show greater proliferative potential, enhanced collagen production in response to transforming growth factor-β1, and a fetal-like phenotype that may contribute to rapid healing with minimal scar formation (Toma *et al.,* 2021). Clinically, oral wounds often repair faster and with less scarring than skin wounds, partly due to intrinsic differences in fibroblast and keratinocyte behavior (El Ghalbzouri *et al.,* 2020). OMFs also display a shorter population doubling time and tend to stop proliferating once confluence is reached, in contrast to cutaneous fibroblasts, which may continue to divide (Okazaki *et al.,* 2002). These features support the use of OMFs as a relevant cellular model for oral tissue engineering and regenerative dentistry.

Given the importance of oxidative stress and inflammation in oral tissue repair, naturally derived bioactive compounds such as carotenoids have gained attention for their potential protective effects. Carotenoids may influence oral tissue repair through antioxidant and anti-inflammatory mechanisms. Kajiura *et al.* (2018) have documented that β-carotene suppressed *Porphyromonas gingivalis* lipopolysaccharide-induced production of inflammatory mediators in human monocytes via nuclear factor-kappa B inactivation, suggesting a potential anti-inflammatory role in periodontal infection-related responses. In human gingival fibroblasts exposed to high glucose, astaxanthin significantly reduced reactive oxygen species (ROS) levels, improved cell viability, and enhanced wound closure, suggesting that its antioxidant properties may support gingival wound-healing responses under oxidative stress (Aras-Tosun *et al*., 2022). More recently, astaxanthin was reported to promote proliferation, migration, collagen production, and osteogenic differentiation in human periodontal ligament fibroblasts while reducing ROS levels and increasing nuclear factor erythroid 2-related factor 2 expression under hyperglycemic condition (Chantadul *et al*., 2026). These findings suggest that carotenoid-based antioxidants may influence cellular behaviors relevant to oral wound healing and periodontal repair.

Palm fruit is recognized as a rich natural source of carotenoids, particularly in terms of provitamin A activity (Choo, 1994). As humans cannot synthesize carotenoids, these compounds must be obtained through the diet (Eggersdorfer & Wyss, 2018). Carotenoid intake has been associated with several health-related benefits, including reduced risk of chronic diseases and support for tissue repair processes (Jiang *et al.*, 2021; Viaña-Mendieta *et al*., 2022; Wang *et al*., 2023). Palm mixed-carotenes (PMC) contain mainly α-carotene and β-carotene, together with smaller amounts of other carotenoids, and these components may act collectively to exert protective biological effects (Islam *et al*., 2024). However, the effects of PMC on human oral mucosal fibroblasts remain insufficiently explored. Considering the regenerative relevance of OMFs and the potential bioactivity of PMC, this study aimed to determine the effects of PMC on the viability of human oral mucosal fibroblasts (HOMFs) in vitro.

Materials and Methods

Materials

Most reagents and chemicals used in this study were purchased from Thermo Fisher Scientific, USA/UK. Reagents or chemicals obtained from other suppliers are stated in the relevant subsections.

Source of PMC

The PMC used in this study were obtained in the form of EVTene™ 8%, a commercially prepared natural mixed-carotene oil concentrate derived from Malaysian crude palm oil *(Elaeis guineensis)* and supplied by ExcelVite Sdn. Bhd. (Chemor, Perak, Malaysia). As this preparation was commercially supplied, extraction and concentration procedures were not performed in the present study. According to the product composition provided by the supplier, the preparation contained mainly β-carotene and α-carotene at approximately

67% and 32%, respectively, with minor amounts of γ-carotene and lycopene.

Sample collection

Primary HOMFs were obtained from oral soft tissue specimens collected from three healthy individuals who underwent surgical removal of impacted third molars. Donors were eligible if they were non-smokers, did not consume alcohol, had no visible oral lesions, and had no history of systemic medication use within the previous six months. A 4 mm tissue specimen was collected from clinically healthy oral mucosa adjacent to the extraction site. The specimen was immediately transferred into phosphate-buffered saline (PBS) supplemented with 1% antibiotic-antimycotic solution, consisting of 10,000 units/mL penicillin, 10,000 µg/mL streptomycin, and 25 µg/mL amphotericin B.

Isolation of HOMFs

The tissue specimens were minced into small fragments and enzymatically digested with 0.3% collagenase type I (Worthington Biochemical Corp., USA) at 37°C for 10 minutes in a shaker incubator to release cells from the extracellular matrix. The digested suspension was centrifuged at 600 × g for 10 minutes, and the resulting cell pellet was transferred into tissue culture flasks.

Cells were cultured in Dulbecco's Modified Eagle Medium/Nutrient Mixture F-12 (DMEM/F-12) supplemented with 10% fetal bovine serum (FBS), 1% antibiotic-antimycotic solution, 1% GlutaMAX, and 1% L-ascorbic acid (Sigma-Aldrich, USA). Cultures were maintained at 37°C in a humidified incubator containing 5% CO_2. To reduce passage-related variability, fibroblasts from passages 4 to 5 were used in all experiments (Azmi et al., 2023).

Cell seeding and treatment

HOMFs were seeded in 96-well plates at 5,000 cells per well, equivalent to 0.1 mL of a 5×10^5 cells/mL suspension. The seeded cells were incubated for 24 hours at 37°C in a humidified atmosphere containing 5% CO_2 to allow attachment. After incubation, the existing culture medium was aspirated and replaced with 0.1 mL of serum-free DMEM/F-12 supplemented with 1% antibiotic-antimycotic solution, 1% GlutaMAX, and 1% L-ascorbic acid. PMC solutions were prepared in serum-free DMEM/F-12 containing 0.1% dimethyl sulfoxide (DMSO). The cells were then treated with PMC at final concentrations of 1.56, 3.33, 6.25, 12.5, 25, 50, and 100 µg/mL. Serum-free DMEM/F-12 containing 0.1% DMSO was used as the negative control, while DMEM/F-12 supplemented with 10% FBS served as the positive control. The experiment was conducted using three independent biological replicates.

MTT assay for cell viability and cytotoxicity

Cell viability was evaluated using the 3-[4,5-dimethylthiazol-2-yl]-2,5-diphenyl tetrazolium bromide (MTT) assay as an indirect indicator of viable, metabolically active cells. The assay was used to assess the cellular response of HOMFs to PMC treatment and to identify any cytotoxic effect.

Following 72 hours of PMC treatment, 10 µL of MTT solution (5 mg/mL in PBS; Sigma-Aldrich, USA) was added to each well and incubated for 4 hours at 37°C. Formazan crystals were dissolved by adding 100 µL of DMSO, and absorbance was measured at 570 nm using a microplate reader (Riss et al., 2016). Background values were corrected, and cell viability was calculated relative to the negative control, which was set as 100%. Samples with viability of 70% or higher were considered non-cytotoxic according to ISO 10993-5 (ISO, 2009).

Statistical analysis

Data are reported as mean ± standard error of the mean. All statistical analyses were performed using SPSS version 29.0 (IBM Corp., USA). Differences between treatment groups were evaluated by one-way analysis of variance (ANOVA), with Tukey's HSD test

applied for post hoc comparisons. A *p*-value below 0.05 was considered statistically significant.

Results

Morphology of HOMFs following PMC treatment

Representative microscopic images of HOMFs following 72-hour treatment are shown in Figure 1. Cells in the negative control, 6.25 µg/mL PMC-treated group, and positive control displayed spindle-shaped, fibroblast-like morphology. No obvious morphological evidence of cytotoxicity was observed in the 6.25 µg/mL PMC-treated group compared with the control groups.

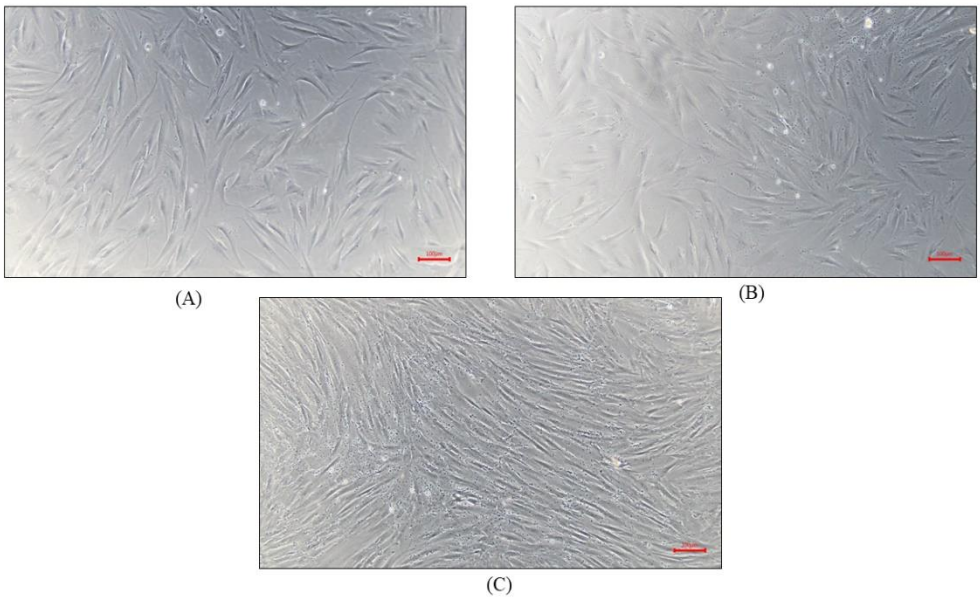

Figure 1. Representative microscopic images of human oral mucosal fibroblasts following 72-hour treatment. (A) Negative control (0 µg/mL palm mixed-carotenes, PMC); (B) 6.25 µg/mL PMC; and (C) positive control (10% fetal bovine serum). The 6.25 µg/mL PMC group was selected because it showed the highest MTT viability response among the PMC-treated groups. Cells displayed spindle-shaped, fibroblast-like morphology across the selected groups, with no obvious morphological evidence of cytotoxicity such as marked cell rounding or detachment in the 6.25 µg/mL PMC-treated group. Scale bar = 100 µm.

Effect of PMC on HOMF viability

The positive control group showed a viability value of 257% relative to the negative control. Among the PMC-treated groups, the highest cell viability was recorded at 6.25 µg/mL, reaching 153%, which was significantly higher than the negative control ($p = 0.005$). Treatment with lower PMC concentrations also increased viability, with values of 123% and 129% observed at 1.56 µg/mL and 3.13 µg/mL, respectively. Although viability remained above the control level at higher concentrations ranging from 12.5 to 100 µg/mL, the response was lower than that observed at 6.25 µg/mL, with values ranging from 111% to 121% (Figure 2). Pairwise analysis showed that viability at 6.25 µg/mL was significantly higher than that at 25 µg/mL ($p = 0.049$), 50 µg/mL ($p = 0.03$), and 100 µg/mL ($p = 0.04$).

Effect of PMC on HOMF cytotoxicity

All PMC-treated groups showed cell viability values above 100%. These values were higher than the 70% viability cut-off specified in ISO 10993-5, indicating that none of the tested PMC concentrations exhibited cytotoxic effects on HOMFs (Figure 2).

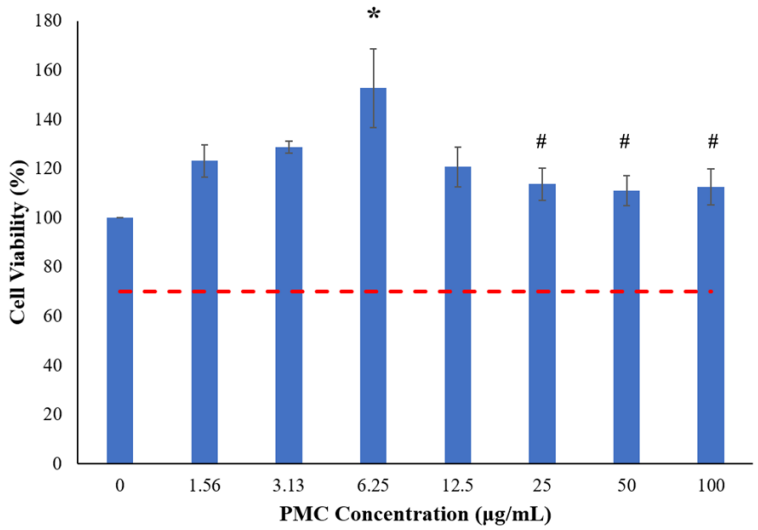

Figure 2. Percentage viability of human oral mucosal fibroblasts following 72-hour exposure to palm mixed-carotenes (PMC) at concentrations of 1.56 –100 µg/mL, as determined by the MTT assay. Values are presented as mean ± SEM from three biological replicates. *$p < 0.05$ compared with 0 µg/mL PMC; #$p < 0.05$ compared with 6.25 µg/mL PMC. The dashed red line indicates the 70% viability reference value for non-cytotoxicity based on ISO 10993-5.

Discussion

This study evaluated the response of HOMFs to PMC exposure using an in vitro cell viability model. The findings showed a non-linear, concentration-dependent pattern, in which HOMF viability increased from the lower PMC concentrations and reached its highest response at 6.25 µg/mL, before declining at higher concentrations. Although all PMC-treated groups showed viability values above the untreated control, only 6.25 µg/mL produced a statistically significant increase. This suggests that 6.25 µg/mL may represent the most favorable concentration for supporting HOMF metabolic activity under the present experimental conditions. In addition, all PMC-treated groups remained above the 70% viability threshold recommended by ISO 10993-5 for in vitro cytotoxicity testing, indicating that PMC were non-cytotoxic to HOMFs within the tested range.

The positive control group showed the highest cell viability, which was expected because 10% fetal bovine serum (FBS) contains nutrients, growth factors, attachment factors, and other bioactive molecules that support cell survival and proliferation (Lee *et al.*, 2022). In comparison, PMC are naturally derived carotenoid compounds rather than direct growth factor substitutes. The negative control provided the baseline viability under serum-free conditions, while the FBS-supplemented positive control represented a growth-supportive condition. PMC were tested under serum-free conditions to determine whether they could maintain HOMF viability without inducing cytotoxicity. Therefore, the ability of PMC to maintain or enhance HOMF viability supports their preliminary cytocompatibility in this cell model but does not confirm direct stimulation of fibroblast proliferation.

The present findings are in agreement with previous reports on the biological safety and protective effects of palm-derived carotenes in other human cell types. Meganathan *et al.* (2022) showed that carotenes from palm oil were not cytotoxic to normal human retinal pigment epithelial cells and did not stimulate proliferation in cancer cells, suggesting a favorable safety profile. The same study also

reported that PMC reduced oxidative stress-related injury in an in vitro model of age-related macular degeneration. In differentiated human neural cells, Magalingam *et al*. (2022) demonstrated that PMC attenuated oxidative stress-induced loss of cell viability and influenced antioxidant defense pathways. In another recent study, Yee *et al*. (2025) reported that PMC enhanced human osteoblast viability while suppressing osteoclast maturation, suggesting a possible role in bone-related cellular regulation. Taken together, these studies support the view that PMC may exert cell-protective effects in different human cell models.

The viability-supporting response observed in HOMFs may be partly explained by the antioxidant properties of the major carotenoid components present in PMC, particularly β-carotene and α-carotene, which may help reduce oxidative stress-related cellular damage and support cellular metabolic activity. Sen Gupta and Ghosh (2013) reported that α- and β-carotene isolated from crude palm oil exhibited antioxidant activity in vitro through radical scavenging, metal chelation, superoxide scavenging, inhibition of lipid peroxidation, and protection against protein denaturation. These antioxidant effects were concentration- and assay-dependent, indicating that carotenoid activity may vary according to the biological or experimental system. In fibroblast-related studies, carotenoids such as β-carotene have also been reported to protect dermal fibroblasts from ultraviolet-associated oxidative damage by neutralizing free radicals, enhancing endogenous antioxidant responses, and modulating signaling pathways such as mitogen-activated protein kinase and nuclear factor-kappa B (Flieger *et al*., 2024; Ma *et al*., 2025). However, oxidative stress markers, antioxidant enzyme activity, mitochondrial function, and extracellular matrix-related markers were not directly assessed in the present study.

From a translational perspective, the non-cytotoxic response of HOMFs to PMC suggests that it may be further explored as a potential bioactive candidate for oral soft tissue applications, including topical wound-healing formulations or biomaterial-based approaches in regenerative dentistry.

Several limitations should be considered when interpreting these findings. First, the study used the MTT assay as the sole endpoint. Although MTT is commonly used to assess cell viability and preliminary cytotoxicity, it primarily reflects cellular metabolic activity and does not directly confirm cell proliferation. Future studies should therefore include proliferation-specific assays or markers to determine whether the increased MTT response represents actual cell growth. Second, the study was performed using an in vitro monoculture model, which cannot fully reproduce the complex environment of oral soft tissues, in which fibroblasts interact with epithelial cells, immune cells, extracellular matrix components, and inflammatory mediators. Further work involving functional assays, such as migration, collagen production, oxidative stress analysis, and wound-healing models, would provide a more comprehensive understanding of the effects of PMC on oral fibroblast behavior. Appropriate in vivo studies may also be needed to determine the relevance of these findings for oral tissue repair or regenerative applications.

Despite these limitations, this study is, to the best of our knowledge, the first to investigate the effects of PMC on HOMFs. The findings provide preliminary evidence regarding the biocompatibility of PMC with HOMFs. The use of ISO 10993-5 criteria strengthens the reliability and translational relevance of the findings. Establishing a non-cytotoxic profile is an important first step before advancing toward more mechanistic and functional investigations of PMC in oral tissue research.

Conclusions

This study showed that PMC were non-cytotoxic to HOMFs under the tested in vitro conditions. All PMC concentrations were found to maintain cell viability above the ISO 10993-5 threshold, with the highest viability response observed at 6.25 μg/mL.

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Conflict of Interests

The authors declare that they have no conflicts of interest.

Ethical Approval

Ethics approval for this study was granted by the institutional research ethics committee (JEP-2023-625). All donors provided informed consent before the oral mucosal tissue samples were collected.

Declaration of Generative AI and AI-Assisted Technologies Use

During the preparation of this work, the author(s) used ChatGPT (OpenAI, GPT-5.4) for language editing and clarity improvement. The author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

References

Aras-Tosun, D., Önder, C., Akdoğan, N., Kurgan, Ş., Aktay, İ., Tuncay, E. *et al*. (2022). Astaxanthin enhances gingival wound healing following high glucose-induced oxidative stress. *BioMed Research International*, 2022, 4043105. https://doi.org/10.1155/2022/4043105

Azmi, A.F., Yahya, M.A.A.M., Azhar, N.A., Ibrahim, N., Ghafar, N.A., Ghani, N.A.A. *et al*. (2023). *In vitro* cell proliferation and migration properties of oral mucosal fibroblasts: A comparative study on the effects of cord blood- and peripheral blood-platelet lysate. *International Journal of Molecular Sciences*, 24(6), 5775. https://doi.org/10.3390/ijms24065775

Chantadul, V., Aphichartsereekul, W., Charoonpatrapong, K., Janebodin, K., Kaewmuangmoon, J. (2026). Astaxanthin enhances migration, Type I and Type III collagen production, and osteogenic differentiation in periodontal ligament fibroblasts under hyperglycemic conditions. *BMC Oral Health*, 26(1), 488. https://doi.org/10.1186/s12903-026-07824-7

Choo, Y.M. (1994). Palm oil carotenoids. *Food and Nutrition Bulletin*, 15(2), 130-137.

Eggersdorfer, M., Wyss, A. (2018). Carotenoids in human nutrition and health. *Archives of Biochemistry and Biophysics*, 652, 18-26. https://doi.org/10.1016/j.abb.2018.06.001

El Ghalbzouri, A., Lamme, E., Ponec, M. (2020). Crucial role of fibroblasts in regulating epidermal morphogenesis. *Cell and Tissue Research*, 310, 189–199. https://doi.org/10.1007/s00441-002-0621-0

Flieger, J., Raszewska-Famielec, M., Radzikowska-Büchner, E., Flieger, W. (2024). Skin protection by carotenoid pigments. *International Journal of Molecular Sciences*, 25(3), 1431. https://doi.org/10.3390/ijms25031431

Islam, F., Khan, J., Zehravi, M., Das, R., Akiful Haque, M., Banu, A. *et al*. (2024). Synergistic effects of carotenoids: therapeutic benefits on human health. *Process Biochemistry,* 136, 254-272. https://doi.org/10.1016/j.procbio.2023.11.033

International Organization for Standardization. (2009). Biological evaluation of medical devices—Part 5: Tests for in vitro cytotoxicity. ISO 10993-5:2009. Geneva: ISO.

Jiang, Y.W., Sun, Z.H., Tong, W.W., Yang, K., Guo, K.Q., Liu, G. *et al*. (2021). Dietary intake and circulating concentrations of carotenoids and risk of type 2 diabetes: a dose-response meta-analysis of prospective observational studies. *Advances in Nutrition*, 12(5), 1723-1733. https://doi.org/10.1093/advances/nmab048

Kajiura, Y., Nishikawa, Y., Lew, J.H., Kido, J.I., Nagata, T., Naruishi, K. (2018). β-carotene suppresses *Porphyromonas gingivalis* lipopolysaccharide-mediated cytokine production in THP-1 monocytes cultured with high glucose condition. *Cell Biology International*, 42(1), 105-111. https://doi.org/10.1002/cbin.10873

Lee, D.Y., Lee, S.Y., Yun, S.H., Jeong, J.W., Kim, J.H., Kim, H.W. *et al*. (2022). Review of the current research on fetal bovine serum and the development of cultured meat. *Food Science of Animal Resource*, 42(5), 775-799. https://doi.org/10.5851/kosfa.2022

Ma, Y., Li, C., Su, W., Sun, Z., Gao, S., Xie, W. *et al.* (2025). Carotenoids in skin photoaging: Unveiling protective effects, molecular insights, and safety and bioavailability frontiers. *Antioxidants,* 14(5), 577. https://doi.org/10.3390/antiox1405

Magalingam, K.B., Somanath, S.D., Haleagrahara, N., Selvaduray, K.R., Radhakrishnan, A.K. (2022). Unravelling the neuroprotective mechanisms of carotenes in differentiated human neural cells: Biochemical and proteomic approaches. *Food Chemistry*, 4, 100088. https://doi.org/10.1016/j.fochms.2022.100088

Marconi, G.D., Fonticoli, L., Rajan, T.S., Lanuti, P., Della Rocca, Y., Pierdomenico, S.D. *et al.* (2021). Transforming growth factor-beta1 and human gingival fibroblast-to-myofibroblast differentiation: Molecular and morphological modifications. *Frontiers in Physiology*, 12, 676512. https://doi.org/10.3389/fphys.2021.676512

Meganathan, P., Mai, C.W., Selvaduray, K.R., Zainal, Z., Fu, J.Y. (2022). Effect of carotenes against oxidative stress induced age-related macular degeneration in human retinal pigment cells. *ACS Food Science & Technology*, 2(11), 1719-1727.

Nanci, A. (2013). *Ten Cate's Oral Histology: Development, Structure and Functions*. 9th ed. Missouri: Elsevier, pp. 1-13.

Okazaki, M., Yoshimura, K., Uchida, G., Harii, K. (2002). Elevated expression of hepatocyte and keratinocyte growth factor in cultured buccal-mucosa-derived fibroblasts compared with normal-skin-derived fibroblasts. *Journal of Dermatological Science*, 30(2), 108-115. https://doi.org/10.1016/s09231811(02)00066-x

Riss, T.L., Moravec, R.A., Niles, A.L., Duellman, S., Benink, H.A., Worzella, T.J. *et al*. (2016). Cell viability assays. In: Markossian S, Grossman A, Baskir H, Arkin M, Auld D, Austin C, et al. (eds.), *Assay Guidance Manual*. Bethesda (MD): Eli Lilly & Company and the National Center for Advancing Translational Sciences. Retrieved 8 January 2025, from: https://www.ncbi.nlm.nih.gov/books/NBK144065/

Sen Gupta, S., Ghosh, M. (2013). In vitro antioxidative evaluation of α- and β-carotene, isolated from crude palm oil. *Journal of Analytical Methods in Chemistry*, 2013, 351671. https://doi.org/10.1155/2013/351671

Toma, A.I., Fuller, J.M., Willett, N.J., Goudy, S.L. (2021) Oral wound healing models and emerging regenerative therapies. *Translational Research,* 236, 17–34. https://doi.org/10.1016/j.trsl.2021.06.003

Viaña-Mendieta, P., Sánchez, M.L., Benavides, J. (2022). Rational selection of bioactive principles for wound healing applications: Growth factors and antioxidants. *International Wound Journal*, 19(1), 100-113. https://doi.org/10.1111/iwj.13602

Vijayashree, R.J., Sivapathasundharam, B. (2022). The diverse role of oral fibroblasts in normal and disease. *Journal of Oral and Maxillofacial Pathology,* 26(1), 6–13. https://doi.org/10.4103/jomfp.jomfp_48_22

Wang, M., Tang, R., Zhou, R., Qian, Y., Di, D. (2023). The protective effect of serum carotenoids on cardiovascular disease: a cross-sectional study from the general US adult population. *Frontiers in Nutrition*, 10, 1154239. https://doi.org/10.3389/fnut.2023.1154239

Yee, M.M.F., Chin, K.Y., Ima-Nirwana, S., Alias, E., Chua, K.H., Wong, S.K. (2025). Evaluation of bone-protecting effects of palm carotene mixture in two- and three-dimensional osteoblast/osteoclast co-culture systems. *International Journal of Medical Sciences*, 22(3), 585-603. https://doi.org/10.7150/ijms.103445

ORIGINAL ARTICLE Open Access

An audit of the quality of dental panoramic radiographs in the Orthodontic Unit, Klinik Pergigian Cahaya Suria

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Abstract

This audit aimed to assess the quality of dental panoramic radiographs in the Orthodontic Unit at Klinik Pergigian (KP) Cahaya Suria by evaluating adherence to radiographic standards, the proportion of diagnostically acceptable images, and the parameters that frequently failed to meet established criteria. A total of 192 pre-treatment panoramic radiographs were analysed, and obtained from two radiology units: Hospital A (28.65%) and Hospital B (71.35%). Each radiograph was assessed using a standardized checklist covering patient identification, exposure parameters, artifact prevention, anatomical structure visibility, and overall diagnostic acceptability based on a two-point grading system. Intra-examiner reliability was ensured through repeated assessments. Data analysis identified trends and areas requiring quality improvement. The audit revealed that 98.96% of the panoramic radiographs were diagnostically acceptable, exceeding the 90% benchmark. Artifact removal compliance was 99.48%, ensuring minimal diagnostic interference. Right/left marking was consistently present in all images. Key anatomical structures such as condyles (93.75%), sinus floor (91.15%), crestal bone (95.83%), and teeth/developing follicles (100%) were highly visible. However, mental foramen visibility was low (42.71%), indicating potential limitations in exposure settings and positioning. Documentation gaps were noted, with 0% age recording and 36.98% missing exposure values, impacting record-keeping and retrospective analysis. The findings indicate that the radiograph quality assessed is highly satisfactory, with most images meeting diagnostic standards. However, improvements are needed in mental foramen visualization, exposure parameter documentation, and record-keeping. Regular audits, staff training, and a quality assurance checklist are recommended to further enhance diagnostic accuracy and compliance with radiographic standards.

Keywords: *dental panoramic radiographs, clinical audit, orthodontic quality improvement*

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Introduction

Dental panoramic radiographs are a crucial diagnostic tool in orthodontics, providing a comprehensive view of the dentition, maxillary and mandibular arches, and surrounding structures (Mallya & Lam, 2018). Panoramic radiography, also known as orthopantomography, is the most commonly requested screening test in dentistry (American Dental Association Council on Scientific Affairs, 2006). It is a crucial adjunct in diagnosis and treatment planning, enabling comprehensive imaging in a single exposure that includes dentition,

the mandible, portions of the maxilla such as the floor of the maxillary sinus, the hard palate, and the temporomandibular joints (TMJs). Nevertheless, the panoramic image presents a complex projection of the jaws, often involving multiple superimpositions and distortions, which can be further aggravated by technical errors during image acquisition (Kaffe *et al*., 1977). Faculty of General Dental Practice (FGDP) or Public Health England (PHE) guidance recommends the use of a two-point grading scale, with images to be recorded as "diagnostically acceptable" ("A") or "diagnostically not acceptable" ("NA") (Public Health England & Faculty of General Dental Practice (UK), 2020). Successful interpretation of panoramic radiographs relies on a comprehensive understanding of the normal anatomy of the head and neck. This foundational knowledge is essential for identifying anatomical structures and variations, which can significantly influence the orthodontic diagnostic process and subsequent treatment planning.

The audit standard requires that at least 95% of digital radiographs are graded as "A" (diagnostically acceptable), ensuring they meet the necessary quality for accurate diagnosis without the need for retakes. For wet film radiographs, the standard is slightly lower, with a target of at least 90% being graded as "A" (diagnostically acceptable) (PHE & FGDP(UK), 2020). These benchmarks are set to maintain high radiographic quality, minimize diagnostic errors, and reduce the need for repeat exposures, thereby enhancing patient safety and care. From the literature review, the most commonly investigated radiograph quality criteria include contrast, sharpness, resolution, distortions, artifacts, and errors related to patient preparation and positioning (Aktuna Belgin & Serindere, 2019; Fux-Noy *et al*., 2023; Marsha *et al*., 2023; Lingam *et al*., 2023; Suparno *et al*., 2023). Common positioning errors include the patient being too far forward or backward, the chin being too high or too low, and the head being asymmetrical. In summary, six parameters determine whether a panoramic radiograph is correctly executed: symmetry between the two sides, an occlusal plane exhibiting a slight upper concavity, the alignment of the two mandibular condyles at the same height, a clear depiction of the dental apexes of the upper teeth, a straight cervical spine, and appropriate exposure parameters (Izzetti *et al*., 2021).

Ministry of Health (MOH) Malaysia licensing requirements specify that the minimum information displayed on a radiograph should include the patient's name, identification number, date of examination, and right or left marker. Healthcare institutions also conduct Quality Assurance Programme (QAP) reject analyses to calculate radiographic rejection rates, identify the causes of rejection, and report the findings to MOH. However, at present time, a dentistry-specific national QAP guideline has not been published by MOH. Therefore, the present audit used established international radiographic quality benchmarks together with a locally developed checklist tailored to the diagnostic requirements of orthodontic practice. While general radiographic quality assessment frameworks, such as those from the Faculty of General Dental Practice (FGDP) or Public Health England (PHE), provided recommendations, these do not cater specifically to the unique diagnostic needs of orthodontics. This gap emphasizes the need to audit and develop tailored standards for orthodontic panoramic radiograph quality, ensuring that radiographs adequately support orthodontic diagnosis and treatment planning. This work aimed to conduct an audit on the quality of dental panoramic radiographs in the Orthodontic Unit, Klinik Pergigian (KP) Cahaya Suria. The goals were to assess adherence to developed radiographic standards, to examine the proportion of radiographs that met the criteria for diagnostically acceptable dental panoramic imaging, and to ascertain the parameters that frequently failed to conform to the established standards.

Materials and Methods

This audit was conducted at the Orthodontic Unit, KP Cahaya Suria in Kuala Lumpur. It was registered with the National Medical Research Registration (NMRR), with research ID: RSCH ID-25-00601-WTL. Ethical approval for this study was obtained from the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia. Pre-treatment dental panoramic radiographs were selected from the first 200 patients registered in 2024, with registration numbers coded from 1/24 to 200/24. The dental panoramic radiographs were printed on X-ray film and were viewed with a light box and magnifier in a darkened room. Each radiograph was assessed once by an orthodontist utilizing a locally developed structured audit checklist to evaluate essential quality parameters specific to orthodontic practice. Data analysis was performed to assess the quality of the radiographs by systematically evaluating the extent to which each radiograph met the established criteria. For each radiograph, the number of criteria fulfilled was calculated and subsequently expressed as a percentage. This approach allowed for a comprehensive description of the radiographic quality across the sample, providing a quantitative representation of how well the radiographs adhered to the defined standards. The results were then analysed to identify trends and patterns in the data, facilitating an objective evaluation of the overall radiographic quality and highlighting areas that may require improvement.

To assess intra-examiner reliability, 30 dental panoramic radiographs were randomly selected and reassessed by the same examiner two weeks after the initial assessment using the same checklist. For each radiograph, an overall quality score was calculated as the percentage of applicable checklist criteria fulfilled. The repeatability of this continuous overall score was evaluated using a two-way mixed-effects, absolute-agreement, single-measure Intraclass Correlation Coefficient, ICC (3,1), with a 95% confidence interval. ICC values of less than 0.40 were interpreted as poor, 0.40–0.59 as fair, 0.60–0.74 as good, and 0.75–1.00 as excellent agreement.

Inclusion criteria

- Pre-treatment dental panoramic radiograph.
- Radiographs taken from Radiology Unit of Hospital A or Hospital B.

Exclusion criteria

- The patient underwent growth modification, fixed appliance treatment, and orthognathic surgery.
- Radiographs that were not taken from Hospital A or B

Analysis of image quality

In addition to the mandatory KKM radiograph-labelling requirements of patient name, identification number, date of examination, and right or left marker, the selected radiographs were analysed using supplementary variables such as sex, age or date of birth, acquisition time, and exposure parameters for internal quality-assurance purposes. Patient-preparation errors were assessed based on the presence of unremoved metallic objects. Positioning-related errors were considered when grading the overall diagnostic acceptability and anatomical visibility of the radiographs; however, specific positioning errors, such as chin-up, chin-down, excessive forward or backward positioning, head tilt, and head rotation, were not individually categorized. The parameters assessed and recorded for the dental panoramic radiographs are listed in Table 1.

Table 1. Parameters and criteria observed from panoramic radiographs.

Parameters	Criteria	Interpretation
Identification: • **Name of patient** • **Sex** • **Age** • **Registration number** • **Date of taking** • **Time of taking**	• Present • Not present	• Yes • No
Mark for left or right	• Right marking • Left marking	• Right • Left
Two-point grading scale of overall quality assessment.	• No errors or minimal errors in either patient preparation, exposure, positioning, image reconstruction, and of sufficient image quality to answer the clinical question • Errors in either patient preparation, exposure, positioning, or image reconstruction which renders the image diagnostically unacceptable	• "Diagnostically acceptable" ("A") • "Diagnostically not acceptable" ("NA")
Density and contrast.	• Unsatisfactory density with adequate contrast between the enamel and the dentine. • Satisfactory density and contrast between the enamel and the dentine. • Excellent density and contrast between the enamel and the dentine.	• Unsatisfactory • Satisfactory • Excellent
Removal of all metallic objects including removable orthodontic appliances, removable prostheses, piercings, glasses, necklaces, hearing aids, and hair pins to prevent artifacts from the radiographed site.	• Removed • Not removed	• Removed • Not removed
Condyles and condylar necks	This criterion assesses whether the condyles and their corresponding necks are visible and well-defined on the panoramic radiograph. The presence of these anatomical structures is essential for evaluating the full extent of the temporomandibular joint (TMJ) region,	

	which may be relevant in orthodontic diagnosis and treatment planning. • Identified: The condyles and condylar necks are fully visible without any significant distortion, cropping, or obstructions. • Not Identified: The condyles and/or condylar necks are either not visible, partially visible, obscured, or excluded from the image field, potentially limiting the diagnostic value of the radiograph.	• Identifiable • Not identifiable
Sinus floor	This criterion evaluates the visibility of the maxillary sinus floor on the radiograph, a key landmark in orthodontic assessment for posterior teeth positioning, root proximity, and sinus pathology. • Identified: The sinus floor is clearly visible with well-defined borders, without significant distortion or obstruction. The anatomical structure is adequately captured for diagnostic purposes. • Not Identified: The sinus floor is not visible, partially visible, or obscured due to image cropping, positioning errors, poor exposure, or radiographic artifacts. This may limit the diagnostic value of the radiograph.	• Identifiable • Not identifiable
Inferior alveolar nerve canals	This criterion evaluates the visibility of the inferior alveolar nerve canal (IANC) on the dental panoramic radiograph. Clear identification of the IANC is essential for assessing nerve proximity to the mandibular teeth, particularly for orthodontic treatment planning and surgical considerations. • Identified: The inferior alveolar nerve canal is clearly visible with well-defined borders, allowing for accurate assessment. • Not Identified: The canal is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic accuracy.	• Identifiable • Not identifiable
Mental foramen	This criterion evaluates the mental foramen's visibility, a key landmark for assessing nerve position in orthodontics and surgical procedures.	

	• Identified: The mental foramen is clearly visible with well-defined borders, allowing for accurate assessment. • Not Identified: The foramen is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic accuracy.	• Identifiable • Not identifiable
Crestal bone position of the alveolar processes	This criterion evaluates the visibility of the crestal alveolar bone in the alveolar process on the dental panoramic radiograph. Clear identification is essential for assessing bone levels, supporting orthodontic treatment planning, and detecting potential bone loss. • Identified: The crestal alveolar bone is clearly visible with well-defined margins • Not Identified: The bone is not visible, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic interpretation.	• Identifiable • Not identifiable
Periodontal ligament spaces and laminae durae	This criterion evaluates the visibility of the periodontal ligament (PDL) space and lamina dura on the dental panoramic radiograph. Clear identification of these structures is important for assessing periodontal health, root integrity, and potential pathology. • Identified: The PDL space appears as a uniform radiolucent line surrounding the tooth root, and the lamina dura is visible as a continuous radiopaque outline. • Not Identified: The PDL space and/or lamina dura are unclear, discontinuous, or obscured due to image quality issues, positioning errors, or radiographic artifacts, potentially affecting diagnostic accuracy.	• Identifiable • Not identifiable
Teeth and developing follicles	This criterion evaluates the visibility of teeth and developing follicles on the dental panoramic radiograph. Clear identification is essential for assessing tooth development, eruption patterns, and any abnormalities. • Identified: Teeth and developing follicles are clearly visible with	• Identifiable

	well-defined margins, allowing for accurate assessment. • Not Identified: Teeth and/or developing follicles are unclear, partially visible, or obscured due to image quality issues, positioning errors, or radiographic artifacts, which may affect diagnostic interpretation.	• Not identifiable

Results

The findings were based on a systematic analysis of radiographs to assess compliance with diagnostic standards and identify areas for improvement in radiographic practice. The following sections present the results of the evaluation and highlight patterns observed in the sample

Table 2 presented the prevalence of parameters that met the required criteria as well as those that did not conform to the established standards. Of the 200 dental panoramic radiographs assessed in this audit, eight were excluded as they were not from either Hospital A or B, resulting in a final sample of 192 radiographs for analysis. Among these, 28.65% were obtained from Hospital A, while 71.35% were from Hospital B. The assessment of patient and image identification demonstrated full compliance in recording patient ID and birthdate, as both were documented in 100% of the images. Similarly, the date of acquisition was recorded in all cases. However, the patient's age was absent in all images (0%), the time of acquisition was only documented in 37.50% of cases, and the sex was recorded in 28.65% of images. Additionally, the exposure value was recorded in 63.02% of the images. Regarding orientation markers, all radiographs included either a right or left marking, with 28.65% displaying a right-side marking and 71.35% a left-side marking.

In terms of overall image quality, the two-point grading system classified 98.96% of the images as diagnostically acceptable ("A"), while only 1.04% were deemed diagnostically unacceptable ("NA"). These findings indicate that nearly all DPRs met the necessary quality standards for clinical use. Figure 1 shows a diagnostically acceptable ("A") radiograph with clear anatomical structures, proper contrast, and sharpness, meeting the required diagnostic standards for clinical assessment, while Figure 2 illustrates a diagnostically unacceptable ("NA") radiograph, which fails to meet the required diagnostic standards due to factors such as poor image quality, improper angulation, and excessive ghost images. Artifact prevention was assessed based on the removal of metallic objects that could interfere with image clarity. The majority of images (99.48%) were free from artifacts, as all removable orthodontic appliances, prostheses, piercings, and other metallic objects had been appropriately removed before image acquisition. Only one case (0.52%) exhibited unremoved artifacts, suggesting strong adherence to pre-radiographic preparation protocols.

Table 2. Prevalence of the parameters that were fulfilled or did not meet the requirements.

Parameters	Criteria	Prevalence
Place taken	Hospital A	55 (28.65%)
	Hospital B	137 (71.35%)
Id	Yes	192 (100%)
	No	0 (0%)
Sex	Yes	55 (28.65%)
	No	137 (71.35%)
Birthday	Yes	192 (100%)
	No	0 (0%)
Age	Yes	0 (0%)
	No	192 (100%)
Date of taking	Yes	192 (100%)
	No	0 (0%)
Time of taking	Yes	72 (37.50%)
	No	120 (62.50%)
Exposure value	Yes	121 (63.02%)
	No	71 (36.98%)
Right or left marking	Right marking	55 (28.65%)
	Left marking	137 (71.35%)
Two-point grading scale *("Diagnostically acceptable" ("A") Or "Diagnostically not acceptable" ("NA"))*	("A")	190 (98.96%)
	("NA")	2 (1.04%)
Removal of all metallic objects including removable orthodontic appliances, removable prostheses, piercings, glasses, necklaces, hearing aids, and hair pins to prevent artifacts from the radiographed site *(Removed/ not removed)*	Removed	191 (99.48%)
	Not removed	1 (0.52%)
Condyles and condylar necks *(Identifiable/Not identifiable)*	Identifiable	180 (93.75%)
	Not identifiable	12 (6.25%)
Sinus floor *(Identifiable/Not identifiable)*	Identifiable	175 (91.15%)
	Not identifiable	17 (8.85%)
Inferior alveolar nerve canals *(Identifiable/Not identifiable)*	Identifiable	157 (81.77%)
	Not identifiable	35 (18.23%)
Mental foramen *(Identifiable/Not identifiable)*	Identifiable	82 (42.71%)
	Not identifiable	110 (57.29%)
Crestal bone position of the alveolar processes *(Identifiable/Not identifiable)*	Identifiable	184 (95.83%)
	Not identifiable	8 (4.17%)
Periodontal ligament spaces and laminae durae *(Identifiable/ Not identifiable)*	Identifiable	136 (70.83%)
	Not identifiable	56 (29.17%)
Teeth and developing follicles *(Identifiable/ Not identifiable)*	Identifiable	100%
	Not identifiable	0 (0%)

Table 3. Statistical treatment of the audit variables and intra-examiner reliability of the overall radiographic quality score.

Variable	Response Format	Included in overall percentage score	Item-level ICC reported
Place taken	Hospital A/ Hospital B	No*	No
Id	Yes/ No	Yes	No
Sex	Yes/ No	Yes	No
Birthday	Yes/ No	Yes	No
Age	Yes/ No	Yes	No
Date of taking	Yes/ No	Yes	No
Time of taking	Yes/ No	Yes	No
Exposure value	Yes/ No	Yes	No
Right or left marking	Present/ Not Present	Yes	No
Two-point grading scale	Acceptable/ Not Acceptable	Yes	No
Removal of metallic objects	Removed/ Not Removed	Yes	No
Condyles and condylar necks	Identifiable/ Not identifiable	Yes	No
Sinus floor	Identifiable/ Not identifiable	Yes	No
Inferior alveolar nerve canals	Identifiable/ Not identifiable	Yes	No
Mental foramen	Identifiable/ Not identifiable	Yes	No
Crestal bone position of the alveolar processes	Identifiable/ Not identifiable	Yes	No
Periodontal ligament spaces and laminae durae	Identifiable/ Not identifiable	Yes	No
Overall percentage quality score	Continuous percentage	Not applicable	Yes: ICC(3,1)

*The place where the radiograph was taken identifies the source of the image and should not normally contribute to the radiographic quality score.

Table 4. Intra-examiner reliability of the overall percentage quality score using intraclass correlation coefficient (ICC).

Reliability Outcome	Number Reassessed	ICC model	ICC Value	95% CI	Interpretation
Overall percentage of applicable audit criteria fulfilled	30	Two-way mixed-effects, absolute agreement, single measure, ICC (3,1)	0.998	0.995–0.999	Excellent agreement

ICC was calculated only for the continuous overall percentage quality score. Item-level ICC values were not reported because the individual checklist variables were categorical.

Figure 1. Diagnostically acceptable ("A") radiograph, demonstrating optimal image quality with appropriate contrast, sharpness, and clarity of anatomical structures.

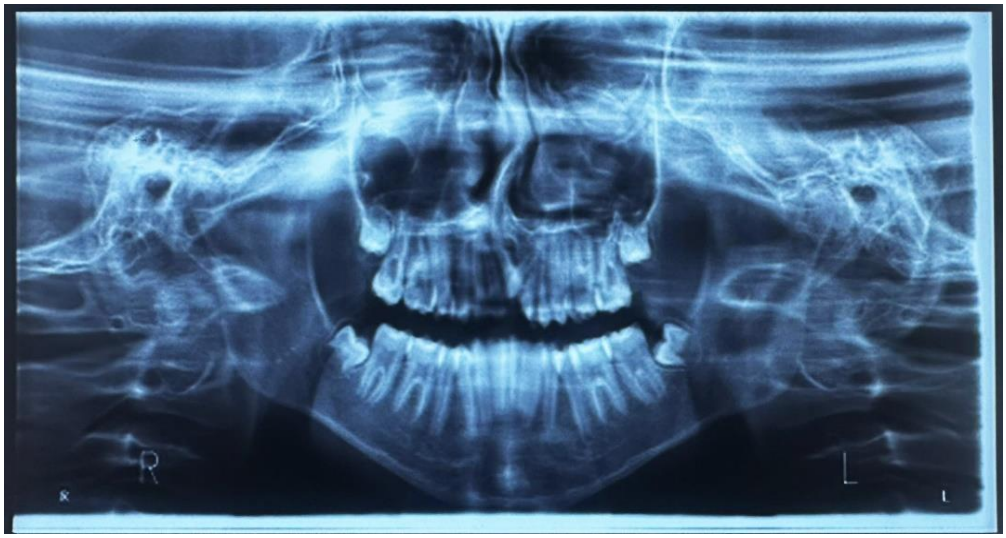

Figure 2. Diagnostically unacceptable ("NA") radiograph characterized by poor image quality, insufficient diagnostic detail, and technical errors that hinder accurate clinical assessment.

The visibility of key anatomical structures was also evaluated. The condyles and condylar necks were identifiable in 93.75% of images, while the sinus floor was visible in 91.15% of cases. The inferior alveolar nerve canals were distinguishable in 81.77% of images, whereas the mental foramen was only identifiable in 42.71%, indicating a limitation in visualization for more than half of the cases. The crestal bone position of the alveolar processes was discernible in 95.83% of images, and the periodontal ligament spaces along with laminae durae were visible in 70.83% of cases. Notably, teeth and developing follicles were clearly identifiable in 100% of the images, ensuring their diagnostic reliability in orthodontic assessments. Table 3 summarises the audit variables, corresponding response formats, and the statistical approach applied to each variable in relation to the overall radiographic quality score and intra-examiner reliability analysis. The audit checklist comprised predominantly categorical variables, including binary responses such as Yes/No, Present/Not Present, Removed/Not Removed, Acceptable/Not Acceptable, and Identifiable/Not Identifiable. These variables were incorporated into the computation of the overall percentage radiographic quality score, as they reflected compliance with predefined radiographic quality criteria. In contrast, the place where the radiograph was taken was excluded from the overall score because this variable served solely to identify the source of image acquisition and was not considered an intrinsic indicator of radiographic quality. Given the categorical nature of the individual checklist items, item-level intraclass correlation coefficients were not calculated. Instead, intra-examiner reliability was assessed using the continuous overall percentage quality score, with agreement evaluated using the intraclass correlation coefficient model ICC (3,1). As shown in Table 4, the intra-examiner reliability of the overall radiographic quality score was assessed using paired percentage scores from 30 randomly selected radiographs evaluated on two occasions. The analysis demonstrated excellent intra-examiner reliability, with an ICC of 0.998 (95% CI: 0.995–0.999).

Compliance with the mandatory radiograph labelling requirements was assessed based on the presence of patient identification, date of examination, and right or left marking. Additional information, including sex, age, acquisition time, and exposure values, was variably displayed. However, these variables were evaluated as supplementary quality-assurance indicators rather than mandatory MOH labelling requirements. Overall, the findings from this audit suggest that the quality of radiographs received in the Orthodontic Unit at KP Cahaya Suria is largely satisfactory, with the vast majority of radiographs being diagnostically acceptable. However, specific areas for improvement include the documentation of patient age and acquisition time, as well as the optimisation of techniques to enhance the visualization of the mental foramen. Addressing these aspects could further improve the diagnostic utility of panoramic radiographs and ensure higher compliance with established imaging standards.

Discussion

The high percentage of diagnostically acceptable images (98.96%) observed in this audit indicates that the current radiographic protocols are highly effective. This finding aligns with established quality standards in dental radiography, such as the guidelines set by the Faculty of General Dental Practice (FGDP), which recommend that no more than 10% of radiographs should be diagnostically unacceptable (PHE & FGDP(UK), 2020). The audit results, with only 1.04% of images deemed unacceptable, fall well within this, demonstrating strong adherence to best practices in image acquisition, patient positioning, and exposure settings. Comparatively, previous studies evaluating the quality of dental panoramic radiographs in general dental practices have reported lower rates of diagnostically acceptable images, often citing issues such as patient movement, improper head positioning, and inconsistent

exposure settings (Fux-Noy *et al*., 2023; Suparno *et al*., 2023; Lingam *et al*., 2023). In contrast, the findings from this audit suggest that these common challenges are effectively managed, likely due to strict adherence to standard operating procedures (SOPs) and adequate radiographic training among staff (Khan *et al*., 2015; Dhillon *et al*., 2012). The presence of a structured quality assurance process may also contribute to minimizing errors that could compromise diagnostic quality. Despite these positive findings, continuous monitoring remains essential to maintain the high quality of radiographs and further reduce the occurrence of unacceptable images (American Dental Association, 2012).

The audit findings demonstrate full compliance in recording essential patient identification details, including patient ID, birthdate, and the date of radiographic acquisition. This is a critical strength, as proper documentation of these details ensures accurate patient tracking, facilitates long-term treatment planning, and minimizes the risk of misidentification (Aakre *et al*., 2006). Maintaining these records aligns with best practices in radiographic quality assurance, contributing to efficient data management and improved patient safety (Tridandapani *et al*., 2013). The audit findings indicate that all dental panoramic radiographs contained right or left markers, ensuring proper image orientation during diagnosis. This is a positive finding, as consistent use of orientation markers is essential for accurate interpretation of dental and skeletal asymmetries in orthodontic cases (Barry *et al*., 2016). Misinterpretation of the left and right sides can lead to diagnostic errors, incorrect treatment planning, and potential complications in orthodontic or surgical interventions (Titley & Cosson, 2014). Ensuring consistent placement of markers prevents confusion in cases of unilateral pathology, asymmetrical growth patterns, or skeletal discrepancies.

However, notable weaknesses were identified in the documentation of patient age and time of image acquisition. The complete absence of age documentation (0%) and the low compliance in recording the sex (28.65%) and time of acquisition (37.50%) highlight gaps in record-keeping that may impact clinical decision-making. Age and sex are crucial factors in orthodontic diagnosis and treatment planning, as they influence tooth development, eruption timing, skeletal growth prediction, and the selection of appropriate orthodontic interventions (Wang *et al*., 2024; Alikhani *et al*., 2018). Similarly, documenting the time of radiographic acquisition is important for exposure tracking and quality control (American Dental Association, 2012). Time-based data can help monitor radiation dosage patterns, assess operator consistency, and identify trends that may influence image quality.

The audit findings revealed that exposure values were documented in 63.02% of dental panoramic radiographs, leaving a significant proportion (36.98%) without recorded exposure settings. This shortfall in documentation raises concerns regarding consistency in image quality and radiation dose optimisation. Proper documentation of exposure parameters, including kilovoltage (kV), milliamperage (mA), and exposure time, is essential for maintaining standardized radiographic quality and ensuring that patient radiation exposure is kept within optimal limits (Benavides *et al*., 2024). Additionally, exposure settings influence contrast, sharpness, and overall diagnostic utility, particularly in orthodontics, where accurate visualization of dental and skeletal structures is crucial for treatment planning. The absence of exposure values limits the ability to analyze potential causes of suboptimal images and makes it difficult to replicate successful settings for future imaging (Granlund *et al*., 2016; Ludlow *et al*., 2008). Moreover, tracking exposure parameters is important for dose optimisation, helping to balance sufficient image quality with minimal radiation exposure in line with the As Low As Reasonably Achievable (ALARA) principle (European ALARA Network, 2019). Although age, sex, acquisition time, and exposure parameters were not consistently displayed, their absence should not be interpreted as non-compliance with MOH radiograph

labelling requirements. These variables were included as supplementary audit indicators because they may facilitate retrospective quality assessment, exposure optimisation, and investigation of technically suboptimal images.

In addition, the audit results demonstrated near-perfect compliance (99.48%) in the removal of metallic objects before radiographic exposure, indicating strong adherence to pre-radiographic preparation protocols, while only 0.52% of cases exhibited unremoved artifacts. This high level of compliance significantly contributes to improved diagnostic accuracy by minimizing superimpositions, distortions, and beam-hardening effects that could obscure critical anatomical structures (Ramos *et al*., 2016). In contrast, studies assessing the quality of dental panoramic radiographs in general dental practices have reported a higher prevalence of artifacts due to inconsistent adherence to pre-radiographic preparation guidelines (Mohtavipour *et al*., 2013). Images with metallic artifacts impact the visibility of the maxillary sinus, mandibular ramus, and adjacent structures (Aktuna Belgin & Serindere, 2019).

The audit findings yielded high visibility rates for several critical anatomical structures in dental panoramic radiographs, indicating that the images provide reliable diagnostic information for orthodontic assessment. Notably, the condyles (93.75%), sinus floor (91.15%), crestal bone (95.83%), and teeth and developing follicles (100%) were consistently well-visualised. These results suggest that the current radiographic protocols effectively capture essential maxillofacial structures, supporting accurate orthodontic diagnosis, treatment planning, and growth assessment. The excellent visualization of developing follicles, in particular, is crucial in pediatric and adolescent patients (American Academy of Pediatric Dentistry, 2018), as it enables precise evaluation of tooth eruption patterns, impaction risks, and potential space discrepancies.

However, a significant area of concern was identified in the visualization of the mental foramen, which was identifiable in only 42.71% of images. This low detection rate suggests potential limitations in exposure settings, patient positioning, or image processing techniques. Visibility of the mental foramen on panoramic radiographs may also be affected by anatomical variation in its position, shape, and relationship to the mandibular premolar roots, as well as differences in surrounding bone density. Superimposition of adjacent anatomical structures and the inherent projection and magnification characteristics of panoramic imaging may further reduce its visibility. Patient-related factors, including age and movement during image acquisition, may also contribute. Therefore, the observed low visibility rate likely resulted from a combination of anatomical, patient-related, and technical factors. The mental foramen is a critical reference point in both orthodontic and surgical procedures, as it marks the exit of the mental nerve, which provides sensory innervation to the lower lip, chin, and adjacent mucosa (Gupta *et al*., 2015). Poor visualization of the mental foramen can have clinical implications, particularly in cases involving extractions, dental implant placement, and orthognathic surgery, where inadvertent nerve damage can result in temporary or permanent paresthesia (Gupta *et al*., 2015; Jasim, 2020). Additionally, in orthodontics, clear identification of the mental foramen is essential for growth and development assessment and for evaluating mandibular asymmetry (Abdullah Bahamid *et al*., 2023).

A limitation of this audit was that individual patient-positioning errors, including chin-up, chin-down, excessive forward or backward positioning, head tilt, and head rotation, were not separately recorded. Future audit cycles should categorize these errors individually to identify the most frequent technical causes of diagnostically unacceptable radiographs. Next, the audit checklist was locally developed from published guidance and literature and was not subjected to formal content validation or pilot testing. Therefore, its applicability and validity in other clinical settings require

further evaluation. Overall, while panoramic radiographs in this audit demonstrated strong diagnostic reliability, targeted improvements in mental foramen visibility are necessary to further enhance their clinical utility. By refining exposure settings, ensuring optimal patient positioning, and incorporating cone beam computed tomography (CBCT) imaging when required, the orthodontic unit can continue to improve radiographic accuracy and minimize the risk of diagnostic errors.

Recommendations

To maintain the high quality of dental panoramic radiographs and address any deviations from standards, it is essential to implement a continuous quality improvement framework. Regular radiographic audits should be conducted to monitor compliance with imaging protocols, assess the consistency of exposure settings, and ensure that all essential anatomical structures are adequately visualised. These audits will help identify recurring issues and provide data-driven insights for refining imaging practices.

Staff training is another critical aspect of quality improvement. Training programs should focus on documentation practices, patient positioning techniques, and exposure parameter optimisation to enhance diagnostic reliability. Ensuring that radiographers consistently record key patient details, such as age and time of acquisition, will improve record-keeping and facilitate retrospective analysis of radiographic quality. Additionally, refining positioning techniques can help address visibility challenges, particularly for structures such as the mental foramen, which had a lower detection rate in this audit.

To further strengthen quality control, implementing a pre-radiographic quality assurance checklist is recommended. This checklist should include verification of patient identification, exposure settings, artifact removal, and proper marker placement before finalizing the radiograph. By ensuring that all essential details are recorded and that imaging protocols are strictly followed, the orthodontic unit can minimize errors, improve diagnostic consistency, and enhance patient safety. Regular review of this checklist, along with periodic refresher training for staff, will help maintain high standards in panoramic radiographs acquisition and interpretation.

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References

Aakre, K. T., & Johnson, C. D. (2006). Plain-radiographic image labeling: a process to improve clinical outcomes. *Journal of the American College of Radiology, 3*(12), 949–953. https://doi.org/10.1016/j.jacr.2006.07.005

Aktuna Belgin, C., & Serindere, G. (2019). Evaluation of error types and quality on panoramic radiography. *International Dental Research, 9*(3), 99–104. https://doi.org/10.5577/intdentres.2019.vol9.no3.2

Alikhani, M., Chou, M. Y., Khoo, E., Alansari, S., Kwal, R., Elfersi, T., Almansour, A., Sangsuwon, C., Al Jearah, M., Nervina, J. M., & Teixeira, C. C. (2018). Age-dependent biologic response to orthodontic forces. *American Journal of Orthodontics and Dentofacial Orthopedics, 153*(5), 632–644. https://doi.org/10.1016/j.ajodo.2017.09.016

American Academy of Pediatric Dentistry (2018). Prescribing dental radiographs for infants, children, adolescents, and individuals with special health care needs. *Pediatric Dentistry, 40*(6), 213–215.

American Dental Association Council on Scientific Affairs (2006). The use of dental radiographs: update and recommendations. *The Journal of the American Dental Association, 137*(9), 1304–1312. https://doi.org/10.14219/jada.archive.2006.0393

American Dental Association Council on Scientific Affairs & U.S. Food and Drug Administration (2012). *Dental radiographic examinations: Recommendations for patient selection and limiting radiation exposure*. American Dental Association. https://www.ada.org/-/media/project/ada-organization/ada/ada-org/files/resources/library/oral-health-

topics/dental_radiographic_examinations_2012.pdf

Bahamid, A. A., Alsaif, S. Y., Almansouri, A. S. M., Alshammri, S. M., Alshahrani, F. A., & Alhusayni, H. A. (2023). Mental foramen position, shape, continuity, and symmetry among malocclusion patients: A radiographic study. *Cureus, 15*(12), e51056. https://doi.org/10.7759/cureus.51056

Barry, K., Kumar, S., Linke, R., & Dawes, E. (2016). A clinical audit of anatomical side marker use in a paediatric medical imaging department. *Journal of Medical Radiation Sciences, 63*(3), 148–154. https://doi.org/10.1002/jmrs.176

Benavides, E., Krecioch, J. R., Connolly, R. T., Allareddy, T., Buchanan, A., Spelic, D., *et al.* (2024). Optimizing radiation safety in dentistry: clinical recommendations and regulatory considerations. *The Journal of the American Dental Association, 155*(4), 280–293.e4. https://doi.org/10.1016/j.adaj.2023.12.002

Dhillon, M., Raju, S. M., Verma, S., Tomar, D., Mohan, R. S., Lakhanpal, M., *et al.* (2012). Positioning errors and quality assessment in panoramic radiography. *Imaging Science in Dentistry, 42*(4), 207–212. https://doi.org/10.5624/isd.2012.42.4.207

European ALARA Network (2019). *Optimization of radiation protection—ALARA: A practical guidebook*. https://www.eu-alara.net/images/stories/EANdocuments/Publications/EAN_ALARA_Book_oct_2019V2.pdf

Fux-Noy, A., Rohana, R., Rettman, A., Moskovitz, M., & Nadler, C. (2023). Panoramic errors in pediatric patients with special needs. *Scientific Reports, 13*(1), 11757. https://doi.org/10.1038/s41598-023-38823-1

Granlund, C., Thilander-Klang, A., Ylhan, B., Lofthag-Hansen, S., & Ekestubbe, A. (2016). Absorbed organ and effective doses from digital intra-oral and panoramic radiography applying the ICRP 103 recommendations for effective dose estimations. *The British Journal of Radiology, 89*(1066), 20151052. https://doi.org/10.1259/bjr.20151052

Gupta, V., Pitti, P., & Sholapurkar, A. (2015). Panoramic radiographic study of mental foramen in selected Dravidians of South Indian population: A hospital-based study. *Journal of Clinical and Experimental Dentistry, 7*(4), e451–e456. https://doi.org/10.4317/jced.52174

Izzetti, R., Nisi, M., Aringhieri, G., Crocetti, L., Graziani, F., & Nardi, C. (2021). Basic knowledge and new advances in panoramic radiography imaging techniques: A narrative review on what dentists and radiologists should know. *Applied Sciences, 11*(17), 7858. https://doi.org/10.3390/app11177858

Jasim, H. H. (2020). Evaluation of mental foramen location: a review article. *Journal of Medical Care Research and Review, 3*(7), 379–385. https://doi.org/10.15520/mcrr.v3i7.107

Kaffe, I., Fishel, D., & Gorsky, M. (1977). Panoramic radiography in dentistry. *Refu'at Hapeh Vehashinayim, 26*(2), 25–30.

Khan, S. Q., Ashraf, B., & Mehdi, H. (2015). Evaluation of patient preparation and positioning errors on digital panoramic radiographs. *Pakistan Oral & Dental Journal, 35*(1), 65–69.

Lingam, A. S., Koppolu, P., Abdulsalam, R., Reddy, R. L., Anwarullah, A., & Koppolu, D. (2023). Assessment of common errors and subjective quality of digital panoramic radiographs in a dental institution, Riyadh. *Annals of African Medicine, 22*(1), 49–54. https://doi.org/10.4103/aam.aam_213_21

Ludlow, J. B., Davies-Ludlow, L. E., & White, S. C. (2008). Patient risk related to common dental radiographic examinations: The impact of 2007 International Commission on Radiological Protection recommendations regarding dose calculation. *The Journal of the American Dental Association, 139*(9), 1237–1243. https://doi.org/10.14219/jada.archive.2008.0339

Mallya, S. M., & Lam, E. W. N. (2018). *White and Pharoah's oral radiology: Principles and interpretation* (8th ed.). Elsevier.

Marsha, E. A., Kiswanjaya, B., & Bachtiar-Iskandar, H. H. (2023). Comparison of positioning errors on panoramic radiographs in Indonesian children, adults, and elderly patients. *Journal of Stomatology, 76*(3), 175–181. https://doi.org/10.5114/jos.2023.131200

Mohtavipour, S. T., Javadzadeh Haghighat, A. S., Dalili, Z., Nemati, S., Mohtavipour, S. S., Narenjisani, M., *et al.* (2013). Common errors in digital panoramic radiographs taken in Rasht Dental School. *Journal of Dentomaxillofacial Radiology, Pathology and Surgery, 2*(2), 32–36. https://doi.org/10.18869/acadpub.3dj.2.2.32

Public Health England & Faculty of General Dental Practice (UK) (2020). *Guidance notes for dental practitioners on the safe use of X-ray equipment* (2nd ed.). https://cgdent.uk/wp-content/uploads/securepdfs/Guidance-notes-for-dental-practitioners-on-the-safe-use-of-x-ray-equipment-2020-online-version.pdf

Ramos, B. C., da Silva Izar, B. R., Costa Pereira, J. L., Souza, P. S., Valerio, C. S., Tuji, F. M., *et al.* (2016). Formation of ghost images due to metal objects on the surface of the patient's face: a pictorial essay. *Imaging Science in Dentistry, 46*(1), 63–68. https://doi.org/10.5624/isd.2016.46.1.63

Suparno, N. R., Faizah, A., & Nafisah, A. N. (2023). Assessment of panoramic radiograph errors: An evaluation of patient preparation and positioning quality at Soelastri Dental and Oral Hospital. *The Open Dentistry Journal, 17*, e187421062309120. https://doi.org/10.2174/0118742106261974230925073155

Titley, A. G., & Cosson, P. (2014). Radiographer use of anatomical side markers and the latent conditions affecting their use in practice. *Radiography, 20*(1), 42–47. https://doi.org/10.1016/j.radi.2013.10.004

Tridandapani, S., Ramamurthy, S., Galgano, S. J., & Provenzale, J. M. (2013). Increasing rate of detection of wrong-patient radiographs: use of photographs obtained at time of radiography. *American Journal of Roentgenology, 200*(4), W345–W352. https://doi.org/10.2214/AJR.12.9521

Wang, J., Huang, Y., Chen, F., & Li, W. (2024). The age-related effects on orthodontic tooth movement and

the surrounding periodontal environment. *Frontiers in Physiology, 15*, 1460168. https://doi.org/10.3389/fphys.2024.1460168

ORIGINAL ARTICLE Open Access

Periodontal status, knowledge, and dental barriers among Kuantan healthcare workers

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Abstract

Periodontal disease remains a pervasive global health challenge, affecting 94.6% of Malaysian adults. Despite this high national prevalence, data regarding healthcare workers remain scarce. This study addresses this gap by evaluating periodontal status, knowledge, and barriers to dental care among Ministry of Health (MOH) employees in Kuantan, Pahang, a cohort that is expected to exhibit high health literacy. Our objectives are to evaluate periodontal status and to determine associated factors for knowledge, barriers to dental attendance, and source of dental knowledge. A cross-sectional study was conducted among 224 MOH employees. Data were collected via a self-administered questionnaire and a clinical Basic Periodontal Examination (BPE). Simple and multiple linear regression analyses identified associated factors for each domain. Periodontal disease was highly prevalent (99.6%), with 42.0% exhibiting moderate (CPI 3) and 23.2% severe (CPI 4) forms. Multiple linear regression showed that being female (adjusted $\beta = 0.533$, $p = 0.001$) and having no deep periodontal pockets (adjusted $\beta = 0.428$, $p = 0.008$) were associated with higher knowledge scores. Conversely, being non-dental personnel (adjusted $\beta = -1.029$, $p < 0.001$) was the strongest factor associated with lower knowledge scores. No specific personal or clinical factors explained the barrier scores. This shows that obstacles like being 'busy' are widespread workplace hurdles rather than differences between individual employees. A striking knowledge–practice gap exists among MOH employees, marked by high disease prevalence despite adequate knowledge. Targeted education strategies addressing specific predictor groups particularly non-dental personnel and individuals with existing deep periodontal pockets are warranted.

Keywords: *barriers, BPE, healthcare workers, knowledge, periodontal disease*

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Introduction

Civil services are frequently utilised by the Malaysian population, particularly in the healthcare sector, where 60–80% of services are accessed through government clinics (NHMS, 2019). This is largely attributable to the wide availability and subsidised nature of such services (Kananatu, 2002). The role of civil servants, especially medical professionals, in promoting oral health is substantial, encompassing screening for oral diseases, emergency care, pain management, and referral (Cruz *et al.*, 2004; Heilbrunn-Lang *et al.*, 2015). These professionals are expected to serve as health educators, given the general public's perception that those working within health institutions possess sound health knowledge.

Several studies have investigated the knowledge, attitudes, and practices of medical professionals towards oral and periodontal health, with inconsistent results (Rodrigues *et al.*, 2024; Shah *et al.*, 2020).

While some groups demonstrate adequate knowledge, others remain poorly equipped regarding periodontal disease. The subsequent effect of this variability on their clinical practice, health promotion roles, and personal oral health outcomes remains insufficiently explored.

The periodontal health status of civil servants in Malaysia remains largely undocumented. While a 2003 government circular encouraged public sector employees aged 40 years and above to undergo physical, laboratory, and dental examinations at government clinics and hospitals, this policy may leave critical gaps. Data from the National Oral Health Survey of Adults (NOHSA) indicates that periodontal disease is highly prevalent, particularly within the 35–44 age group, suggesting that the current age-restricted screening framework is insufficient (Mohd-Dom *et al*., 2013; NOHSA, 2020). Consequently, available dental records for civil servants are typically limited to a single, baseline pre-employment screening, which is rarely updated throughout their careers.

Therefore, this study was conducted to provide baseline data on the periodontal status and oral health literacy of MOH employees in Kuantan, Pahang. This study aimed to: (1) evaluate the periodontal status among MOH personnel in Kuantan, Pahang; (2) determine associated factors for knowledge, barriers to dental attendance, and source of dental knowledge scores using multiple linear regression.

Materials and Methods

Prior to study commencement, ethical approval was obtained from the Medical Research Ethics Committee [Reference no: NMRR-21-1425-59959]. This cross-sectional study was conducted over two years (2021–2023) among MOH employees in Kuantan, Pahang. A one-stage stratified cluster sampling method was used to select participants from six divisions of the Pahang State Health Department (JKNP), which were public health, medical, dental, management, pharmacy, and safety and quality of food. Collectively, sixteen operational units within these divisions were involved in the study. All permanent and contract MOH personnel aged 18 years and above who were present during data collection and provided informed consent were included. Exclusion criteria comprised edentulous individuals, those with only one remaining tooth, mentally incapacitated or illiterate subjects, those who declined either component of the assessment, and individuals with contraindications to periodontal probing (*e.g.*, bleeding disorders, acute infectious diseases).

Sample size calculation

The sample size for this study was calculated based on two primary objectives using Statulator (Statulator®, Sydney, Australia) and PS: Power and Sample Size Calculation software (Dupont & Plummer, 1990). For objective 1 (estimation of periodontal disease prevalence), assuming 6% of the population has a healthy periodontium (NOHSA, 2020) and a population size of 4,675 (JKNP, 2021), a minimum of 86 subjects was required (5% absolute precision, 95% confidence). For objective 2 (identifying associated factors for periodontal knowledge), sample size requirements were evaluated for both univariate and multivariate approaches. To detect a significant difference in continuous knowledge scores derived from an effect size ($\lambda = 0.39$)(Umeizudike *et al*., 2015), it was required to recruit 208 subjects ($\alpha = 0.05$, power = 0.80). The final recruited sample of 224 subjects successfully met these requirements. Furthermore, post-hoc power calculations confirmed that this sample of 224 provides robust power (>0.80) to evaluate up to six predictors simultaneously in the multiple linear regression model, detecting medium effect sizes $f^2 \geq 0.15$ and significance level of 0.05.

Questionnaire and clinical assessment

A dual-language (English and Malay) self-administered questionnaire, adapted from a

Malaysian study, was used (Yahya *et al*., 2010). The questionnaire comprised four sections: demographics, a knowledge scale, a barriers-to-dental-attendance scale, and a source-of-dental-knowledge scale. The knowledge scale on periodontal diseases comprised six items, scored dichotomously (1 point for correct, 0 points for incorrect or "don't know" responses), yielding a continuous total score ranging from 0 to 6, where higher scores reflect superior theoretical knowledge. The barriers-to-dental-attendance scale consists of six items measured on a reverse-coded 5-point Likert scale (1 = Strongly Agree, 5 = Strongly Disagree) designed to quantify qualitative obstacles, meaning higher scores signify lower perceived barriers. Conversely, the source-of-dental-knowledge comprises six items scored on a standard 5-point Likert scale (5 = Strongly Agree, 1 = Strongly Disagree) to measure information-seeking behaviours, where higher scores reflect a stronger agreement on the knowledge sources. Content and face validity were confirmed by a panel of two periodontists. Internal consistency was assessed using Cronbach's alpha (α); knowledge domain α = 0.589, barrier domain α = 0.709, and source of dental knowledge domain α = 0.853.

Periodontal status was assessed using the Basic Periodontal Examination (BPE) (British Society of Periodontology, 2019). Assessment was done by "walking" the probe around the teeth to find the highest score in each sextant. The dentition was divided into 6 sextants, and the highest score for each sextant was recorded. The score for each sextant was presented in CPI (Community Periodontal Index) score. All teeth in each sextant are examined (except for 3rd molars unless 1st and/or 2nd molars are missing). For a sextant to qualify for recording, it o0-/[xmust contain at least 2 teeth. Three investigators were calibrated against an experienced periodontist before data collection, achieving a Kappa score of 0.80 (substantial agreement). The highest CPI score across all sextants was recorded as the participant's final score.

Statistical analysis

Data were analysed using R Statistical Software (R Core Team, 2026). Descriptive statistics were used to characterise the study population. For each outcome domain (knowledge score, barriers-to-dental-attendance score, and source-of-dental-knowledge score), simple linear regression was first performed to examine unadjusted associations with sociodemographic and clinical variables. Variables with $p < 0.25$ in simple regression or those of clinical relevance were subsequently entered into multiple linear regression models. Backward elimination using the Akaike Information Criterion (AIC) was applied to derive the most parsimonious final models. Before interpreting final models, the four assumptions of multiple linear regression were assessed: linearity (Residuals vs. Fitted plots), normality of residuals (Q-Q plots and Shapiro-Wilk test), homoscedasticity (Scale-Location plots), and multicollinearity (Variance Inflation Factor; VIF). For the knowledge score model, robust standard errors (HC3) were applied due to minor heteroscedasticity. Statistical significance was set at $p < 0.05$.

Results

Demographic characteristics

A total of 224 MOH employees participated. The mean age was 36.7 years (SD = 7.70), with 68.8% aged under 40 years. The majority were female (68.3%), Malay (88.8%), and held a diploma or degree qualification (83.0%). Supporting staff comprised 58.5% of the sample. The largest group had 6–14 years of working experience (42.9%). Only 10.3% reported having a comorbidity. Full demographic details are presented in Table 1. This table summarizes the distribution of age, gender, ethnicity, education level, job position, years of service, and comorbidity status among the Ministry of Health (MOH) employees in Kuantan.

Table 1. Characteristics of study sample (n=224).

Variables	N (%)
Age	
< 40 years old	154 (68.8)
⩾ 40 years old	70 (31.2)
Gender	
Male	71 (31.7)
Female	153 (68.3)
Race	
Malay	199 (88.8)
Chinese	12 (5.4)
Indian	7 (3.1)
Others	6 (2.7)
Education level	
Secondary school	38 (17.0)
Diploma	88 (39.2)
Degree	98 (43.8)
Job position	
Officers	93 (41.5)
Supporting staff	131 (58.5)
Dental personnel status	
Dental	20 (8.9)
Non- Dental	204 (91.1)
Working years	
Less than 1 year	13 (5.8)
1 year to 5 years	56 (25)
6 years to 14 years	96 (42.9)
15 years and above	59 (26.3)
Presence of comorbidity	
Yes	23 (10.3)
No	201 (89.7)

Periodontal status

Periodontal disease was highly prevalent, affecting 99.6% of participants. The most common finding was CPI 3 (pockets 3.5–5.5 mm), observed in 94 participants (42.0%), followed by CPI 2 (calculus and bleeding on probing) in 67 participants (29.9%). CPI 4 (pockets ≥ 5.5 mm) was recorded in 50 participants (23.2%). Only one participant (0.4%) had a healthy periodontium (CPI 0), and 4.5% had CPI 1 (Figure 1).

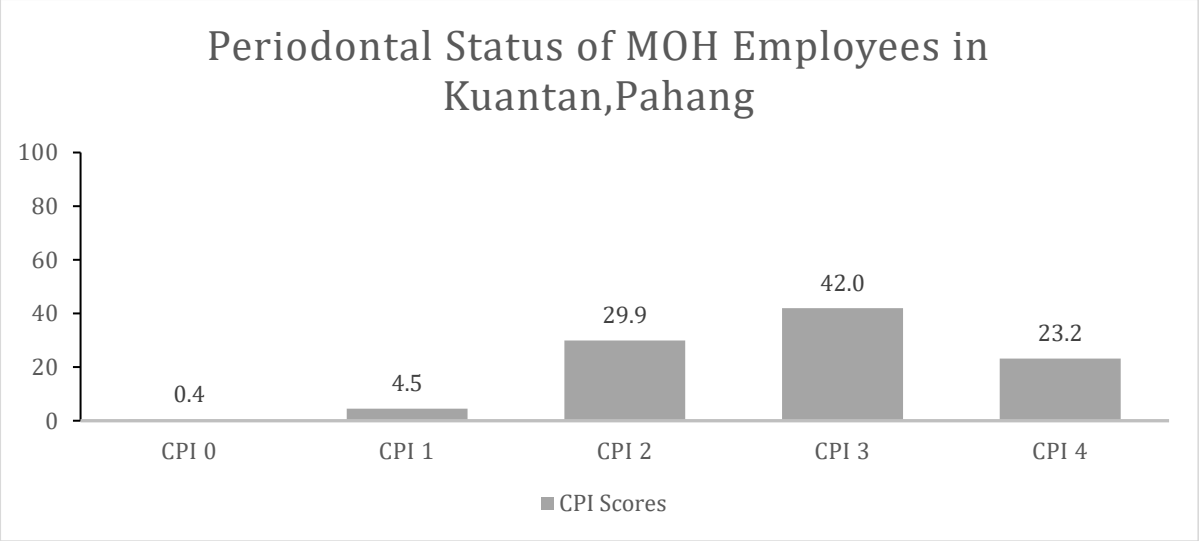

Figure 1. Periodontal status of MOH employees in Kuantan, Pahang (n=224).

Knowledge score

In simple linear regression, gender (female), dental personnel category, presence of deep periodontal pockets (CPI 3 and 4), education level, and job position were significantly associated with knowledge score (Table 2). Following backward elimination, the final multiple linear regression model was statistically significant ($p < 0.001$) and explained 14.9% of the variance in knowledge score (adjusted $R^2 = 0.149$). Non-dental personnel scored significantly lower than dental personnel (adjusted $\beta = -1.029$; 95% CI: −1.358, −0.701; $p < 0.001$), representing the strongest association. Being female was independently associated with a higher knowledge score (adjusted $\beta = 0.533$; 95% CI: 0.213, 0.853; $p = 0.001$). Absence of deep periodontal pockets (CPI 3 and 4) was associated with a higher score (adjusted $\beta = 0.428$; 95% CI: 0.114, 0.742; $p = 0.008$). Education level also showed a positive association with knowledge score (adjusted $\beta = 0.403$; 95% CI: 0.005, 0.801; $p = 0.049$). Full model results are presented in Table 2.

Barrier-to-dental-attendance score

Simple linear regression revealed no statistically significant associations between any of the examined sociodemographic or clinical variables and barrier scores. Nevertheless, multiple linear regression was performed to account for potential confounding, with variables selected based on clinical relevance. The final model, comprising education level, job position, presence of CPI 3 and 4, and presence of CPI 4, was not statistically significant ($p = 0.191$) and accounted for only 1.0% of the variance (adjusted $R^2 = 0.010$). No individual factor was statistically significant (Table 3).

Table 2. Factors associated with knowledge score using simple and multiple linear regression (n=224).

Factors	Simple linear regression		Multiple linear regression	
	β^a (95% CI)	*P*-value	β^b (95% CI)	*P*-value
Age	-0.02 (-0.04, 0.00)	0.092		
Gender				
Male	-	-	-	-
Female	0.63 (0.30, 0.97)	<0.001	0.533 (0.213, 0.853)	0.001
Race				
Malay	-	-		
Chinese	0.29 (-0.43, 1.01)	0.420		
Indian	0.09 (-0.84, 1.02)	0.850		
Others	0.04 (-0.96, 1.05)	0.930		
Presence of comorbidities				
Yes	-	-		
No	0.52 (0.00, 1.00)	0.052		
Education level				
Secondary school and lower	-	-	-	-
Diploma and degree	0.55 (0.13, 0.98)	0.011	0.403 (0.005, 0.801)	0.049
Working years				
Less than 1 year	-	-		
1–5 years	-0.33 (-1.10, 0.41)	0.378		
6–14 years	-0.21 (-0.93, 0.50)	0.554		
More than 15 years	-0.40 (-1.10, 0.34)	0.291		
Job Position				
Officers	-	-		
Supporting staff	-0.33 (-0.66, -0.01)	0.043		
Dental personnel status				
Dental	-	-	-	-
Non-dental	-1.10 (-1.65, -0.56)	<0.001	-1.029 (-1.358, -0.701)	<0.001
Presence of CPI 3 and 4				
Yes	-	-	-	-
No	0.49 (0.16, 0.82)	0.004	0.428 (0.114, 0.742)	0.008
Presence of CPI 4				
Yes	-	-		
No	0.31 (-0.07, 0.69)	0.108		

β^a = unstandardized coefficient from simple linear regression; β^b = unstandardized coefficient from multiple linear regression with robust standard errors (HC3); - = reference category; CI = confidence interval

Table 3. Factors associated with barrier score using simple and multiple linear regression (n=224).

Factors	Simple linear regression		Multiple linear regression	
	β[a] (95% CI)	*P*-value	β[b] (95% CI)	*P*-value
Age	0.01 (-0.06, 0.09)	0.734		
Gender				
Male	—	—		
Female	0.65 (-0.58, 1.90)	0.301		
Race				
Malay	—	—		
Chinese	-0.14 (-2.7, 2.40)	0.920		
Indian	-0.35 (-3.70, 3.00)	0.830		
Others	2.4 (-1.2, 5.9)	0.190		
Presence of comorbidities				
Yes	—	—		
No	-0.06 (-2.00, 1.80)	0.948		
Education level				
Secondary school and lower	—	—	—	—
Diploma and degree	0.85 (-0.68, 2.40)	0.272	1.37 (-0.25, 2.98)	0.098
Working years				
Less than 1 year	—	—		
1–5 years	-0.35 (-3.00, 2.30)	0.800		
6–14 years	0.22 (-2.3, 2.80)	0.870		
More than 15 years	0.23 (-2.40, 2.90)	0.860		
Job position				
Officers	—	—	—	—
Supporting staff	0.69 (-0.47, 1.90)	0.244	0.91 (-0.42, 2.24)	0.177
Dental personnel status				
Dental	—	—		
Non-dental	0.70 (-1.30, 2.70)	0.498		
Presence of CPI 3 and 4				
Yes	—	—	—	—
No	-0.77 (-2.00, 0.43)	0.207	-0.89 (-2.27, 0.49)	0.206
Presence of CPI 4				
Yes	—	—	—	—
No	0.29 (-1.10, 1.70)	0.677	0.92 (-0.58, 2.41)	0.228

[a] Unadjusted. [b] Adjusted for CPI 3&4, job position, education level, and CPI 4. — = reference category.

Source-of-dental-knowledge score

In simple linear regression, being female, job position (supporting staff), and working years (6–14 years) showed associations with this domain. Following backward elimination (race removed), the final multiple linear regression model was statistically significant ($p < 0.001$) and explained 6.5% of the variance (adjusted $R^2 = 0.065$). Female was the strongest predictor (adjusted β = 0.211; 95% CI: 0.074, 0.347; p = 0.005). Working experience of 6–14 years (adjusted β = −0.346; 95% CI: −0.649, −0.043; p = 0.026) and more than 15 years (adjusted β = −0.340; 95% CI: −0.666, −0.014; p = 0.042) were independently associated with lower scores compared to those with less than one year of experience. Supporting staff scored significantly higher than officers (adjusted β = 0.172; 95% CI: 0.019, 0.326; p = 0.029). Presence of comorbidities showed a borderline inverse association (adjusted β = 0.220; p = 0.054) (Table 4).

Table 4. Simple and multiple linear regression of factors associated with source-of-dental-knowledge score (n=224).

Factors	Simple linear regression		Multiple linear regression	
	β[a] (95% CI)	*P*-value	β[b] (95% CI)	*P*-value
Age	-0.006 (-0.015, 0.004)	0.247		
Gender				
Male	—	—	—	—
Female	0.235 (0.083, 0.387)	0.003	0.211 (0.074, 0.347)	0.005
Race				
Malay	—	—		
Chinese	-0.092 (-0.412, 0.229)	0.574		
Indian	0.156 (-0.258, 0.571)	0.458		
Others	0.394 (-0.052, 0.841)	0.083		
Presence of comorbidities				
Yes	—	—	—	—
No	0.226 (-0.011, 0.464)	0.061	0.220 (-0.003, 0.443)	0.054
Education level				
Secondary school and lower	—	—		
Diploma and degree	-0.029 (-0.222, 0.164)	0.765		
Working years				
Less than 1 year	—	—	—	—
1–5 years	-0.174 (-0.503, 0.156)	0.303	-0.214 (-0.525, 0.097)	0.178
6–14 years	-0.306 (-0.624, 0.012)	0.059	-0.346 (-0.649, -0.043)	0.026
More than 15 years	-0.211 (-0.540, 0.119)	0.210	-0.340 (-0.666, -0.014)	0.042
Job position				
Officers	—	—	—	—
Supporting staff	0.143 (-0.003, 0.289)	0.054	0.172 (0.019, 0.326)	0.029
Dental personnel status				
Dental	—	—		
Non-dental	0.027 (-0.226, 0.280)	0.835		
Presence of CPI 3 and 4				
Yes	—	—		
No	0.101 (-0.051, 0.252)	0.192		
Presence of CPI 4				
Yes	—	—		
No	-0.070 (-0.241, 0.101)	0.421		

[a] Unadjusted. [b] Adjusted; final model selected by backward elimination (removed: race). — = reference category

Discussion

This study reveals a critical knowledge–practice gap in oral health among MOH employees in Kuantan, Pahang. Despite reporting generally adequate knowledge levels and broad endorsement of various dental information sources, 99.6% of participants demonstrated clinical evidence of periodontal disease, including 42.0% with moderate (CPI 3) and 23.2% with severe forms (CPI 4). These findings are consistent with the high national prevalence of periodontal disease reported in NOHSA 2020 and support earlier work demonstrating that health literacy does not invariably translate into appropriate health behaviour (Nordin *et al*., 2021; Shah *et al*., 2020; Zadik *et al*., 2008). Healthcare workers may be particularly susceptible to this gap due to a tendency to prioritise acute medical

concerns over their own preventive dental care, compounded by professional overconfidence in self-monitoring oral health.

The multiple linear regression model for knowledge scores identified dental personnel status as the strongest associated factor, with non-dental staff scoring approximately 1.03 points lower than their dental colleagues. This is consistent with prior studies demonstrating that formal dental training substantially enhances oral health knowledge (Silk *et al*., 2009; Yao *et al*., 2019). Non-dental healthcare workers typically receive minimal oral health education during undergraduate training, and continuing professional development in this domain remains limited outside the dental profession (Barzoki *et al*., 2025; Sarioglu & Kirtiloglu, 2026). Being female was independently associated with a higher knowledge score, consistent with broader evidence that women demonstrate greater engagement with health information and preventive health behaviours (Baker *et al*., 2014; Rata Mohan *et al*., 2025). The independent association between absence of deep periodontal pockets (CPI 3 and 4) and higher knowledge scores suggests that greater knowledge may be protective against disease progression though the cross-sectional design limits the causal inference.

The multiple linear regression model for barrier-to-dental-attendance scores was non-significant and explained only 1.0% of the variance, indicating that the sociodemographic and clinical variables examined in this study do not adequately predict perceived barriers to dental care. This finding underscores the multidimensional nature of dental care barriers, which are likely driven by psychosocial constructs, including dental anxiety, self-efficacy, perceived susceptibility, and financial considerations that were not captured in the present study (van der Zande *et al*., 2021). The borderline trend for education level ($p = 0.098$) may hint that more educated workers are more aware of unmet dental needs, though this interpretation requires cautious handling given the non-significant overall model. Regardless of the severity of the periodontal disease, most participants reported being 'too busy' or facing 'long waiting times' as their main barriers. This suggests that the real issues are scheduling and long waits, which require clinic-level changes rather than just trying to change individual patient behaviour.

The source-of-dental-knowledge model was significant ($p < 0.001$), though it accounted for modest variance (adjusted $R^2 = 0.065$). Being female emerged as the strongest predictor, consistent with evidence that women engage with a broader range of health information channels (Dluhos-Sebesto *et al*., 2021). The significant drop in scores among workers with 6 or more years of experience suggests they may rely primarily on established routines rather than actively seeking out new dental knowledge. Supporting staff scored higher than officers, possibly reflecting greater engagement with informal and community-based knowledge sources. The Internet and clinical advice were rated as the most influential knowledge sources (mean scores 4.45 and 4.44, respectively), with 97% of respondents endorsing each. These findings highlight the importance of digital health communication strategies for oral health promotion in this population.

The findings from these three regression models suggest that targeted interventions should prioritise non-dental healthcare workers, who demonstrate both lower knowledge and equivalent disease burden. To improve oral health, the most efficient strategy is to add basic oral health training to professional development programs for non-dental personnel and deliver it through user-friendly online platforms. However, online education cannot overcome practical hurdles like busy work schedules and long wait times. These systemic issues require administrative solutions, such as adding quick oral health checks directly into employees' routine annual medical exams.

Several limitations should be considered. The cross-sectional design impedes causal inference; therefore, the associations

identified in the regression models may be influenced by unmeasured confounders. Additionally, Cronbach's alpha for the knowledge domain was 0.589, which is below the conventional threshold of 0.70; thus, these specific results must be interpreted with caution. Finally, this study was conducted within a single district in Pahang, limiting the generalizability of the findings to other regions or institutional contexts within Malaysia.

Conclusions

This study demonstrates a widespread prevalence of periodontal disease among MOH employees in Kuantan, coexisting with generally adequate knowledge levels, a finding indicative of a significant knowledge–practice gap. Our analysis found that an individual's specific dental background, gender, and the severity of their periodontal disease directly influence their knowledge scores. Furthermore, factors like job position and work experience shape where employees look for dental information, while daily logistical barriers to seeking care affect everyone uniformly. Ultimately, these insights underscore the need for tailored, accessible oral health initiatives that target vulnerable employee groups, utilize digital platforms, and systematically remove the workplace barriers preventing staff from scheduling visits. This research provides a valuable foundation for future, larger-scale studies among healthcare workers throughout Malaysia.

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Declaration of Generative AI and AI-Assisted Technologies Use

During the preparation of this work, the authors used Google Gemini (Gemini 3.5 Flash) to polish the rough draft for academic tone and clarity. Additionally, Claude 4.6 Sonnet (Anthropic) was utilized to help generate code for the R statistical software. However, data analysis, statistical interpretation, and research conclusions were performed by the first author. Lastly, after using these tools, the authors reviewed and edited the content as needed and took full responsibility for the content of the published article.

References

Baker, P., Dworkin, S.L., Tong, S., Banks, I., Shand, T., Yamey, G. (2014). The men's health gap: men must be included in the global health equity agenda. *Bulletin of World Health Organisation,* 92, 618–620. https://doi.org/10.2471/BLT.13.132795

Barzoki, E.R., Fallah, S., Marofi, S., Talebi, M. (2025). Evolving aspects of oral care in modern nursing: a systematic review. *BMC Oral Health*, 25, 1585. https://doi.org/10.1186/s12903-025-07000-3

British Society of Periodontology (2019). Basic Periodontal Examination (BPE). Retrieved 26 May 2026, from https://www.bsperio.org.uk/assets/downloads/BSP_BPE_Guidelines_2019.pdf

Cruz, G.G. dela, Rozier, R.G., Slade, G. (2004). Dental screening and referral of young children by pediatric primary care providers. *Pediatrics*, 114, e642–e652. https://doi.org/10.1542/peds.2004-1269

Dluhos-Sebesto, C., Jethwa, T.E., Bertasi, T.G.O., Bertasi, R.A.O., Nishi, L.Y.M., Pantin, S.A.L. *et al*. (2021). Women's health information survey: common health concerns and trusted sources of health information among different populations of female patients. *Women's Health Reports*, 2, 173–181. https://doi.org/10.1089/whr.2020.0118

Dupont, W.D., Plummer, W.D. (1990). Power and sample size calculations. *Controlled Clinical Trials*, 11, 116–128. https://doi.org/10.1016/0197-2456(90)90005-M

Heilbrunn-Lang, A.Y., de Silva, A.M., Lang, G., George, A., Ridge, A., Johnson, M. *et al*. (2015). Midwives' perspectives of their ability to promote the oral health of pregnant women in Victoria, Australia. *BMC Pregnancy Childbirth*, 15, 110. https://doi.org/10.1186/s12884-015-0536-x

JKNP (2021). *Bilangan kakitangan kementerian kesihatan daerah kuantan*.

Kananatu, K. (2002). Healthcare financing in Malaysia. *Asia Pacific Journal of Public Health*,14, 23–28. https://doi.org/10.1177/101053950201400106

Mohd-Dom, T.N., Abdul-Muttalib, K., Ayob, R., Yaw, S.L., Mohd-Asadi, A.S., Abdul-Manaf, M.R., Syed Mohamed Aljunid (2013). Periodontal status and provision of periodontal services in Malaysia: trends and way forward. *Malaysian Journal of Public Health Medicine*, 13, 38–47.

NHMS (2019). Fact Sheet: National Health and Morbidity Survey 2019. Retrieved 26 May 2026, from https://iku.nih.gov.my/images/IKU/Document/REPORT/NHMS2019/Report_NHMS2019-NCD_v2.pdf

NOHSA (2020). Penemuan Utama. 26 May 2026, from https://hq.moh.gov.my/ohp/images/pdf/4.-penyelidikan-kesihatan-pergigian/fact-sheet-nohsa-2020.pdf

Nordin, N.N., Vaithilingam, R.D., Saub, R., Nasir, N.H., Mohd Asari, A.S., Bashah, B. *et al*. (2021). Awareness, knowledge, attitudes and practices on the management of diabetes mellitus patients with periodontitis amongst Malaysian primary care practitioners. *Malaysian Family Physician*,16, 44–55. https://doi.org/10.51866/oa1131

R Core Team (2026). R: A Language and Environment for Statistical Computing.

Rata Mohan, D.S., Jawahir, S., Manual, A., Abdul Mutalib, N.E., Mohd Noh, S.N., Ab Rahim, I. *et al*. (2025). Gender differences in health-seeking behaviour: insights from the National Health and Morbidity Survey 2019. *BMC Health Services Research*, 25, 900. https://doi.org/10.1186/s12913-025-13020-0

Rodrigues, E., Oliveira, G.J.P.L. de, Alves, R. de O., Abreu, I.S. de, Herval, Á.M., Mattos, F. de F., Soares, P.B.F. (2024). Assessment of the nursing staff's knowledge on periodontal disease and its associations with systemic changes. *Revista de Odontologia da UNESP,* 53,1-10, https://doi.org/10.1590/1807-2577.000124

Sarioglu, A., Kirtiloglu, T. (2026). Curriculum gaps in periodontal knowledge among medical students: a cross-sectional study. *European Journal of Dental Education*. https://doi.org/10.1111/eje.70132

Shah, D.A.I., Roslan, N., Zamansari, K., Izzah, Tuan Mohd Rahimi, T.N.A., Ali, M.F., *et al.* (2020). Oral health knowledge among healthcare professionals and their challenges in dealing with patients' oral health problems. *Jurnal Sains Kesihatan Malaysia*,18, 39–47. https://doi.org/10.17576/jskm-2020-1802-05

Silk, H., O'Grady Stille, S., Baldor, R., Joseph, E. (2009). Implementation of STFM's "Smiles for Life" oral health curriculum in a medical school interclerkship. *Family Medicine*, 41, 487–91.

Umeizudike, K.A., Onajole, A.T., Ayanbadejo, P.O. (2015). Periodontal health knowledge of nonmedical professionals and their oral hygiene behavior in a teaching hospital in Nigeria. *European Journal of General Dentistry*, 4, 48–54. https://doi.org/10.4103/2278-9626.154161

Van der Zande, M.M., Exley, C., Wilson, S.A., Harris, R. V. (2021). Disentangling a web of causation: An ethnographic study of interlinked patient barriers to planned dental visiting, and strategies to overcome them. *Community Dentistry of Oral Epidemiology*,49, 144–157. https://doi.org/10.1111/cdoe.12586

Yahya, N.A., Abbas, N.S., Zakaria, N.A. (2010). Perceived knowledge and awareness of periodontal health amongst ante-natal mothers. *Jurnal Kesihatan Masyarakat*, 16 (2). 57-65. ISSN 1675-1663.

Yao, K., Yao, Y., Shen, X., Lu, C., Guo, Q. (2019). Assessment of the oral health behavior, knowledge and status among dental and medical undergraduate students: A cross-sectional study. *BMC Oral Health*,19. https://doi.org/10.1186/s12903-019-0716-6

Zadik, Y., Galor, S., Lachmi, R., Proter, N. (2008). Oral self-care habits of dental and healthcare providers. *International Journal of Dental Hygiene*, 6, 354–360. https://doi.org/10.1111/j.1601-5037.2008.00334.x

REVIEW ARTICLE Open Access

From conventional to advanced approaches in the endodontic-restorative interface: a narrative review

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Abstract

In the ever-evolving panorama of dental science, the interface between endodontics and restorative dentistry stands as a crucible where traditional doctrine battles cutting edge innovation. This article aims to analyse the strengths and weaknesses of conventional approaches in the endodontic-restorative interface, contemporary bonding materials and restorative plans, including the use of bioactive materials and minimally-invasive approaches. A literature search for English-language publications from January 2000 to July 2025 with a predetermined criteria was conducted via Google Scholar and PubMed using the search terms 'endodontics AND restorative', and Scopus using the search term 'restoration of endodontically treated teeth'. Additional relevant articles were identified through manual review of the reference list from selected publications. Advanced techniques for the restoration of endodontically treated teeth emphasises structural reinforcement, function, and aesthetics, with a focus on preserving as much of the natural tooth as possible. Emerging materials and techniques have demonstrated comparable, or in some respects, superior performance to conventional post-core retained crowns. However, application of these approaches require careful case selection, precise clinical technique, appropriate material choice, and awareness of their limitations in order to secure successful treatment outcomes.

Keywords: *endocrowns, endodontics, endodontic-restorative, root canal treatment*

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Introduction

The restoration of endodontically treated teeth (ETT) is widely investigated, yet highly controversial topic. Fundamentally, endodontic treatment is a biological intervention aimed at removing the infected pulp, disinfecting the root canal system, creating a hermetic seal, and restoring compromised teeth with durable materials. Over time, this treatment paradigm has its drawbacks, including excessive removal of the coronal tooth structure, potential marginal discrepancies, reduced aesthetic outcomes, and compromised long-term survival of the ETT. To ensure successful endodontic treatment, effective control of intraradicular infection, good coronal seal and provision of an optimal definitive

restoration are factors that need to be well executed (Mehta *et al.,* 2025). Various restorative techniques have been described to address the challenges related to coronal seal, each with their own strengths and limitations (Martin *et al.,* 2016).

Following the concepts of minimally invasive endodontic procedures, guided endodontics is emerging as a viable option for a more precise and safer access cavity preparation while preserving the remaining coronal tooth structure. Bio-minimalism as a trend emphasises preserving the remaining coronal tooth structure without compromising the fundamental endodontic objectives (Fernandes & Dessai, 2001). The concept of preserving pericervical dentine and of anatomy-guided access cavity preparation (e.g. truss access, orifice-directed access, minimal invasive/ultraconservative access) is emerging as critical to maintain tooth strength. Truss access cavity have two or more occlusal cavities directed towards root canals while ultraconservative access is a single occlusal cavity that is smaller than the traditional access (Dioguardi *et al.,* 2025). Despite approach in the anatomy-guided access cavity preparation, owing to more dentine to improve fracture resistance, studies have shown conflicting findings where it may (Patil *et al.,* 2022) or may not improve the fracture strength (Karobari *et al.,* 2021) compared to a ultraconservative access design. Meta-analyses data supported the ultraconservative access cavity design, which may improve fracture resistance due to a greater resilience to occlusal loads compared to traditional endodontic access design (Dioguardi *et al.,* 2025). Based on reported data, the minimal invasive approach can preserve as much remaining tooth structure as possible, thereby minimising the risk of further complications.

The use of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) systems and digital dentistry incorporated with artificial intelligence has facilitated digital scanning, milling, and 3-dimensional printing to allow for more precise restorations with regards to improved fitting, thickness of luting cement, and marginal integrity. These systems allow fabrication to follow standardised processes with improved quality materials, thus offering favourable options during the preoperative stage as well as during subsequent definitive restorations (Edelhoff *et al.,* 2019). Monolithic restorations such as milled endocrowns can reduce the number of laboratory steps and can be designed to preserve more tooth structure.

Advances in adhesives and restorative materials have also produced substantial improvements in resin-based composites through improved filler technology, nanomodified matrices, and improved handling, durability, and aesthetics. Adhesives containing ion-releasing or remineralising components that aim to bond different structures and to protect and rebuild it by inhibiting collagen degradation and promoting calcium/phosphate deposition at the resin-dentine interface are actively being studied (Toledano *et al.,* 2022).

This article aims to analyse the strengths and weaknesses of conventional approaches in the endodontic-restorative interface, contemporary bonding materials and restorative plans, including the use of bioactive materials, and minimally invasive approaches.

Materials and Methods

A literature search was conducted via Google Scholar and PubMed using the search terms ‘endodontics AND restorative’, and Scopus using the search term ‘restoration of endodontically treated teeth’. The search included English language publications from January 2000 to July 2025 with a predetermined criteria such as clinical studies, retrospectives, case reports/series, *in vitro* and reviews. Two independent assessors reviewed the scientific content of the identified articles. Additional relevant studies were selected through manual review of the reference lists of selected articles. Disagreements between assessors were resolved through a consensus discussion. This review includes 64 articles

related to endodontics and restorative interface, comprising various study designs.

Conventional approaches at the endodontic-restorative interface

Over the decades, conventional approaches have formed the standard of care for the restoration of ETT. These include access cavity designs, post-and-core techniques, ferrule design, full-coverage crowns for cuspal protection, and the use of rigid posts such as metal and/or cast systems. Conventional access cavity preparation or straight-line access requires maximal removal of coronal tissue to facilitate vision into the anatomical landmarks and root canal instrumentation disinfection, thus enabling precise obturation of the root canal system. The access preparation is often triangular in anterior teeth and trapezoidal or rhomboid in molars, involving full removal the roof of the pulp chamber to ensure direct access to all root canals, thus minimising potential procedural mishaps. This approach frequently results in a considerable amount of tooth structure being removed, including the pulp chamber roof, pericervical dentine, and/or marginal ridges, and is exacerbated when pathological conditions such as caries and/or visible crack lines are present. Additionally, further restoration such as crown preparation is necessary to restore structural integrity and improve retention and resistance.

When the remaining coronal tooth structure left is insufficient, an intraradicular post is traditionally placed into the ETT to provide retention for the core that supports a definitive extra coronal restoration (Sorrentino *et al.,* 2016). Traditionally, prefabricated intraradicular metal posts or custom casts are used. The core is then built up using a metal cast, amalgam, or other restorative materials, followed by full-coverage crowns. The use of metal or rigid posts with high elastic modulus under occlusal load allows for the transfer of stress to the root dentine. However, their lack of flexibility could lead to concentration of stress forces, and ultimately catastrophic root fractures (Akkayan & Gülmez, 2002). Historically, this approach was widely accepted due to the durability of metal posts. However, over the years, a direct coronal-radicular build-up without the need for an intraradicular post has been recommended for molars with a sufficient pulp chamber (McComb, 2008), particularly in cases characterised by compromised remaining coronal tooth structure (Jardim *et al.,* 2025).

Conventional restorative theory emphasises the geometric principles of tooth preparation, such as ensuring appropriate retention form to prevent restoration dislodgement, the resistance form to prevent cuspal fracture or tooth deformation under occlusal load, as well as the crown height, taper, and finish lines to facilitate crown insertion. The crowns serve to protect the remaining coronal tooth structure, distribute occlusal loads, protect cusps from fracture, thus retaining ETT function and delaying the tooth extraction process. A sufficient ferrule consisting of a minimal band of 1.5-2.0mm of sound tooth structure above the crown margin is considered critical at resisting lateral and lifting forces, ultimately preventing tooth fracture and increasing resistance to crown dislodgment (McComb, 2008; Alshabib *et al.,* 2023). In case of an insufficient ferrule, conventional management often involves a crown-lengthening surgery to expose the cavity margin thus exposing adequate intact tooth structure, or orthodontic extrusion to facilitate the creation of a proper ferrule prior to crown placement.

Contemporary concepts and materials

The intersection between endodontics and restorative dentistry is shifting rapidly due to evolving concepts in biology, biomechanics, and adhesive science. The goal of modern restoration philosophy is to maximise tooth preservation, optimise longevity, reduce potential failures, and improve both function and aesthetic outcomes through minimally invasive preparations that emphasise conservation of the pericervical dentine, marginal ridges, and enough coronal structure to avoid or limit the need for rigid intraradicular posts.

Similarly, access cavity preparation has evolved towards conservative and/or orifice-directed designs to maintain tooth strength while still allowing for efficient instrumentation, disinfection, and obturation (Hussien & Laithy, 2023; Dioguardi *et al.,* 2024). These can be achieved through the use of magnification device and illumination, thereby allowing the clinician to preserve sound tooth structure as much as possible, remove the necrotic pulp tissue, and provide straight line access to the canal orifices to ensure effective endodontic procedures (Elmatary *et al.,* 2025).

Furthermore, monoblock or integrated restorations that integrate the core and crown, and sometimes use the pulp chamber space for retention as in the case with endocrowns are becoming increasingly common, particularly in cases involving severely compromised tooth structure. These approaches aim to reduce the restorative interface, thus introducing fewer weak points, simplifying the restorative workflow, and reducing or eliminating intrusive intraradicular posts.

Besides advances in preparation technique/design, there is a growing shift towards using modern adhesive systems engineered with functional monomers that are capable of creating more durable chemical bonds with the dentine and/or enamel. Additionally, bioactive or ion-releasing materials e.g. zinc facilitate remineralisation, inhibit collagen breakdown, and improve the qualities of the hybrid layer through their action as matrix-metalloproteinases inhibitors and signalling pathway regulators. Together, the materials stimulate dentine mineralisation and remineralisation processes, thereby increasing the longevity of dentine bonding (Toledano *et al.,* 2022).

Successful cementation protocols are critical to ensure effective adhesion, prevent biofilm formation at the tooth-restoration margin, avoid microleakage into the root canal system, thus minimising the risk of mechanical and/or biological complications (He *et al.,* 2021; Heboyan *et al.,* 2023; Patel *et al.,* 2025). The 3-step adhesive system remains the gold standard for cementing indirect restorations. However, universal adhesives, selective etching, and self-etch adhesive cementation protocols are simplifications that have been introduced for higher bond strength and reduced moisture sensitivity. However, these approaches have been limited by reports of technical errors; for example, despite the shortened chair side time with the use of self-etched adhesive systems, these systems behave as permeable membranes that are highly susceptible to degradation at the interface level (Abad-Coronel *et al.,* 2019).

Advanced concepts and materials at the endodontic-restorative interface are increasingly focused on more conservative, biomimetic, and adhesive-based strategies (Alshabib *et al.,* 2023) to ensure the preservation of tooth structure. Improved bonding performance, the use of restorative materials that match or mimic tooth biomechanics, and appropriate design of extra-coronal restorations that can reduce interfaces and potential failure modes are being explored in current research.

Clinical considerations

Preoperative assessment

When establishing treatment planning, various factors need to be considered by the clinician to ensure favourable treatment outcomes. During the preoperative stage, the remaining coronal tooth structure must be assessed, taking into consideration the thickness of the walls, depth and shape of pulp chamber, and presence of ferrule before deciding on endocrowns or post-core retained crowns as the most appropriate restorative option.

When a significant amount of coronal tooth structure is intact and no evidence of an underlying carious lesion is present, existing restoration is retained to allow to facilitate endodontic treatment. However, presence of extra-coronal restoration hinders effective preoperative assessment of the remaining

coronal tooth structure. Depending on clinical cases, the extra-coronal restoration might require removal to facilitate thorough preoperative assessment. A tooth lacking sound dentine to establish a sufficient ferrule carries an unfavourable prognosis, further complicating the decision-making process.

In clinical cases with extensive carious lesions, caries removal prior to assessment of the remaining coronal structure is required. When the cavity margin is located at the subgingival level, deep margin elevation or crown lengthening surgery may be performed to facilitate pre-endodontic restoration. In cases where teeth in the aesthetic zone are compromised or tooth discolouration is apparent, comprehensive planning is necessary to improve aesthetics not only during the intracanal stage, but also at the post-operative stage. In cases with a long-span dental bridge, assessment of the remaining coronal tooth structure is not possible without dismantling the bridge. The decision to remove or retain the existing restoration should be assessed carefully in all clinical cases, taking into consideration various factors. Therefore, thorough preoperative planning with informed patient consent is critical to ensure predictable restoration outcomes.

Intra-endodontic stage

For the pre-endodontic interim restoration, the selection of an appropriate adhesive system is critical, and should include modern adhesives with improved reliable chemical bonding to the dentine and/or enamel. Interim restoration can facilitate tooth isolation, provide an effective coronal seal, support tooth function and improve aesthetics, particularly when involving teeth in the aesthetic zone. When conventional temporisation methods are not suitable, a durable temporary restoration and removable partial denture can be used as a provisional solution. Subsequent definitive restoration can be carried out at a later stage after completion of the endodontic treatment.

Post-endodontic stage

The aesthetics, opposing dentition, risk of tooth wear, and tooth shade must be considered during treatment planning. When a significant amount of coronal tooth structure is present, composite resin can be suitable for definitive restoration.

Deciding on the need for an intraradicular post depends on the clinical cases such as size and position of the tooth in the arch, amount of remaining coronal tooth structure, functional requirements of the tooth, and root canal configuration (McComb, 2008). In clinical cases where intraradicular post placement is indicated, favourable stress distribution must be planned. The use of a fabricated metal cast post and core that conforms to the root canal anatomy ensures effective fit and adaptation, and using fibre posts instead of rigid posts can reduce the risk of significant complications to the tooth, such as catastrophic tooth fracture. While fibre posts are biomechanically more compatible with dentine than metal posts, their clinical relevance at enhancing long-term outcomes is highly debated (Carvalho *et al.,* 2018; Mannocci *et al.,* 2022) because ETT with fibre posts have comparable survival rates to those restored with metal posts (Bhuva *et al.,* 2021). It is essential to utilise the intraradicular post system that corresponds to the root canal morphology without disrupting the existing obturation (Patel *et al.,* 2025) and that the use of threaded posts should be avoided owing to the stress accumulation within the root canal (Patel *et al.,* 2025).

When using endocrowns, clinicians must consider the occlusal thickness and reduction design to optimise load planes. Adequate pulp chamber depth must be prepared to provide retention for the endocrowns without undermining the remaining walls. Apart from that, minimally invasive approaches also include alternatives such as onlays, overlays, endolays, and vonlays. Onlays cover the occlusal surfaces, overlays are onlays where coverage is extended to the cusps, endolays

or endo-overlays are modified endocrowns without an axial circumferential shoulder margin, and vonlays or veneerlays are a combination of onlays and veneers where the restoration coverage is extended to include the buccal surface for improved aesthetics (Figure 1). The principle of minimally invasive procedures refers to preservation of sound tooth structure by avoiding a full-coverage dental crowns, which requires more extensive removal of the tooth structure. When a full coverage crown is needed, the preparation margin should be kept at a supragingival or minimally subgingival level whenever possible to minimise the risk of periodontal complications. To prevent catastrophic tooth fracture, the clinician should select flexible materials and designs, preserve the dentine, and avoid overpreparation. Patient-centred concerns, such as aesthetics, financial implications, chairside time, number of dental visits, and outcome expectations should guide clinicians in the decision-making process.

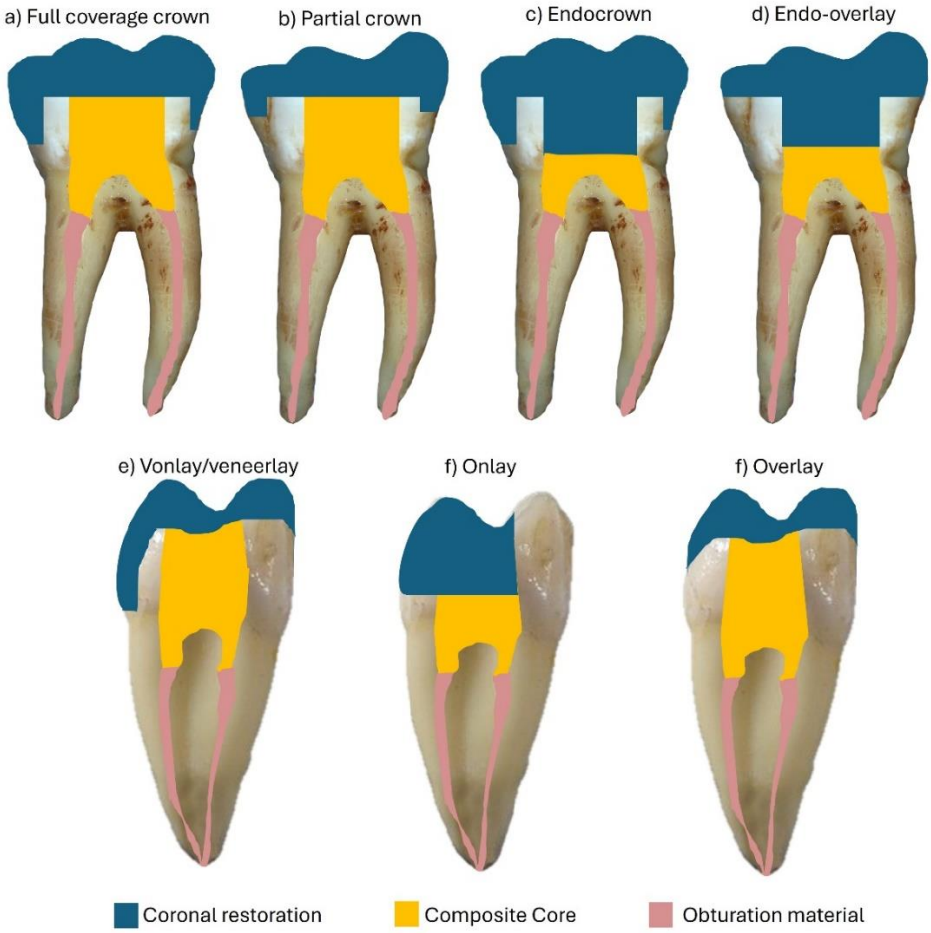

Figure 1. Schematic diagram showing the differences between indirect restoration of ETT, (a-d) mandibular molar cross-sectional buccal view and (e-f) mandibular premolar cross-sectional proximal view.

In a meta-analysis study, single crowns on ETT achieved a 92% success rate, whereas fixed dental prostheses demonstrated a 79% success rate over a six-year observation period, highlighting single crowns as a favourable method for successful treatment outcomes in ETT restoration (Ploumaki *et al.,* 2013). Available data on the restoration of pulpotomised teeth via placement of full-coverage crowns is limited, however, studies indicate higher success rates compared to conventional direct restorations (Philip &

Suneja, 2022). Endocrowns have also showed favourable clinical outcomes, with reported survival rates of approximately 82% to 98%, supporting their use as a conservative and predictable alternative to intraradicular post-and-core retained crowns in molars with significant loss of coronal tooth structure (Kontakou Zoniou *et al.,* 2025).

Advanced techniques and digital integration

Digital integration and workflow

The integration of intraoral scanners and CAD/CAM technology has simplified restoration of ETT through enabling precise digital impression (Figure 2), rapid design, and efficient fabrication of restorations such as endocrowns and custom post-and-core systems, often within a single clinical session. Digital workflows reduce chair side time, improve patient comfort, and enhance the accuracy and fit of restorations, resulting in more predictable and durable clinical outcomes (Davidovich *et al.,* 2020; Al-Qarni, 2022; Neves *et al.,* 2022).

Computer-Aided Design and Computer-Aided Manufacturing systems use intraoral scanners to capture highly accurate digital impressions, improving the fit and marginal adaptation of restorations compared to conventional methods. Direct digitalisation with intraoral scanners offers better adaptation for custom post-and-core fabrication compared to conventional indirect techniques, although scanning deep root canals can remain challenging (Dimitrova *et al.,* 2024). Overall, digital workflows reduce errors associated with conventional impressions and enhance the precision of restorations (Al-Qarni, 2022; Dimitrova *et al.,* 2024; Hiraba *et al.,* 2024).

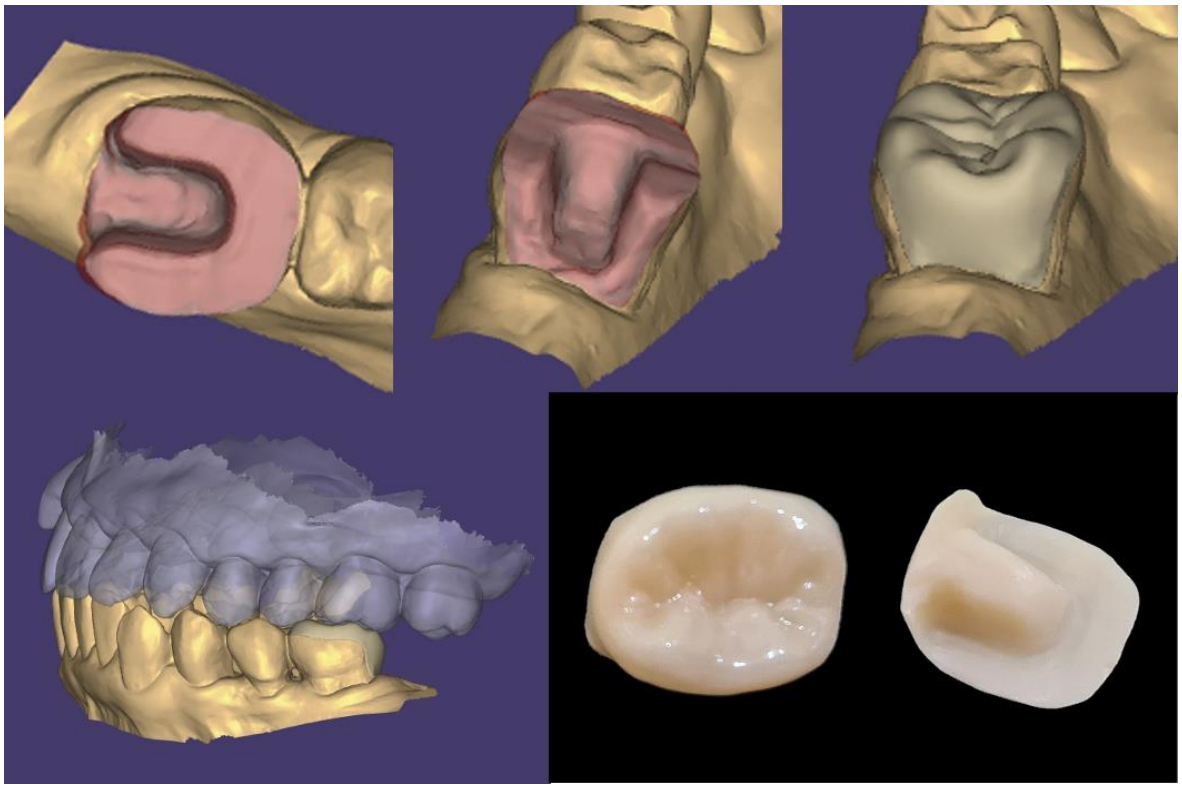

Figure 2. Digital design and construction of zirconia endo-overlay for tooth 36

Additionally, the digital workflow enables chairside or laboratory-based design and milling of restorations in a single session, which significantly reduces treatment time. Endocrowns and custom post-and-core systems can be designed and fabricated immediately and rapidly, allowing for efficient, minimally invasive, and conservative treatment that preserves tooth structure (Al-Qarni, 2022; Hiraba *et al.,* 2024). The high efficiency and accuracy of CAD/CAM systems also facilitate the production of restorations with clinically acceptable fit and marginal gaps (Wakwak *et al.,* 2023; Hiraba *et al.,* 2024). Endocrown restorations leverage the pulp chamber for retention, eliminating the need for conventional posts. Computer-Aided Design and Computer-Aided Manufacturing fabricated endocrowns, especially those constructed from high-strength ceramics or hybrid materials such as lithium disilicate or resin nanoceramics demonstrate high fracture resistance, improved survival rates, and excellent adaptation, and are suitable for restoring posterior teeth with extensive coronal loss (AlHelal, 2023; Hiraba *et al.,* 2024; Jalali *et al.,* 2024; Keskin *et al.,* 2024). Endocrowns offer a conservative, aesthetic, and durable restoration solution, while digital workflows enable efficient and precise fabrication (Davidovich *et al.,* 2020; Janiga, 2021, Neves *et al.,* 2022; Popa *et al.,* 2024; Wejden *et al.,* 2024).

In *in vitro* studies on compromised endodontically treated premolars (Guo *et al.,* 2016) and molars (Rayyan *et al.,* 2019), teeth restored with endocrowns had higher fracture strength than those treated with post-core retained crowns, suggesting their effectiveness at restoring the structural integrity of posterior teeth without the need for intraradicular posts. Additionally, a meta-analysis of clinical studies showed an estimated overall five-year survival rate of 91.4% for endocrowns and 98.3% for conventional crowns, while the estimated overall five-year success rates were 77.7% for endocrowns and 94% for conventional crowns (Al-Dabbagh, 2021). Although no significant differences were observed in the survival and/or success rates between these restorations, endocrowns were the preferred conservative option in selected clinical cases, particularly in endodontically treated posterior teeth (Guo *et al.,* 2016; Rayyan *et al.,* 2019). Furthermore, in finite element analysis stress distribution tests, endocrowns reduced stress concentration at the inner wall of the root canal compared to post-core retained crowns, suggesting that endocrowns better protected root integrity and were less prone to root fracture compared to intraradicular posts (Lin *et al.,* 2020).

Recent modifications to the design of endocrowns have focused especially on the marginal forms. The designs described in literature are: (1) a 90-degree butt joint involving cervical area, (2) 90-degree butt joint limited to 2mm coronal area, (3) axial reduction with shoulder margin at the cervical area, (4) a 20-degree bevelling margin limited to 2mm of the coronal area. The 90-degree butt-joint and 20-degree bevelling margin limited to 2mm coronal area designs are conservative options for endocrowns, and are also known as endolays or endo-overlays.

Custom post-and-core

Digital techniques have enabled the design and milling of custom posts and cores that are tailored to the patient's anatomy, thereby improving fit and reducing the risk of root perforation. Commonly used materials used include zirconia, composite resin, hybrid ceramics and fibre-reinforced posts (Al-Qarni, 2022). Custom CAD/CAM posts show superior adaptation, retention, and bond strength compared to prefabricated systems, with zirconia posts exhibiting the highest fracture resistance (Al-Qarni, 2022; Gutiérrez *et al.,* 2022; Dimitrova *et al.,* 2024; Hamitoglu & Ozkurt-Kayahan, 2025).

Adhesive and biomimetic approaches

Adhesive and biomimetic approaches have transformed the restoration of ETT, emphasizing the preservation of the natural

tooth structure, mimicking biomechanical properties and enhancing long-term outcomes. Adhesive dentistry enables minimally invasive restorations by bonding restorative materials directly to tooth tissues, reducing the need for extensive preparation and mechanical retention. This approach preserves the enamel, dentine, and dentino-enamel junction, which are critical for tooth strength and longevity (Carvalho *et al.,* 2018; Barreto *et al.,* 2024; Caussin *et al.,* 2024). Adhesive techniques range from direct composite restorations for teeth with minimal tissue loss to indirect adhesive restorations such as onlays, overlays, and endocrowns (Figure 2) that provide strong, predictable outcomes for teeth with moderate to extensive structure loss (Bhalla *et al.,* 2020; Dioguardi *et al.,* 2022). Meanwhile, fibre-reinforced composites and glass-fibre posts offer improved biomechanical compatibility and reduced catastrophic failure risk compared to conventional metal posts (Carvalho *et al.,* 2018; Barreto *et al.,* 2024).

Biomimetic dentistry aims to restore the tooth's structure, function, and biomechanics by replicating their natural structure and function. Its principles include maximal preservation of sound tooth structure, including avoiding unnecessary removal for posts or full crowns (Carvalho *et al.,* 2018; Kimble *et al.,* 2023; Barreto *et al.,* 2024), material selection that mimics natural tissues, such as ceramics or hybrid materials for enamel replacement and fibre-reinforced composites for dentine replacement that closely match the tooth's mechanical properties (Barreto *et al.,* 2024), partial adhesive restorations that distribute occlusal forces more naturally and reduce the risk of root fracture (Barreto *et al.,* 2024; Popa *et al.,* 2024), and avoiding the use of posts when possible.

The endo-overlay is an advanced adhesive and biomimetic approach that prioritizes structural integrity and functional compatibility for restoring ETT. Similar to conventional endocrowns, it utilizes the pulp chamber for macromechanical retention, but limits the margin to the coronal 2mm, a feature more consistent with overlay and onlay designs (Table 1, Figure 3 b,c,g,h). The design reduces unnecessary removal of sound tooth structure and optimizes adhesion to the remaining dentine and enamel. A recent *in vitro* study found that endocrown preparations with axial reduction concentrates majority of the stress at the cervical margin when compared to endo-overlay designs, where the likelihood of restoration debonding is high (Zheng *et al.,* 2022). In another *in vitro* research, zirconia endo-overlays showed comparable fracture resistance to more extensive axial preparations, supporting their application as a minimally invasive restoration technique for ETT (Jurado *et al.,* 2025).

In parallel with these findings, a four-year retrospective clinical study similarly reported no significant difference in survival rates or clinical performance between endocrown and overlay restorations for posterior ETT (Ayata *et al.,* 2025). Furthermore, another investigation indicated superior fracture resistance of onlays over zirconia endocrowns, further reinforcing the principle that adhesive integrity and preservation of remaining tooth structure are pivotal to biomechanical outcomes, surpassing the influence of cavity coverage extent. Preservation of pericervical dentine in conjunction with adhesive bonding strategies is thus vital for sustaining the structural integrity of restored teeth, thereby reinforcing fracture resistance, however, these goals are often challenging to achieve in clinical cases with extensive tooth structure loss (Carvalho *et al.,* 2018; Caussin *et al.,* 2024; Mishra *et al.,* 2025). The shift from post-core crowns to endocrowns and more recently, to endo-overlays, exemplifies an ongoing move toward adhesive, conservative, and biologically harmonious restorative approaches.

With advances in restorative design, margin management techniques have also evolved to support minimally invasive and biologically compatible outcomes. The deep marginal elevation (DME) approach, where subgingival margins are relocated coronally using composite resin, has demonstrated promising outcome for subgingival defect restoration in suitable cases. This approach

aids procedures such as digital impression and rubber dam isolation when dealing with adhesively bonded ceramic restorations (Hausdörfer *et al.,* 2024). Compared to surgical crown lengthening, DME is more conservative, with similar bleeding on probing at 12 months but less periodontal probing depth and attachment loss (Farouk *et al.,* 2023). Clinical and histological studies show that DME preserves supracrestal tissue integrity and minimizes inflammation and gingival recession when performed within biologically acceptable limits and under proper isolation (Taylor & Burns, 2024). Conversely, conventional full-coverage crowns, which often require greater axial reduction and deeper margin placement, risk violating the biological width and may predispose the surrounding tissues to inflammation or attachment loss. Restorations using DME have shown improved plaque control, reduced probing depth, and enhanced gingival stability relative to conventional crowns, underscoring its utility as a biologically compatible restorative technique (Bertoldi *et al.,* 2020; Ahmed & Moukarab, 2025). When combined with adhesive partial-coverage restorations, such as overlays or endo-overlays, DME can further enhance marginal adaptation, restorative access, and periodontal harmony, further reinforcing the biologically-centred philosophy of adhesive and biomimetic restorative dentistry.

Biomechanical and clinical considerations

Restoring ETT requires a comprehensive understanding of both biomechanical principles and clinical factors to ensure long-term function, strength, and survival of the tooth. The primary challenge during restoration is the loss of coronal tooth structure due to caries, trauma, and endodontic access preparation, which significantly reduces tooth strength and increases the risk of fracture, particularly in the cervical region (Caussin *et al.,* 2024).

A crucial biomechanical factor is the ferrule effect, where preserving a 1.5 to 2 mm band of sound tooth structure above the finish line markedly increases fracture resistance. This structural reinforcement helps distribute occlusal load and prevents catastrophic failures (Soares *et al.,* 2018; Mishra *et al.,* 2025; Mously *et al.,* 2025).

Table 1. Differences between overlay, endodontic-overlay and traditional endocrown.

Type	Coverage	Pulp chamber incorporation	Margin design
Onlay	Covers affected cusps only	May or may not involve pulp chamber	No circumferential margin
Overlay	Covers all cusps; occlusal coverage only	No	No circumferential margin
Endodontic-overlay	Covers all cusps	Yes	No circumferential margin
Endocrown	Full crown replacement	Yes	Circumferential margin

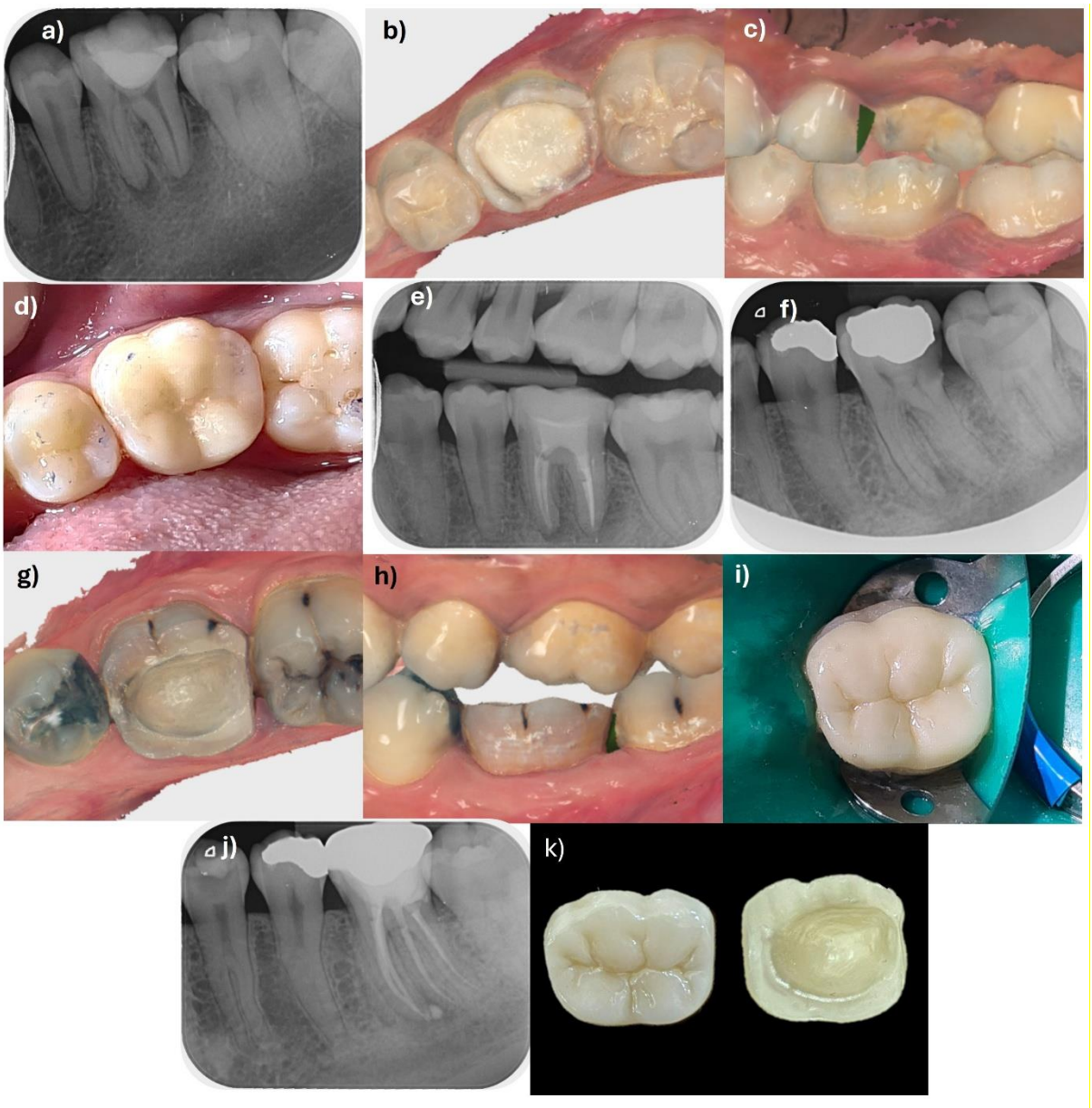

Figure 3. Clinical cases showing distinctions between onlay restoration and endo-overlay with DME on ETT. Case 1: (a) pre-operative radiograph of tooth 36. (b) intra-oral scanned image of tooth 36 after completion of endodontic treatment prepared for onlay (occlusal view); (c) buccal view showing no cuspal reduction, consistent with onlay design; (d) cementation of lithium disilicate onlay; and (e) post-cementation radiograph. Case 2: (f) pre-operative radiograph of tooth 36 showing deep caries margin on distal (g) intra-oral scanned image of tooth 36 after completion of endodontic treatment prepared for endo-overlay (occlusal view) with DME on distal; (h) buccal view of tooth 36 showing occlusal reduction for full cuspal coverage; (i) cementation of zirconia endo-overlay under rubber dam, (j) post-cementation radiograph showed good adaptation of overlay with the DME, and (k) endo-overlay design with 90-degree butt-joint margin limited to coronal 2mm

Table 2. Summary of the biomechanical and clinical factors ETT restoration.

Factors	Mechanism	Clinical Impact	Reference
Ferrule effect	1.5 to 2 mm band of sound tooth structure above the finish line	Increases fracture resistance	Soares *et al.,* 2018; Mishra *et al.,* 2025; Mously *et al.,* 2025
Restorative material selection	Material selection has closer mechanical properties to replaced tooth structure	Effective stress distribution, reduced risk of catastrophic fracture	Soares *et al.,* 2018; Mously *et al.,* 2025
Adhesive technique	Improved bonding between restoration and both coronal and radicular tooth structure	Enhances retention, preserves tooth structure	Caussin *et al.,* 2024
Restoration design	Quantity and quality of remaining tooth structure	Influences invasiveness of the restorative technique and reparability	Lenz *et al.,* 2024; Mously *et al.,* 2025; Naik *et al.,* 2025
Timing of restoration	Early placement of definitive restorations reduces the risk of microleakage and fracture	Early restoration improves survival	Caussin *et al.,* 2024

The choice of restorative material is equally important during treatment planning. Materials with mechanical properties closer to those of dentine, such as fibre-reinforced posts, provide a more favourable stress distribution compared to rigid metal posts, thereby reducing the risk of root fractures (Soares *et al.,* 2018; Mously *et al.,* 2025). Concurrently, advancements in adhesive dentistry have enhanced the survival of ETT by improving bonding at both the coronal and radicular levels. However, reliable adhesion in root canals remains challenging due to canal morphology and dentine microstructure (Caussin *et al.,* 2024).

Optimal restoration depends on the quantity and quality of the remaining tooth structure. Teeth with sufficient coronal dentine may be restored using direct or indirect adhesive techniques, while severely compromised teeth often require post placement for core retention (Mishra *et al.,* 2025). Minimally invasive approaches, such as endocrowns, are particularly advantageous in molars and premolars, as they preserve more tooth structure and demonstrate superior biomechanical performance compared to conventional post-and-core crowns (Lenz *et al.,* 2024; Mously *et al.,* 2025; Naik *et al.,* 2025).

Additionally, the timing of restoration is another determinant of success. Early placement of definitive restorations following endodontic therapy reduces the risk of microleakage and fracture, thereby enhancing long-term survival (Caussin *et al.,* 2024).

Patterns of failure vary with the design of restoration. Adhesive restorations and endocrowns usually fail in a more repairable manner, whereas conventional rigid post-and-core systems are prone to catastrophic root fractures (Lenz *et al.,* 2024; Mously *et al.,* 2025; Naik *et al.,* 2025). Finally, patient-specific factors such as occlusal loading, parafunctional habits, aesthetic concerns, and oral hygiene must always be considered during treatment planning (Mishra *et al.,* 2025).

Current challenges and future directions

Current challenges in restoring ETT

ETT restoration often requires complex clinical decision-making. One of the most significant challenges during restoration is preserving and maintaining the structural integrity of teeth. Due to caries, trauma, and endodontic access preparation, ETT are inherently weaker and more prone to fracture.

Despite having a position statement on the restoration of ETT (Mannocci *et al.,* 2021) and clinical recommendation (Bhuva *et al.,* 2021), treatment planning is often individualised based on remaining coronal tooth structure, aesthetic demands, and functional requirements, further complicating decision-making (Carvalho *et al.,* 2018; Caussin *et al.,* 2024).

The limitations associated with biomechanical and adhesive approaches continue to hinder predictable treatment outcomes. Achieving durable adhesive bonding in root canals remains challenging due to the complex canal anatomy and structure of the dentine. Concurrently, functional stresses predispose ETT to catastrophic failures, such as root fractures (Carvalho *et al.,* 2018; Caussin *et al.,* 2024). Furthermore, occlusal and functional considerations are often overlooked in research, despite their significant impact on long- term restoration survival (Mannocci *et al.,* 2022; Caussin *et al.,* 2024).

Finally, robust long-term clinical evidence on the newer adhesive systems, biomimetic, and minimally invasive restorative approaches for ETT is still lacking. Much of the current knowledge is derived from *in vitro* studies or short-term clinical trials, leaving much uncertainty about the long-term performance and effectiveness of these approaches (Carvalho *et al.,* 2018; Mannocci *et al.,* 2022).

Future direction in ETT restoration

In the future, the restoration of ETT will shift in the direction of biomimetic and conservative strategies that prioritize maximal preservation of natural tooth structure. This includes the use of partial coverage restorations, advanced adhesive techniques and minimally invasive preparation designs (Carvalho *et al.,* 2018; Caussin *et al.,* 2024; Mishra *et al.,* 2025).

There is also positive potential in the development of innovative restorative materials. High-strength ceramics, fibre-reinforced posts, and advanced adhesive systems are being engineered to achieve greater biomechanical compatibility with dentine, thereby enhancing the durability of restoration outcomes and reducing the risk of catastrophic failures (Caussin *et al.,* 2024; Mishra *et al.,* 2025).

The integration of digital workflows is another promising advancement: CAD/CAM technology and intraoral scanning enables more precise, efficient, and customised restorations. This approach supports the fabrication of endocrowns and individualised post-and-core systems, improving both restoration accuracy and clinical outcomes (Mannocci *et al.,* 2022; Mishra *et al.,* 2025).

Furthermore, personalised decision-making tools, such as the Restorative Difficulty Evaluation System (RDES) are being developed to guide clinicians in deciding optimal treatment strategies tailored to individual cases. These systems incorporate the structural, functional, and aesthetic demands of the patient during treatment planning (Mishra *et al.,* 2025). The RDES facilitates the clinicians to evaluate the restorative difficulties by addressing the criteria/parameters and scores ranged from score 1 with favourable tooth condition to 6 with severely compromised tooth (Ferrari *et al.,* 2022). Through this approach, clinicians can determine whether the tooth has a low, moderate or high RDES, thereby can re-evaluate the treated tooth at the end of therapies and/or at each follow-up visit to

improve knowledge about the prognosis of ETT after being restored (Ferrari *et al.,* 2022).

In brief, the restoration of ETT continues to face significant biomechanical and clinical challenges, particularly with regards to structural preservation, material selection, adhesive reliability, and the limited availability of long-term evidence. Nevertheless, future directions driven by biomimetic philosophies, innovation in restorative materials, digital workflow integration, and evidence-based frameworks offer promising avenues for more predictable and durable outcomes.

Conclusions

Conventional treatment modalities for endodontic and restorative procedures involves several steps, including endodontic treatment, temporisation, intraradicular post placement, core build-up, crown preparation, impression-taking, laboratory fabrication, and crown cementation. The overall process entails prolonged treatment time, large financial implications, and frequent patient visits to the clinic. Conventional approaches of the endodontic-restorative interface are guided by the removal of infected tissue, straight access, retention via intraradicular posts and cores, and full coverage crowns. However, these methods are associated with weakening of the tooth structure, potential tooth fracture, and unfavourable outcomes when too much tissue is removed or when post-placement is aggressive. Modern strategies increasingly balance conventional principles with the preservation of tooth structure, improved adhesive techniques, and minimally invasive design that emphasises structural reinforcement, function, and aesthetics while preserving as much natural tooth as possible. Recent advances focus on the use of adhesive dentistry, high-strength materials, and minimally invasive approaches, with treatment decision-making tailored to the individual case to optimise long-term outcomes and enhance tooth preservation.

Conflict of Interest

No conflict of interest reported.

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References

Abad-Coronel, C., Naranjo, B., Valdiviezo, P. (2019). Adhesive systems used in indirect restorations cementation: review of the literature. *Dentistry Journal*, *7*(3), 71.

Ahmed, O.S., Moukarab, D. (2025) Impact of marginal elevation in restored endodontically treated teeth with CAD/CAM ceramic endocrowns on the marginal adaptation (*in vitro*). *Journal of Contemporary Dental Practice,* 26(5):473-480.

Akkayan, B., Gülmez, T. (2002). Resistance to fracture of endodontically treated teeth restored with different post systems. *The Journal of Prosthetic Dentistry*, *87*(4), 431-437.

Al-Dabbagh, R.A. (2021). Survival and success of endocrowns: a systematic review and meta-analysis. *The Journal of Prosthetic Dentistry*, *125*(3), 415-e1.

AlHelal, A.A. (2023). Biomechanical behavior of all-ceramic endocrowns fabricated using CAD/CAM: a systematic review. *Journal of Prosthodontic Research*, *68*(1), 50-62.

Al-Qarni, F. (2022). Customized post and cores fabricated with CAD/CAM technology: a literature review. *International Journal of General Medicine*, 15, 4771 - 4779.

Alshabib, A., Abid Althaqafi, K., AlMoharib, H.S., Mirah, M., AlFawaz, Y.F., Algamaiah, H. (2023). Dental fiber-post systems: an in-depth review of their evolution, current practice and future directions. *Bioengineering*, *10*(5), 551.

Ayata, M., Oktay, E. K., Albayrak, H., Çakar, M., Özcan, M. (2025). Evaluation of the clinical performance of endocrown and overlay restorations: a 4-year retrospective study. *Journal of Dentistry*, *160*, 105874.

Barreto, D., Lerma, L., Palencia, P., Fierro, N. (2024). Adhesive approach for endodontically treated teeth, literature review. *International Journal of Applied Dental Sciences.* 10(2), 329-332.

Bertoldi, C., Monari, E., Cortellini, P., Generali, L., Lucchi, A., Spinato, S. *et al.* (2020). Clinical and histological reaction of periodontal tissues to subgingival resin composite restorations. *Clinical Oral Investigations*, *24*(2), 1001-1011.

Bhalla, V., Chockattu, S., Srivastava, S., Prasad, S. (2020). Decision making and restorative planning for adhesively restoring endodontically treated teeth: An update. *Saudi Endodontic Journal*, 10, 181-186.

Bhuva, B., Giovarruscio, M., Rahim, N., Bitter, K., Mannocci, F. (2021). The restoration of root filled teeth: a review of the clinical literature. *International Endodontic Journal*, *54*(4), 509-535.

Carvalho, M.A.D., Lazari, P.C., Gresnigt, M., Del Bel Cury, A.A., Magne, P. (2018). Current options concerning the endodontically-treated teeth restoration with the adhesive approach. *Brazilian Oral Research*, *32*, e74.

Caussin, E., Izart, M., Ceinos, R., Attal, J.P., Beres, F., François, P. (2024). Advanced material strategy for restoring damaged endodontically treated teeth: a comprehensive review. *Materials*, *17*(15), 3736.

Davidovich, E., Dagon, S., Tamari, I., Etinger, M., Mijiritsky, E. (2020). An innovative treatment approach using digital workflow and CAD-CAM part 2: The restoration of molar incisor hypomineralization in children. *International Journal of Environmental Research and Public Health*, *17*(5), 1499.

Dimitrova, M., Vlahova, A., Kazakova, R. (2024). Assessment of CAD/CAM fabrication technologies for post and core restorations - a narrative review. *Medicina*, *60*(5), 748.

Dioguardi, M., Alovisi, M., Comba, A., Baldi, A., Troiano, G., Cadenaro, M. *et al.* (2022). The influence of indirect bonded restorations on clinical prognosis of endodontically treated teeth: a systematic review and meta-analysis. *Dental Materials*, *38*(8), e203-e219.

Dioguardi, M., Esperouz, F., Bizzoca, M.E., Illuzzi, G., Sanesi, L., Sovereto, D. *et al.* (2025). Analysis of the impact of the minimally invasive access preparation on the fracture resistance in endodontics, Systematic Review of Vitro Study. *Current Oral Health Reports*, *12*(1), 29.

Dioguardi, M., La Notte, D., Sovereto, D., Quarta, C., Martella, A., Ballini, A. (2024). Influence of cavity designs on fracture resistance: Analysis of the role of different access techniques to the endodontic cavity in the onset of fractures: narrative review. *The Scientific World Journal*, *2024*(1), 1648011.

Edelhoff, D., Stimmelmayr, M., Schweiger, J., Ahlers, M.O., Güth, J.F. (2019). Advances in materials and concepts in fixed prosthodontics: a selection of possible treatment modalities. *British Dental Journal*, *226*(10), 739-748.

Elmatary, A., Moawad, E., Heidarifar, O., Stone, S. (2025). Endodontic access cavity preparation: challenges and recent advancements. *British Dental Journal*, *238*(7), 469-475.

Farouk, A.T., Hassanein, O.E.S., Fahmy, O.I., Elkady, A.M., ElNahass, H. (2023). Biological evaluation of indirect restorations in endodontically treated posterior teeth with deeply located proximal margins following deep margin elevation versus surgical crown lengthening: a randomized controlled trial. *Clinical Oral Investigations*, *28*(1), 24.

Fernandes, A.S., Dessai, G.S. (2001). Factors affecting the fracture resistance of post-core reconstructed teeth: a review. *International Journal of Prosthodontics*, *14*(4).

Ferrari, M., Pontoriero, D.I., Ferrari Cagidiaco, E., Carboncini, F. (2022). Restorative difficulty evaluation system of endodontically treated teeth. *Journal of Esthetic and Restorative Dentistry*, *34*(1), 65-80.

Guo, J., Wang, Z., Li, X., Sun, C., Gao, E., Li, H. (2016). A comparison of the fracture resistances of endodontically treated mandibular premolars restored with endocrowns and glass fiber post-core retained conventional crowns. *The Journal of Advanced Prosthodontics*, *8*(6), 489.

Gutiérrez, M.A., Guerrero, C.A., Baldion, P.A. (2022). Efficacy of CAD/CAM glass fiber posts for the restoration of endodontically treated teeth. *International Journal of Biomaterials*, *2022*(1), 8621835.

Hamitoglu, B., Ozkurt-Kayahan, Z. (2025). Fracture resistance of endodontically treated teeth restored with CAD-CAM milled and prefabricated post-and-core systems. *Journal of Prosthodontics*. 1-7.

Hausdörfer, T., Lechte, C., Kanzow, P., Rödig, T., Wiegand, A. (2024). Periodontal health in teeth treated with deep-margin-elevation and CAD/CAM partial lithium disilicate restorations-a prospective controlled trial. *Clinical Oral Investigations*, *28*(12), 670.

He, J., Zheng, Z., Wu, M., Zheng, C., Zeng, Y., Yan, W. (2021). Influence of restorative material and cement on the stress distribution of endocrowns: 3D finite element analysis. *BMC Oral Health*, *21*(1), 495.

Heboyan, A., Vardanyan, A., Karobari, M.I., Marya, A., Avagyan, T., Tebyaniyan, H. *et al.* (2023). Dental luting cements: an updated comprehensive review. *Molecules*, *28*(4), 1619.

Hiraba, H., Nishio, K., Takeuchi, Y., Ito, T., Yamamori, T., Kamimoto, A. (2024). Application of one-piece endodontic crowns fabricated with CAD-CAM system to molars. *Japanese Dental Science Review*, 60, 81-94.

Hussien, S.A., Laithy, A.A., 2023. The effect of restoration of endodontically treated teeth with different restorations in both modern and traditional access cavity preparations. *Egyptian Dental Journal*, *69*(4), 3141-3148.

Jalali, S., Asgari, N., Pirooz, P., Younespour, S., Atri, F. (2024). Comparison of clinical efficacy of CAD CAM endocrowns made of feldspathic ceramic, zirconia lithium silicate, and lithium disilicate: a two-year mixed cohort study. *Journal of Dentistry*, *149*, 105019.

Janiga, A.M. (2021). The endocrown: a unique method for restoring endodontically treated teeth. *General Dentistry*, *69*(5), 52-55.

Jardim, J.S., Ferreira, V.D.M.F., e Oliveira, H.F.F., Faé, D.S., Lemos, C.A.A. (2025). Is the use of an intraradicular post essential for reducing failures in restoring endodontically treated teeth? a systematic review and meta-analysis. *Journal of Dentistry*, 105739.

Jurado, C.A., Afrashtehfar, K.I., Robles, M., Alaqeely, R.S., Alsayed, H.D., Lindquist, T.J. *et al.* (2025).

Effect of preparation design and endodontic access on fracture resistance of zirconia overlays in mandibular molars: an *in vitro* study. *Journal of Prosthodontics,* 34(4):412-421.

Karobari, M.I., Aziz, A.F.A., Makandar, S.D., Ghani, N.R.N.A., Halim, M.S., Noorani, T.Y. (2021). Fracture resistance of teeth with truss endodontic access: an *in vitro* study and literature review. *European Journal of General Dentistry*, *10*(01), 44-49.

Keskin, S.C., Sakar, A., Bolay, S. (2024). A 3-year clinical evaluation of endocrown restorations with two different materials using the computer-aided design/computer-aided manufacture system. *Journal of Dentistry*, *151*, 105405.

Kimble, P., Stuhr, S., McDonald, N., Venugopalan, A., Campos, M.S., Cavalcanti, B. (2023). Decision making in the restoration of endodontically treated teeth: effect of biomimetic dentistry training. *Dentistry Journal*, *11*(7), 159.

Kontakou Zoniou, A., Tzimas, K., Pappa, E., Rahiotis, C. (2025). Clinical performance of endocrowns in molars: a scoping review. *Medicina*, *61*(9), 1562.

Lenz, U., Bacchi, A., Della Bona, A. (2024). Biomechanical performance of endocrown and core-crown restorations: a systematic review. *Journal of Esthetic and Restorative Dentistry*, *36*(2), 303-323.

Lin, J., Lin, Z., Zheng, Z. (2020). Effect of different restorative crown design and materials on stress distribution in endodontically treated molars: a finite element analysis study. *BMC Oral Health*, *20*(1), 226.

Mannocci, F., Bhuva, B., Roig, M., Zarow, M., Bitter, K. (2021). European Society of Endodontology position statement: the restoration of root filled teeth. *International Endodontic Journal*, *54*(11), 1974-1981.

Mannocci, F., Bitter, K., Sauro, S., Ferrari, P., Austin, R., Bhuva, B. (2022). Present status and future directions: the restoration of root filled teeth. *International Endodontic Journal*, *55*, 1059-1084.

Martin, W., Taylor, C., Jawad, S., Roudsari, R.V., Darcey, J., Qualtrough, A. (2016). Modern endodontic principles part 7: the restorative interface. *Dental Update*, *43*(4), 319-334.

McComb, D. 2008. Restoration of the endodontically treated tooth. *Ensuring Continued Trust*. 1-2

Mehta, D., Coleman, A., Lessani, M. (2025). Success and failure of endodontic treatment: predictability, complications, challenges and maintenance: Success and failure of endodontic treatment: predictability, complications, challenges and maintenance. *British Dental Journal*, *238*(7), 527-535.

Mishra, L., Francis, T., Nooji, D., Aggarwal, H., McColl, E., Eachempati, P. (2025). Current concepts in restoring endodontically treated teeth. *Dental Update*, *52*(1), 26-34.

Mously, H.A., Naguib, G.H., Abougazia, A.O., Almabadi, A.A., Qutub, O.A., Hamed, M.T. (2025). Anterior endocrowns as an alternative to core crown restorations: a systematic review. *International Dental Journal*, *75*(1), 59-74.

Naik, R., Mynam, N.,R,S., Mounika, P., Teja, U., Srinivas, V. (2025). Comparative evaluation of the fracture resistance and marginal adaptation of endodontically treated teeth restored with different prosthodontic techniques: a clinical and *in vitro* study. *International Journal of Environmental Sciences*, 65-69.

Neves, E., Almeida, G., Júnior, J. (2022). Endocrown in digital: literature review. *International Journal of Advanced Engineering Research and Science.* 9(12), 655-660.

Patel, S.R., Youngson, C., Jarad, F. (2025). Principles guiding the restoration of the root-filled tooth: principles guiding the restoration of the root-filled tooth. *British Dental Journal*, *238*(7), 508-516.

Patil, P., Newase, P., Pawar, S., Gosai, H., Shah, D., Parhad, S.M. (2022). Comparison of fracture resistance of endodontically treated teeth with traditional endodontic access cavity, conservative endodontic access cavity, truss endodontic access cavity, and ninja endodontic access cavity designs: An *in vitro* study. *Cureus*, *14*(8).

Philip, N., Suneja, B. (2022). Minimally invasive endodontics: a new era for pulpotomy in mature permanent teeth. *British Dental Journal*, *233*(12), 1035-1041.

Ploumaki, A., Bilkhair, A., Tuna, T., Stampf, S., Strub, J.R. (2013). Success rates of prosthetic restorations on endodontically treated teeth; a systematic review after 6 years. *Journal of Oral Rehabilitation*, *40*(8), 618-630.

Popa, G.D., Gheorghiu, I.M., Nistor, C.C., Scarlatescu, S.A., Marinescu, I.R., Petcu, C. et al. (2024). Endocrown - a change of paradigm for restoring the endodontically treated teeth. *Romanian Journal of Stomatology/Revista Romana de Stomatologie*, *70*(3), 325-329.

Rayyan, M.R., Alauti, R.Y., Abanmy, M.A., AlReshaid, R.M., Ahmad, H.A. (2019). Endocrowns versus post-core retained crowns for restoration of compromised mandibular molars: an *in vitro* study. *International Journal of Computerized Dentistry*, *22*(1).

Soares, C.J., Rodrigues, M.D.P., Faria-e-Silva, A.L., Santos-Filho, P.C.F., Veríssimo, C., Kim, H.C. *et al.* (2018). How biomechanics can affect the endodontic treated teeth and their restorative procedures?. *Brazilian Oral Research*, *32*(suppl 1), e76.

Sorrentino, R., Di Mauro, M.I., Ferrari, M., Leone, R., Zarone, F. (2016). Complications of endodontically treated teeth restored with fiber posts and single crowns or fixed dental prostheses - a systematic review. *Clinical Oral Investigations*, *20*(7), 1449-1457.

Taylor A., Burns L. (2024) Deep margin elevation in restorative dentistry: a scoping review. *Journal of Dentistry,* 146:105066.

Toledano, M., Toledano-Osorio, M., Hannig, M., Carrasco-Carmona, Á., Osorio, M.T., García-Godoy, F. *et al.* (2022). Zn-containing adhesives facilitate collagen protection and remineralization at the resin-dentin interface: a narrative review. *Polymers*, *14*(3), 642.

Wakwak, M., Adly, K., Abdelhady, A., Elmanakhly, A. (2023). Microleakage assessment of CAD/CAM endo crown restorations (an *in vitro* study). *Current Research in Dentistry*, 14, 1-7.

Wejden, B.A., Yosra, G., Elhouda, L.N., Zohra, N., Dalenda, H., Jilani, S. *et al.* (2024). Digital workflow optimization for endocrown restorations on root-treated teeth. *Scholars Journal of Dental Sciences*, *9*, 119-125.

Zheng, Z., Sun, J., Jiang, L., Wu, Y., He, J., Ruan, W. *et al.* (2022). Influence of margin design and restorative material on the stress distribution of endocrowns: a 3D finite element analysis. *BMC Oral Health*, *22*(1), 30.

REVIEW ARTICLE Open Access

Hamartomas, choristomas and teratomas of the oral cavity: a contemporary narrative review

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Abstract

Hamartomas, choristomas and teratomas represent an important group of developmental lesions that may occur within the oral and maxillofacial region. Although each entity is benign in nature, their clinical and histopathological resemblance to odontogenic tumours, soft-tissue neoplasms and other intraoral proliferations frequently results in diagnostic uncertainty. The overlap in clinical appearance among these developmental lesions demands a clear understanding of their biological basis and diagnostic criteria. This review provides an updated narrative synthesis of the current perspectives on hamartomas, choristomas and teratomas of the oral cavity, including their etiopathogenesis, clinical presentations, diagnostic considerations and management.

Keywords: *choristoma, hamartoma, oral cavity, review, teratoma*

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Introduction

Hamartomas, choristomas and teratomas are distinct developmental lesions that occasionally present within the oral and maxillofacial complex. Their unusual tissue composition and developmental origin, combined with their potential to mimic benign neoplasms, have contributed to long-standing debates regarding their classification (de Souto Medeiros *et al.*, 2024). The term "hamartoma" derived from the Greek *hamartía* meaning "error" was introduced by Albrecht in 1904 and refers to a mass composed of disorganised but mature tissues native to its anatomical location (de Souto Medeiros *et al.*, 2024; Patil *et al.*, 2015). In contrast, the term "choristoma", originating from the Greek *chōristos* meaning "separated", designates the presence of histologically normal tissue in an anatomically inappropriate site (de Souto Medeiros *et al.*, 2024). These definitions,

though established for more than a century, continue to evolve as new insights regarding the developmental and molecular basis of these entities emerge.

Teratomas represent another category of developmental lesion relevant to the oral cavity, although significantly rarer. These lesions are composed of tissues arising from two or more germ cell layers and may present within the head and neck region as congenital masses (de Souto Medeiros *et al.*, 2024). Oral teratomas, including epignathus, can be life-threatening at birth due to airway obstruction (Kolekar *et al.*, 2016; WHO, 2022). Their inclusion in discussions of developmental pathology is essential, as their biological origin and clinical implications differ from both hamartomas and choristomas (Kolekar *et al.*, 2016).

This narrative review synthesises the current understanding of hamartomas, choristomas and teratomas affecting the oral cavity, incorporating developmental mechanisms, clinicopathological characteristics, diagnostic criteria and contemporary considerations in classification. The review aims to clarify distinctions between these lesions and benign tumours, thereby supporting accurate diagnosis and management.

Definitions and biological distinctions

Hamartomas are benign malformations composed of an abnormal arrangement of mature tissue elements normally present in the region of occurrence (Neville *et al.*, 2023). Despite their tumour-like appearance, their growth parallels that of the surrounding tissues, and they lack the capacity for metastasis or invasive behaviour. Their architecture may be disordered or excessive, but the cellular components remain cytologically benign (Leiter Herrán *et al.*, 2017). They often present in childhood but may first be detected in adulthood, particularly when asymptomatic.

Choristomas exhibit similar clinical behaviour with hamartomas, but differ fundamentally in tissue origin (Neville *et al.*, 2023). They consist of normal, mature tissue located at an anatomically inappropriate site (Fu *et al.*, 2024). The tissue retains its expected morphology and function but is found in a location not typically associated with that tissue type, such as bone on the dorsal tongue or salivary gland tissue within the mandibular bone (Fu *et al.*, 2024).

Teratomas are true developmental growths composed of tissues from more than one germ layer, ectoderm, mesoderm and endoderm (Neville *et al.*, 2023). Although most commonly reported in the sacrococcygeal region, teratomas may occur within the head and neck, including the oral cavity (WHO, 2022). They may be classified as mature or immature based on the degree of cellular differentiation. Oral teratomas, particularly epignathus, may include complex tissues such as cartilage, hair follicles, respiratory epithelium or gastrointestinal structures (Huang & Pan, 2017). Although oral cavity teratomas are rare and generally benign in newborns, they carry a risk of malignant transformation, particularly when incompletely resected or diagnosed in older children (Ueno *et al.*, 2009).

Clear diagnostic differentiation is essential for clinical management. The narrative review proposes refined criteria for the classification of hamartomas and choristomas, stressing developmental origin, mass formation, benign growth patterns, and tissue nativity or ectopic distribution. These criteria help ensure appropriate use of terminology and avoid misinterpretation of developmental defects, reactive lesions or true neoplasms.

Etiopathogenesis

Hamartomas arise from aberrations in embryonic development involving disordered proliferation, differentiation or organisation of tissues that are native to the site. Genetic contributions have been well documented, particularly in syndromic presentations. Mutations involving PTEN, SMAD4, STK1 and BMPR1A contribute to

syndromes such as PTEN hamartoma tumour syndrome, including Cowden syndrome, which frequently presents with multiple mucocutaneous hamartomas and increased neoplastic risk (Pilarski, 2019; WHO, 2022). Gardner syndrome is an autosomal dominant condition resulting from APC gene mutations and is associated with multiple odontomas, osteomas, epidermoid cysts, and supernumerary teeth affecting the head and neck region (Black *et al.*, 2024).

Choristomas result from embryological misplacement of normal tissue into abnormal locations, leading to ectopic tissues such as thyroid, salivary, or respiratory epithelium within the oral region (Walling, 1987). Oral heterotopic gastrointestinal cysts represent a rare form of choristoma, most commonly affecting the tongue and floor of the mouth, and may remain asymptomatic or present with site-dependent clinical manifestations (Maldonado *et al.*, 2025). Their pathogenesis, while developmental, follows a distinct trajectory from hamartomas, as the tissues involved are normal but misplaced.

Teratomas originate from pluripotent germ cells capable of differentiating into multiple tissue types (McDonald *et al.*, 2020). When such cells become sequestered in the craniofacial region during embryogenesis, they may form complex masses containing tissues from multiple germ layers. The presence of tissues foreign to the oral cavity, such as skin appendages, neural tissue or gastrointestinal epithelium, is characteristic (McDonald *et al.*, 2020; WHO, 2022). Although rare, craniofacial teratomas demonstrate the potential for significant morbidity due to airway obstruction, feeding difficulties and craniofacial distortion.

Clinical presentations

Hamartomas of the oral cavity

Hamartomas in the oral cavity encompass a range of odontogenic and non-odontogenic developmental proliferations (Patil *et al.*, 2015; Woo, 2017). Among odontogenic lesions, odontomas remain the most widely recognised example. Although classified as benign mixed odontogenic tumours, these lesions are generally considered hamartomatous, as they consist of fully differentiated dental tissues arranged either in an organized pattern, as seen in compound odontomas, or as an amorphous mass in the complex variant (Neville *et al.*, 2023). Their limited growth potential, spontaneous maturation and virtual absence of recurrence after conservative removal support their interpretation as the terminal stage of odontogenic tissue development (Patil *et al.*, 2015). Several authors have proposed a developmental continuum in which ameloblastic fibroma progresses to ameloblastic fibro-odontoma and ultimately to odontoma. Age (13.5 years) and lesion size (2.1 cm) have been suggested as cut-off points to distinguish a developing odontoma from a true neoplasm; however, the universality of this maturation sequence remains debated (Soluk-Tekkesin & Vered, 2021).

In addition to odontoma, a number of odontogenic lesions exhibit biological behaviour more compatible with hamartomas than true neoplasms (Soluk-Tekkesin & Wright, 2022). Adenomatoid odontogenic tumour is officially classified by the World Health Organization (WHO) as a benign odontogenic tumour; however, its clinical and histopathological characteristics, including its slow growth, encapsulation, negligible recurrence rate and consistently low proliferative indices on immunohistochemistry, have led many investigators to propose that it is essentially hamartomatous in nature (Soluk-Tekkesin & Wright, 2022; WHO, 2022; Woo, 2017). Its behaviour sharply contrasts with that of invasive odontogenic neoplasms and aligns more closely with self-limiting developmental proliferations.

Peripheral odontogenic lesions further illustrate this hamartomatous spectrum. These extraosseous odontogenic proliferations arise from remnants of the dental lamina or from the basal layers of the oral epithelium, and include peripheral odontogenic fibroma, the soft-tissue variants

of calcifying epithelial odontogenic tumour, and the peripheral form of adenomatoid odontogenic tumour (Ide *et al.*, 2005). Although these lesions can clinically mimic neoplasms, they are typically indolent, grow slowly, and rarely recur after simple excision. Their origin from residual odontogenic epithelium and non-invasive behaviour have led many to consider peripheral odontogenic tumours as hamartomas rather than true neoplasms, though the classification of certain lesions remains controversial due to their biological behaviours and limited growth potential.

Non-odontogenic hamartomas, including lymphangiomas, vascular or neurovascular hamartoma, exostoses and leiomyomatous hamartoma are also encountered in the oral cavity (Neville *et al.*, 2023). Lymphangiomas are benign, hamartomatous tumor-like growths of lymphatic vessels. Like other vascular malformations, it is doubtful that they are true neoplasms; instead, they most likely represent developmental anomalies that arise from sequestrations of lymphatic tissue that do not communicate normally with the rest of the lymphatic system, with the dorsal surface of the tongue being the most commonly affected site (Neville *et al.*, 2023). A vascular or neurovascular hamartoma of the oral cavity is a rare, benign developmental lesion characterized by a disorganized proliferation of mature nerve bundles and blood vessels. Clinically, it typically presents as a painless, smooth, pinkish-red nodule and is most commonly located on the dorsal surface of the tongue (Gabriel Levi *et al.*, 2025).

Exostoses are common, self-limited bony outgrowths of the oral cavity with an unclear etiology, though their development may sometimes follow an autosomal dominant pattern (Neville *et al.*, 2023). They are more frequently observed in females between 30 and 50 years of age, possibly reflecting a combination of genetic factors and the slow, gradual growth of the lesion from puberty into adulthood (de Souto Medeiros *et al.*, 2024).

Leiomyomatous hamartoma is a rare, benign developmental lesion characterized by a disorganized overgrowth of mature smooth muscle bundles intermixed with other indigenous tissues (Neville *et al.*, 2023). It most commonly occurs on the midline dorsal tongue and presents as a slow-growing, painless, sessile or pedunculated mass, often detected at birth or during early childhood, although adult cases have also been reported. Histopathologically, it is composed of mature smooth muscle arranged in a haphazard pattern without cytologic atypia, supporting its hamartomatous rather than neoplastic nature (Nava-Villalba *et al.*, 2008).

Choristomas of the oral cavity

Choristomas of the oral cavity represent foci of histologically normal tissue occurring at sites where they are not ordinarily found. These lesions are developmental in origin and reflect heterotopic tissue deposition rather than neoplastic transformation (Neville *et al.*, 2023). Although uncommon, choristomas encompass a diverse range of tissues, illustrating the complexity of craniofacial embryogenesis.

Osseous choristomas are among the best-documented oral choristomas and most frequently arise on the posterior dorsum of the tongue and these lesions present as firm, sessile or pedunculated nodules and contain mature lamellar bone within the soft tissue (Goswamy *et al.*, 2012). Cartilaginous choristomas, although less frequent, similarly occur on the tongue or buccal mucosa and consist of normal hyaline cartilage situated in a non-cartilaginous site (Sakrikar *et al.*, 2022). Both lesions are thought to result from displaced embryonic rests or metaplastic transformation induced by local developmental influences (Gorini *et al.*, 2014).

Salivary gland choristomas constitute another important category and involve ectopic salivary tissue located outside the usual anatomical distribution of the major or minor salivary glands (Torres Medina *et al.*, 2021). The Stafne bone cavity is a developmental lingual concavity of the mandible, most commonly located in the posterior region below the mandibular

canal. It is typically asymptomatic and discovered incidentally on radiographs. Histologically, the cavity may contain normal salivary gland tissue, fat, or connective tissue, leading some authors to describe it as a salivary gland choristoma within bone. As a choristoma, it represents normal tissue in an ectopic location, rather than a true neoplasm. Its non-expansile, benign nature means that intervention is rarely required (Lee *et al.*, 2016).

A range of rarer choristomas has been reported. Lingual thyroid choristoma arises from aberrant thyroid tissue retained along the thyroglossal tract, most commonly at the foramen caecum (Constantin *et al.*, 2023). Sebaceous gland choristomas present as ectopic sebaceous lobules in sites devoid of Fordyce granules, such as the buccal mucosa (Marques *et al.*, 2022). Respiratory epithelial choristomas and gastric mucosal choristomas, although extremely rare, highlight the possibility of misplaced endodermal derivatives within the oral cavity (Ombres *et al.*, 2022). Glial choristomas, consisting of heterotopic neuroglial tissue, are distinctly uncommon but well documented and likely result from embryonic sequestration of neuroectoderm (Glavis-Bloom *et al.*, 2019).

Collectively, the diversity of oral choristomas underscores their developmental nature. Their composition reflects tissues that are entirely normal in structure but rendered abnormal by their ectopic location. Although the classification of oral choristomas as developmental heterotopias is generally well established, the etiopathogenesis of certain subtypes, particularly osseous choristomas, remains incompletely understood. Proposed mechanisms include embryonic rests, branchial arch remnants, metaplastic changes induced by chronic trauma or inflammation, and ossification of ectopic mesenchymal tissue; however, no single theory fully explains all reported cases (Gorini *et al.*, 2014). Recognition of these entities as heterotopias is essential, as their clinical presentation can mimic benign tumours, cysts, or reactive proliferations. Surgical excision is generally curative, and recurrence is exceedingly rare.

Teratomas of the oral cavity

Teratomas of the oral cavity and head and neck are rare germ cell tumours composed of mature or immature tissues derived from all three embryonic germ layers (Neville *et al.*, 2023). Their most dramatic intraoral manifestation is epignathus, a congenital teratoma arising from the oropharynx, palate or adjacent craniofacial structures. These lesions often contain diverse tissue elements such as bone, cartilage, glandular epithelium, skin adnexa and neural tissue. Newborns may present with respiratory obstruction, feeding difficulties and significant craniofacial distortion, making prompt multidisciplinary intervention essential (de Souto Medeiros *et al.*, 2024).

Head and neck teratomas exist along a spectrum ranging from mature to immature and malignant germ cell tumours. Mature teratomas are composed predominantly of well-differentiated tissues and generally behave in a benign manner, whereas immature teratomas contain embryonic neuroectodermal elements associated with more aggressive clinical behaviour (Chakravarti *et al.*, 2011). Malignant transformation, although uncommon, has been documented, and malignant germ cell tumours such as yolk sac tumour or embryonal carcinoma may rarely arise in this region (Zhang *et al.*, 2013).

Histopathologically, the diagnosis is established by identifying derivatives of the three germ layers, with immature neuroectoderm representing the hallmark of immature teratoma (WHO, 2022). Although teratomas of the oral cavity are primarily congenital, malignant germ cell tumours may also occur in older children and adults, albeit infrequently (Lohana *et al.*, 2020). Prognosis depends on tumour maturity, anatomical extent and the need for airway management at birth. Mature teratomas have an excellent prognosis following complete excision, whereas malignant germ cell tumours require multimodal oncological management and carry a significantly poorer outcome.

Figure 1 shows schematic classification of hamartomas, choristomas, and teratomas of the oral cavity with representative examples according to their biological origin and tissue composition.

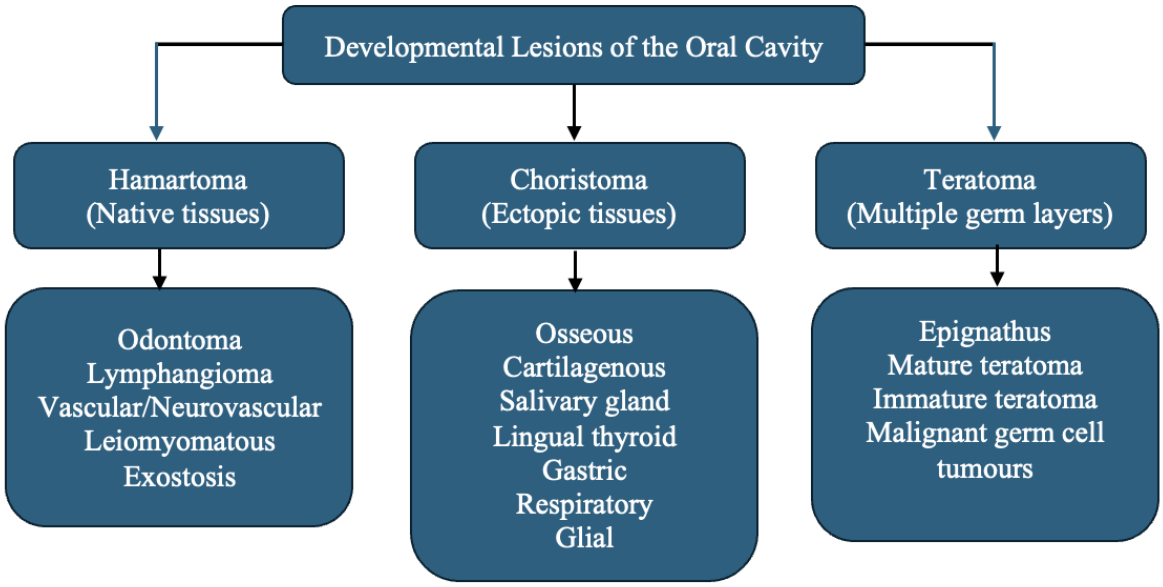

Figure 1. Schematic classification of hamartomas, choristomas, and teratomas of the oral cavity. Representative examples of each developmental lesion are shown according to their biological origin and tissue composition.

Diagnostic considerations and management

The diagnosis of hamartomas, choristomas and teratomas of the oral cavity requires careful integration of clinical, radiographic and histopathological findings, as these lesions may mimic a variety of benign neoplasms (de Souto Medeiros *et al.*, 2024). The anatomical location and tissue composition are the most reliable distinguishing features. Hamartomas are identified by the presence of mature tissues native to the site arranged in a disorganised or excessive fashion, whereas choristomas consist of normal tissue types occurring at anatomically inappropriate locations (de Jesus *et al.*, 2025). Teratomas differ from both by exhibiting elements derived from multiple germ layers and by displaying structural complexity not seen in other developmental lesions. Radiographic evaluation is particularly useful in characterising intraosseous hamartomas such as odontomas or osseous choristomas, which demonstrate well-circumscribed radiopaque components within the jawbones (de Jesus *et al.*, 2025). Teratomas, in contrast, frequently present as heterogeneous masses containing mixed cystic, solid and calcified elements, a pattern that may raise suspicion even before definitive histological assessment.

Management strategies reflect the biological behaviour of these developmental lesions. Hamartomas are generally treated with simple surgical excision or enucleation, and recurrence is exceedingly rare (de Souto Medeiros *et al.*, 2024). Choristomas also respond well to conservative surgical removal, and long-term outcomes are excellent (de Souto Medeiros *et al.*, 2024). Teratomas, however, may require more urgent and extensive intervention because of their size, anatomical relationships, and potential to compromise the airway, particularly in neonates with oropharyngeal involvement. Complete surgical excision is curative for mature teratomas, whereas immature or malignant variants necessitate

ongoing multidisciplinary follow-up, with additional oncological treatment determined by tumour type and behaviour (de Souto Medeiros *et al.*, 2024).. Prompt recognition and appropriate surgical planning remain essential to preventing morbidity and ensuring optimal outcomes.

Comparative summary of hamartomas, choristomas and teratomas of the oral cavity, highlighting their developmental origin, tissue composition, clinical behaviour, diagnostic hallmarks and management considerations to facilitate accurate differentiation from true neoplastic lesions is presented in Table 1.

Table 1. Comparative overview of hamartomas, choristomas and teratomas of the oral cavity.

Aspect	Hamartomas	Choristomas	Teratomas
Biological nature	Developmental malformations composed of disorganised but mature tissues indigenous to the site	Developmental heterotopias consisting of histologically normal tissue located in an anatomically aberrant site	Germ cell–derived developmental tumours containing tissues from two or more embryonic germ layers
Clinical behaviour	Non-invasive, self-limited growth paralleling surrounding tissues	Indolent, non-aggressive lesions with minimal growth potential	Variable behaviour ranging from benign (mature) to aggressive or malignant (immature or transformed lesions)
Age at presentation	Typically childhood or early adulthood; may be incidental findings	Broad age range, often detected incidentally	Predominantly congenital or neonatal; rare cases in older children and adults
Pathogenesis	Aberrant tissue organisation and proliferation during embryogenesis; may be sporadic or syndromic (e.g., PTEN-related disorders)	Embryological misplacement or sequestration of normal tissue during craniofacial development	Abnormal persistence and differentiation of pluripotent germ cells within the craniofacial region
Tissue composition	Mature tissues native to the affected oral site, arranged excessively or irregularly	Fully differentiated, normal tissues foreign to the anatomical location	Complex admixture of ectodermal, mesodermal and/or endodermal derivatives
Common oral examples	Odontoma, haemangioma, lymphangioma, exostoses, oral melanocytic nevi	Osseous and cartilaginous choristomas, salivary gland choristoma (e.g., Stafne bone cavity), lingual thyroid, gastric, glial and respiratory epithelial choristomas	Epignathus and other congenital oropharyngeal teratomas
Diagnostic hallmark	Histopathological identification of an unencapsulated proliferation of mature indigenous tissues with preserved cytological features and no evidence of cytological atypia	Histopathological confirmation of mature, histologically normal tissue in an ectopic anatomical location, supported by correlation with the clinical site	Histopathological demonstration of tissues derived from two or more embryonic germ layers, often corroborated by imaging showing a heterogeneous lesion with calcified, cystic, or solid components
Management and prognosis	Conservative surgical excision; recurrence is rare	Simple excision is curative; excellent prognosis	Complete surgical resection essential; prognosis depends on tumour maturity and extent

Conclusions

Hamartomas, choristomas and teratomas of the oral cavity represent biologically distinct developmental lesions that may closely mimic benign neoplasms in their clinical presentation. A thorough understanding of their embryological origins, tissue composition and characteristic growth patterns is essential to achieving accurate diagnosis and delivering appropriate management.

References

Black, A. I., Bunn, B., Motloba, P., & Gwengu, P. (2024). The head and neck features of Gardner's Syndrome: a case report and review of the literature. *South African Dental Journal*, *79*, 387-390. https://doi.org/10.17159/sadj.79i06.18335

Chakravarti, A., Shashidhar, T. B., Naglot, S., & Sahni, J. K. (2011). Head and neck teratomas in children: a case series. *Indian Journal of Otolaryngology and Head & Neck Surgery*, *63*(2), 193-197. https://doi.org/10.1007/s12070-011-0224-8

Constantin, B. N., Marina, T. C., Eugen, S. H., Ileana, E., & Adrian, G. (2023). Tongue base ectopic thyroid tissue-is it a rare encounter? *Medicina (Kaunas)*, *59*(2). https://doi.org/10.3390/medicina59020313

de Jesus, I. D. O., Costa, A., de Oliveira Santos, D., Cardoso, S. V., Nero, N., Loyola, A. M., *et al.* (2025). Clinicopathologic study of oral mucosa-derived hamartomas and choristomas and literature review. *International Journal of Dentistry*, *2025*, 5750421. https://doi.org/10.1155/ijod/5750421

de Souto Medeiros, M. R., da Silva Barros, C. C., Rolim, L. S. A., Pinto, L. P., Miguel, M. C. d. C., & da Silveira, É. J. D. (2024). Hamartomas, choristomas, and teratomas of the oral cavity: a 49-years cross-sectional study in an oral diagnostic service. *Journal of Stomatology, Oral and Maxillofacial Surgery*, *125*(5), 101765. https://doi.org/https://doi.org/10.1016/j.jormas.2024.101765

Fu, Y., Zhao, Y., Chu, T., Qin, Q., Yang, H., Cui, Z., *et al.* (2024). Case reports of oral choristomas and a review of the literature. *Journal of Stomatology Oral and Maxillofacial Surgery*, *125*(4s), 101897. https://doi.org/10.1016/j.jormas.2024.101897

Gabriel Levi, E.-G., Andrew Kevin, G.-H., Fabiola, S.-C., Roberto Onner, C.-T., & Erick, N.-T. (2025). Neurovascular hamartoma of the tongue: Case report and current concepts. *Advances in Oral and Maxillofacial Surgery*, *18*, 100541. https://doi.org/https://doi.org/10.1016/j.adoms.2025.100541

Glavis-Bloom, J., Nahl, D., Rubin, E. M., Nael, A., & Dao, T. (2019). Congenital neuroglial choristoma of the foot. *Radiology Case Reports*, *14*(6), 718-722. https://doi.org/10.1016/j.radcr.2019.03.025

Gorini, E., Mullace, M., Migliorini, L., & Mevio, E. (2014). Osseous choristoma of the tongue: a review of etiopathogenesis. *Case Reports in Otolaryngology*, *2014*, 373104. https://doi.org/10.1155/2014/373104

Goswamy, M., Tabasum, S., Kudva, P., & Gupta, S. (2012). Osseous choristoma of the periodontium. *Journal of Indian Society of Periodontology*, *16*(1), 120-122. https://doi.org/10.4103/0972-124x.94619

Huang, Y., & Pan, H. (2017). A fetus with a mass in the oral cavity: a rare case of oral immature teratoma. *International Journal of Clinical and Experimental Pathology*, *10*(7), 7890-7892.

Ide, F., Obara, K., Mishima, K., Saito, I., Horie, N., Shimoyama, T., & *et al.* (2005). Peripheral odontogenic tumor: a clinicopathologic study of 30 cases. General features and hamartomatous lesions. *Journal of Oral Pathology & Medicine*, *34*(9), 552-557. https://doi.org/10.1111/j.1600-0714.2005.00355.x

Kolekar, S. S., Chincholi, T., Nangare, N., & Patankar, R. (2016). Oral teratoma. *International Journal of Applied and Basic Medical Research*, *6*(1), 54-56. https://doi.org/10.4103/2229-516x.174015

Lee, J. I., Kang, S. J., Jeon, S. P., & Sun, H. (2016). Stafne Bone Cavity of the Mandible. *Archives of Craniofacial Surgery*, *17*(3), 162-164. https://doi.org/10.7181/acfs.2016.17.3.162

Leiter Herrán, F., Restrepo, C. S., Alvarez Gómez, D. I., Suby-Long, T., Ocazionez, D., & Vargas, D. (2017). Hamartomas from head to toe: an imaging overview. *British Journal of Radiology*, *90*(1071), 20160607. https://doi.org/10.1259/bjr.20160607

Lohana, C., Jhatial, M. A., Sheikh, F., & Hassan, S. (2020). A rare case of adult mixed germ cell tumor of head and neck. *International Journal of Medical Reviews and Case Reports*, *5*. https://doi.org/10.5455/IJMRCR.Mixed-Germ-Cell-Tumor-Head-Neck-case-report

Maldonado, A., Muñoz, R., Cabrera, J., de Arruda, J. A. A., de Andrade, B. A. B., Villarroel-Dorrego, M., *et al.* (2025). Heterotopic gastrointestinal cyst of the oral cavity: a rare clinical report and literature review. *Journal of Stomatology Oral and Maxillofacial Surgery*, *126*(5, Supplement), 102406. https://doi.org/https://doi.org/10.1016/j.jormas.2025.102406

Marques, L. C., Figueira, L. M., Almeida, L., Rozza-de-Menezes, R. E., Silva-Junior, A., Cunha, K. S., *et al.* (2022). Congenital sebaceous choristoma of the tongue: a rare case report. *Journal of Clinical and Experimental Dentistry*, *14*(5), e446-e452. https://doi.org/10.4317/jced.59451

McDonald, D., Wu, Y., Dailamy, A., Tat, J., Parekh, U., Zhao, D., *et al.* (2020). Defining the teratoma as a model for multi-lineage human development. *Cell*, *183*(5), 1402-1419.e1418. https://doi.org/10.1016/j.cell.2020.10.018

Nava-Villalba, M., Ocampo-Acosta, F., Seamanduras-Pacheco, A., & Aldape-Barrios, B. C. (2008). Leiomyomatous hamartoma: report of two cases and review of the literature. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*, *105*(4), e39-45. https://doi.org/10.1016/j.tripleo.2007.12.021

Neville, B. W., Damm, D. D., Allen, C. M., & Chi, A. C. (2023). *Oral and Maxillofacial Pathology-E-Book*. Elsevier Health Sciences.

Ombres, C. M., Lestadi, I., & Putra, J. (2022). Lingual choristoma with gastric epithelium revisited. *Head and Neck Pathology*, *16*(2), 503-506. https://doi.org/10.1007/s12105-021-01362-0

Patil, S., Rao, R. S., & Majumdar, B. (2015). Hamartomas of the oral cavity. *Journal of International Society of Preventive and Community Dentistry*, *5*(5), 347-353. https://doi.org/10.4103/2231-0762.164789

Pilarski, R. (2019). PTEN hamartoma tumor syndrome: a clinical overview. *Cancers*, *11*(6), 844. https://www.mdpi.com/2072-6694/11/6/844

Sakrikar, A., Agrawal, U., Pimpale, G., & Agrawal, P. (2022). Cartilaginous choristoma of tongue - a case report and review. *Journal of Oral and Maxillofacial Pathology*, *26*(3),

395-398. https://doi.org/10.4103/jomfp.jomfp_31_22

Soluk-Tekkesin, M., & Vered, M. (2021). Ameloblastic fibro-odontoma: at the crossroad between "developing odontoma" and true odontogenic tumour. *Head and Neck Pathology*, *15*(4), 1202-1211. https://doi.org/10.1007/s12105-021-01332-6

Soluk-Tekkesin, M., & Wright, J. M. (2022). The World Health Organization classification of odontogenic lesions: a summary of the changes of the 2022 (5th) Edition. *Turkish Journal of Pathology*, *38*(2), 168-184. https://doi.org/10.5146/tjpath.2022.01573

Torres Medina, M. H., Topete, R. F., Villalba, M. N., & Zepeda Nuño, J. S. (2021). Gingival salivary gland choristoma: An unusual case report. *Journal of Oral and Maxillofacial Pathology*, *25*(Suppl 1), S90-s93. https://doi.org/10.4103/jomfp.JOMFP_284_19

Ueno, S., Hirakawa, H., Matsuda, H., Tei, E., Kaneko, A., Ohta, Y. *et al.* (2009). A case of neonatal mature teratoma transformed to malignancy in the neck extending to the mouth floor. *Tokai Journal of Experimental and Clinical Medicine*, *34*(4), 130-134.

Walling, A. D. (1987). Ectopic thyroid tissue. *American Family Physician*, *36*(3), 147-150.

WHO, C. o. T. E. B. (2022). *Head and neck tumours. Lyon (France): International Agency for Research on Cancer; 2023.* (W. M. T. Edward Odell, Susan Muller, Ed. Vol. vol. 9) https://publications.iarc.fr.

Woo, S.-B. (2017). *Oral Pathology: A Comprehensive Atlas and Text* (2nd ed.). Elsevier.

Zhang, Q., Huang, Y., Bao, C. Y., & Li, L. J. (2013). Yolk sac tumour involving floor of mouth: case report. *British Journal of Oral and Maxillofacial Surgery*, *51*(5), e67-69. https://doi.org/10.1016/j.bjoms.2012.04.074

REVIEW ARTICLE Open Access

Artificial intelligence in diagnostic dentistry: technology and Islamic ethical compliance

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Abstract

Artificial Intelligence (AI) has advanced in dental diagnostics, improving accuracy, efficiency, and clinical decision-making through Machine Learning (ML) and Deep Learning (DL). However, ethical concerns, particularly those from an Islamic perspective, remain inadequately explored. This narrative review aims to (1) summarise current applications of AI in dental diagnostic practice, (2) discuss ethical challenges of AI, and (3) evaluate these applications through an Islamic ethical point of view. A structured, non-systematic narrative was conducted using a two-stream literature search. The first stream identified peer-reviewed studies on AI applications in dental diagnostics. Meanwhile, the second stream explored Islamic ethics, bioethics, and jurisprudential sources relevant to healthcare technologies. Building on this, searches utilised predefined keywords, with inclusion restricted to English language full-text articles, primarily published between 2015 and 2025. Accordingly, titles, abstracts, and full-text availability were screened for relevance. While AI demonstrates high diagnostic performance in various dental fields, it faces ethical challenges related to data quantity, quality, bias, transparency, generalisability, and clinical integration. In line with this, Islamic ethical principles, particularly the purpose of Islamic law (*Maqaṣid al-Shariah* and *Al-Masadir al-Aqliyya)*, can serve as the primary basis for AI applicability in dentistry. Integrating Islamic ethical values into AI-driven dental diagnostics promotes a human-centred, accountable, and ethically robust approach, ensuring technological rapid expansion aligns with patient safety, social justice, and moral respectability.

Keywords: *artificial intelligence, dental fiqh, diagnostic dentistry, ethical, Islamic perspectives*

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Introduction

Artificial Intelligence (AI) simulates human intelligence through machines and technology, particularly in areas such as learning, problem-solving, and decision-making that typically involve human capabilities. The most common explanation of AI is the development of a computer framework capable of executing human thought, including visual perception, speech recognition, decision-making, and prediction daily problems. AI combines different fields such as medicine, mathematical, and science to solve daily problems. By training on wide prepared data, AI machines performing more complex tasks efficiently, thus making it easier for people handle routine challenges (Ding *et al.*, 2023). Over the years, AI has advanced significantly, integrating clinical datasets into the pipeline of automated AI models, thereby enhancing healthcare performance,

particularly in diagnostics. Clinical assistance from AI has been proven to reduce clinicians' workload, improve diagnostic accuracy and aid in decision-making (Akram, 2025; Surdu *et al.*, 2024). In dentistry, which relies heavily on clinical experience, AI addresses this limitation by helping dentists avoid errors and misinterpretations. It also excels in precise detection and classification tasks, thereby enhancing efficiency (Butnaru *et al.*, 2025) and reducing the burden of the conventional human diagnostic approach. For example, AI has been evaluated and demonstrated to perform accurate teeth charting and is also capable of diagnosing the presence of caries (Ezhov *et al.*, 2021, Kabir *et al.*, 2022).

While numerous studies highlight the efficacy of AI in dental diagnostics, others address ethical and legal challenges to its use in clinical applications (El Khoury *et al.*, 2025). Essentially, these challenges can be overcome when clinicians develop AI that aligns with the ethical principles of justice and beneficence, thereby upholding human responsibility in practice (Yunos & Hamdan, 2025). In addition, the AI model's development suggests that patient data and clinicians are closely linked, raising ethical concerns. These include the risk of data manipulation, the clinician's bias in interpreting data, and the lack of transparency in AI development. Notably, Western or secular views often dominate the early stages of AI evolution, where ethical dilemmas frequently arise and are sometimes overlooked in the pursuits of advanced technological models.

As AI is increasingly used in daily life, its plausible performance eventually leads individuals to face dilemmas in which they must choose between trusting technology alone or considering ethical values when using or developing AI. In Islam, the most profound values in Muslim daily life rely on human-to-God (*habl min Allah*) and human-to-human (*habl min al-nas*) relationships (Samsudin, 2018). This concept can also be applied to humans while developing or using AI (Ali *et al.*, 2025). These principles are rooted in *Shariah* objectives such as trusteeship (*Amanah*), justice (*Al-'Adalah*), authorisation (*Isti'zan*), public welfare (*Maslahah*), and preservation (*Hifz*). Thus, whenever human activity adheres to Islamic ethics literally, they prioritise societal benefits and seek Allah's pleasure (*habl min Allah*) (Yunos & Hamdan, 2025). In essence, this attitude is a practice of Islam as a way of life that empowers humans to fulfil their role as servants (*'ibad*) and vicegerents (*khalifah*) on Earth.

While many studies focus on AI advancement, there is a significant shortage of research addressing AI issues related to Islamic ethics. After all, in each step of AI deployment, humans still play a vital role in how the AI process should run. Hence, the reliability and accountability of AI will still be the responsibility and power of humans. However, nowadays, the technological framework has focused on ethical guidelines that did not stem from Islamic teaching. This paper, therefore, aims to provide a general overview of current applications of AI in dental diagnostics while directly exploring them through the lens of Islamic ethics to foster a balanced perspective on technological advancement.

This narrative review consolidates the extant literature on AI applications in oral health diagnostics and their confluence with Islamic ethical considerations. Although the application of AI in the diagnostic field has certain limitations regarding Islamic ethical conduct, clinicians cannot disregard this and succeed in balancing this world and hereafter (*duniawi* and *ukhrawi*).

Materials and Methods

The literature search was conducted by a single reviewer, and all article screening was performed independently. Firstly, all studies relevant to the keywords were screened, and any duplicate titles were removed. The inclusion criteria for this review were limited to only English-language full-text publications from January 2015 to December 2025. All searches were restricted to electronic databases, and no manual search was performed. The literature search used the same keywords throughout all five

databases: Scopus, PubMed, Wiley, ClinicalKey, and ScienceDirect. This search implements a structured, non-systematic method since direct "AI dentistry" AND "Islamic ethics" papers are scarce. Therefore, a two-stream strategy was employed, which keywords included "Artificial Intelligence", "Machine Learning", "Islamic ethics", "*Maqasid al-shariah*" and "diagnostic dentistry". Boolean operators (AND/OR) were applied to refine results.

The first stream focused on identifying academic literature on AI applications in dental diagnostics. In contrast, the second stream concurrently explored research on Islamic ethical principles relevant to emerging technologies and healthcare.

First Search Terms:

("artificial intelligence" OR "deep learning" OR "machine learning") AND ("dent*" OR "oral") AND ("diagnos*" OR "detection" OR "screening")

The second stream included "Islamic ethics AI," "Islamic bioethics healthcare," "*Sharia* AI regulation," and Muslim perspectives on technology ethics, enabling a comprehensive exploration of ethical frameworks to AI in healthcare.

Second Search Terms:

("Islamic ethics" OR "*maqasid*" OR "*Maqaṣid al-Shariah*" OR "*shariah*" OR "*fiqh*" OR "*fatwa*") AND ("AI" OR "artificial intelligence" OR "deep learning" OR "machine learning "OR "algorithm*")

The search terms were applied to the titles and keywords in the database in which relevant to artificial intelligence application in dental diagnosis and Islamic ethics with AI implementation. The inclusion criteria for this review were full-text English-language articles from original research, narrative reviews, scoping reviews, and systematic reviews addressing the application of AI in oral and dental diagnosis. The primary dataset types utilised were photos, periapical bitewing, Orthopantomography (OPG), and Cone Beam Computed Tomography (CBCT). All studies are most closely related to disease detection, classification, and comparison of AI-based tools.

On the other hand, articles focusing on non-diagnostic aspects of dentistry would be excluded from the list. Articles were also further screened if they lacked sufficient relevance to the search, were duplicates, or were not full-text available. We also limited the studies to those published within the last 10 years (2015 - 2025) to ensure the review captures only recent, reliable advancements in AI. The search dates refer to the dates on which database searches were executed, and the final search was conducted to ensure inclusion of the most relevant articles from 3 December 2025 to 25 January 2026.

Results

The literature search was done across five databases. Firstly, the first stream only focuses on AI in dentistry diagnostic studies. A total of 144 articles were screened based on the available abstract; these were 8 from ClinicalKey, 13 from PubMed, 74 from ScienceDirect, 39 from Scopus and 10 from Wiley. After eliminating duplicate records and considering the exclusion criteria, only 32 articles remained for further scrutiny (Figure 1).

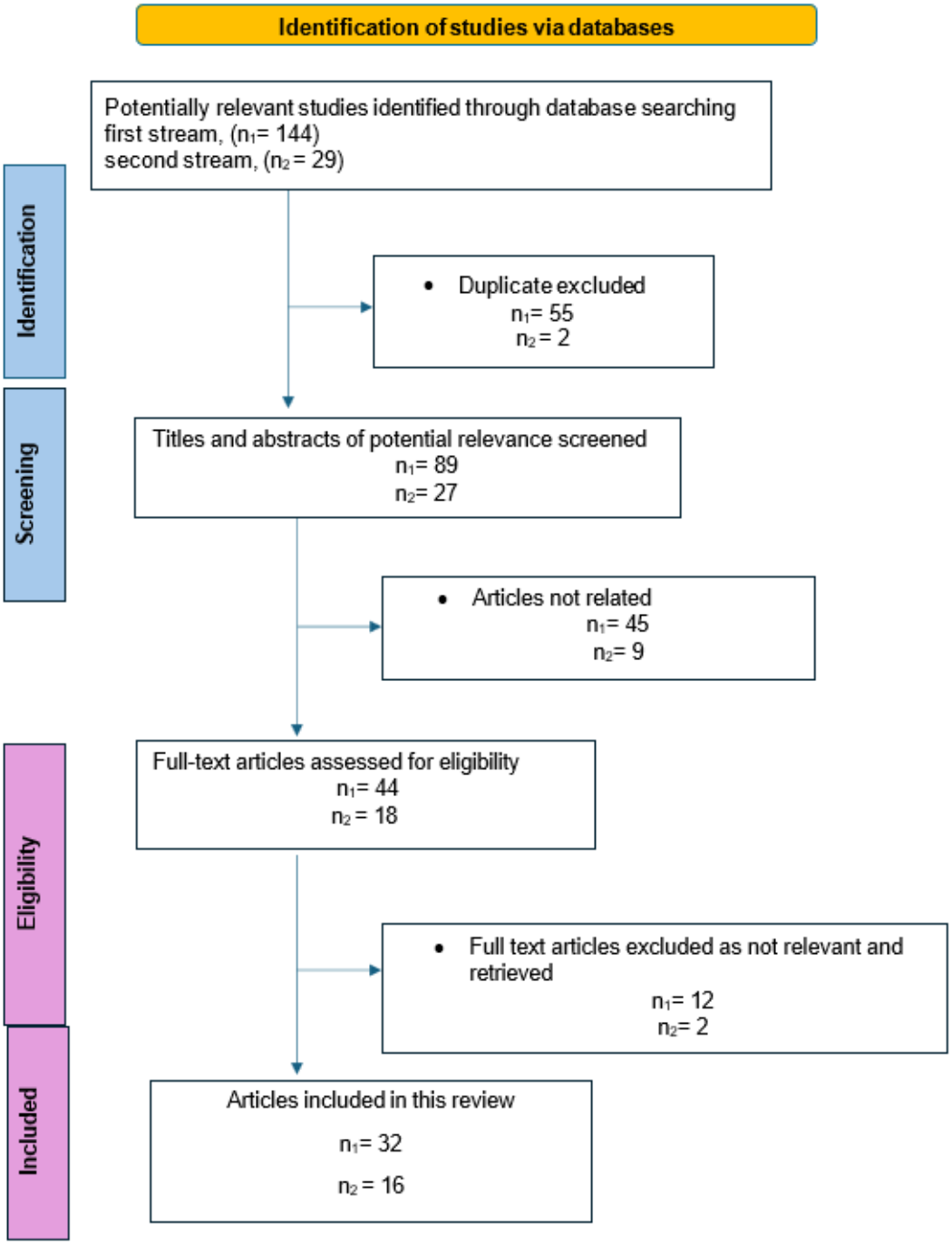

Figure 1. Workflow diagram of search procedure for narrative review.

Discussion

AI in diagnostic dentistry

AI empowers machines to execute tasks that mirror human intelligence through iterative training cycles that focus on data analysis, interpretation, and model deployment. This adaptive learning enables an AI system to identify patterns first, then generate predictions, and eventually evolve with more incoming datasets, all of which significantly advance its role in dental diagnostics machines (Alinazi *et al.,* 2024*;* Shimizu *et al.,* 2022*)*.

AI encompasses several subfields, including Machine Learning (ML), Deep Learning (DL), natural language processing (NLP), and computer vision. Notably, ML and DL are both subsets of AI, also commonly used in dentistry, though they differ in data processing, complexity and learning mechanisms (Table 1). In particular, ML typically relies on simpler networks suited to smaller datasets, with learning patterns predefined mainly by humans. Thus, ML primarily learns from human-guided data, as observed in general daily applications such as spam email detection and weather trend prediction. Conversely, DL is a subset of ML that employs complex multi-layered neural networks, which require large training datasets and substantial computational power. This complex learning is also known as Convolutional Neural Networks (CNN), which can process and integrate all data from various sources such as visual, voice, and text. The examples of daily use of DL includes ChatGPT, Siri, and Gemini (Khattak *et al.*, 2025).

Following this, AI can be further classified into narrow AI and general AI depending on their functions and abilities. Narrow AI performs specific tasks within limited domains, such as data analysis or processing. As it works well with smaller datasets, its algorithms use linear regression, decision trees, and support vector machines. Nevertheless, the selection of criteria and problem formulation depend mainly on human expertise. For example, AI can reduce human error, be a time saver, and enable clinician-independent practice when AI automatically and precisely determines dental impression tray size (Hasan *et al.*, 2021).

Although its efficiency has been proven in various dental specialties, it serves as an adjunct to and assists the clinician's workflow, rather than replacing the dentist's judgement (Lin *et al.*, 2024).

On the other hand, general AI aims to achieve broad, human-like cognitive performance by integrating data across multiple domains. CNN is a model of general AI also known as DL, which demonstrates high efficiency in dental caries diagnosis and anatomical extraction. The key advantage is that it automatically extracts pivotal features from datasets, reducing manual dependence. For example, an AI model can accurately determine the mandibular incisive canal within a short time frame and outperform a clinician's judgement (da Andrade-Bortoletto *et al.*, 2025). Nonetheless, DL requires extensive dataset annotation, substantial computational input, and specialised technical expertise, especially for fine-tuning hyperparameters and neural network architecture.

In AI, both ML and DL can work across various supervision modes, including supervised, semi-supervised, and unsupervised learning (Figure 2). In AI, both ML and DL can work across various supervision modes, including supervised, semi-supervised, and unsupervised learning. As such, supervised learning requires human experts to first label data, such as dental images, as either caries or non-caries. Both ML and DL models are trained to compare their predictions with these known answers. However, ML relies on human-defined patterns and justification, whereas DL automatically learns the features from raw data. Meanwhile, in semi-supervised learning, there will be a small number of datasets with labels and a large number without.

Table 1. Comparison of AI learning for diagnostic study (Khattak *et al.*, 2025; Shujaat, 2025).

Aspect	Machine Learning	Deep Learning	Automated Machine Learning
Definition	Systems learn from data to identify complex, nonlinear interactions and make predictions.	A subset of ML using deep neural networks to learn hierarchical features automatically.	Automates the entire ML application process, from data preprocessing to model deployment.
Relationship	Broad field of AI.	Subset of ML.	Builds upon ML and DL, automates their processes.
Key characteristic	Excels in identifying complex patterns; requires expert oversight for model development.	Automates feature extraction; highly effective for image analysis; requires extensive data and specialised knowledge.	Simplifies complex ML tasks for non-experts; automates steps.
Expertise required	Data scientists/computer engineers for critical tasks like data preprocessing, feature extraction, algorithm selection, and hyperparameter tuning.	Specialised knowledge for fine-tuning hyperparameters and neural network architecture.	Minimal technical expertise required for users, enabling non-experts to create models.
Typical clinical applications	Diagnostics, treatment planning, and prognosis prediction across various domains (Lin *et al.*, 2024).	Dental imaging tasks such as implant classification, caries detection, caries classification, teeth numbering and segmentation of anatomical structures (da Andrade-Bortoletto *et al.*, 2025; Farook *et al.*,2025.; Fontenele *et al.*, 2023; Ghorbani *et al.*, 2025; Kim *et al.*, 2025; Mendes *et al.*, 2025; Negi *et al.*, 2024; Sributsayakarn *et al.*, 2025)	Streamlining workflows, automating hyperparameter tuning, and enhancing diagnostic and predictive accuracy, particularly in image-based diagnostic tasks such as supernumerary, congenitally missing teeth and teeth wear progression (Makrygiannakis *et al.*, 2025; van Nistelrooij *et al.*, 2024).

Limitations	Requires expert oversight; complexity is a barrier to adoption.	Relies on large, annotated datasets, computational resources, and technical expertise.	Reduces interpretability and dependence on extensive, high-quality datasets and can be computationally demanding.

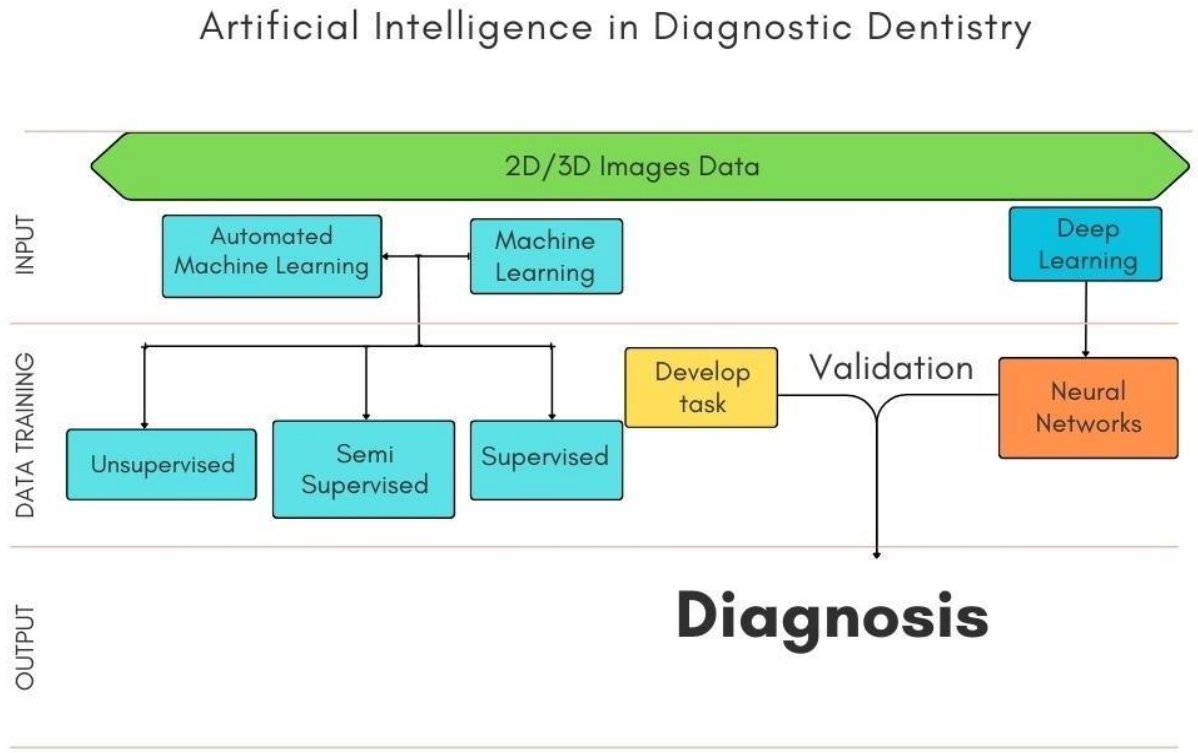

Figure 2. Flowchart of AI concept in diagnostic dentistry.

This improves performance when expert annotation is limited. Moreover, in unsupervised learning, there are no labels, and both ML and DL learn to detect hidden patterns and group data. Essentially, ML really depends on human input, while DL is more autonomous and powerful in analysing complex data, especially in dental imaging (Najeeb & Islam, 2025).

Nowadays, automated machines are gaining popularity in diagnostic dentistry, as their automated systems tune and adapt to optimise model outputs. Unlike conventional ML and DL, which involve time-consuming trial-and-error development and require expert programmer input, automated ML streamlines the process (Bichu *et al.*, 2021; Samaranayake *et al.*, 2025; Shujaat, 2025; Surdu *et al.*, 2024). Additionally, robust patient datasets, including imaging across dental specialities, further improve AI's efficiency in diagnostic precision and optimising treatment workflows (Morise Mahrous *et al.*, 2025). This model demonstrated significant diagnostic accuracy in detecting caries, restorations, implants, and other anomalies. Despite the major challenges of automated ML in dentistry, it lacks transparency in decision-making, which may affect patients, and has limited interpretability. Thus, ML, DL and automated machine learning demonstrate distinct consideration, especially the technical expertise required for developing models and their applicability in diagnostic studies.

AI model deployment

The AI model development process in dentistry can be reflected in how a clinician learns, applies knowledge, and refines judgement, though in a computational manner. It begins with data input, where the AI system receives a large volume of clinically relevant information, either in data or visual form. Notably, dental AI data most commonly consists of clinical photographs, bitewing images, OPG images, and CBCT images. These images serve as the "raw experience" for the system. At the same time, patient demographic or clinical data may be added as contextual information. However, they are not always essential; hence, they are left anonymous. Accordingly, specific models require demographic details and complete patient histories, necessitating informed consent prior to use. Moreover, this stage demands standardised data quality, generalised data feeding, and balanced datasets, whose responsibilities fall to clinicians to ensure reliable diagnostic modelling, especially in disease detection (Shoorgashti *et al.*, 2025).

The second phase of the AI model development is the training phase, which is the most crucial step and requires significant human skill and refinement. At this stage, experts annotate or label datasets to identify features that are important for recognition. Correspondingly, AI learns by noticing common visual characteristics such as shapes, outlines, colours, and surface details. The system eventually becomes better at recognising patterns after dataset iteration and mathematical rules are used for correct diagnosis.

To improve the efficiency and accuracy of the newly developed model, dataset augmentation is recommended, particularly when the data sample size is limited. Techniques such as blurring, skewing, rotating, and adjusting image parameters can help generalise the datasets to different data variations (Ghods *et al.*, 2023). Note that the AI models do not memorise images. Rather, they learn by statistical relationships between visual features and diagnostic outcomes using mathematical functions. Nevertheless, excessive data augmentation during training may introduce unintended bias and fail to accurately reflect real clinical conditions, increasing the risk of 'overfitting'.

AI learning is refined during model optimisation, an iterative process in which the AI makes predictions, compares them with expert-labelled "ground truth" and quantifies its errors. Using these errors, the system automatically adjusts its internal parameters to reduce mistakes. Over many cycles, this process improves key performance metrics, *i.e.*, accuracy, sensitivity, and specificity. This stage is analogous to clinical calibration and audit in human practice. Concurrently, the human role in this process involves validating the AI's diagnostic outputs and rectifying discrepancies that arise, ensuring the clinical relevance and safety of the AI-driven method. In line with this, an AI model must meet predetermined performance criteria prior to being used in a clinical workflow. Hence, a pilot study is required.

Finally, in the clinical stage, the AI model is tested to predict or diagnose new, unseen real-world datasets. Instead of providing a simple yes-or-no answer, the AI typically produces probability-based outputs, indicating a percentage likelihood of the correct diagnosis. In addition, the outputs are designed to support clinical decision-making by highlighting suspicious findings, prioritising areas for review, or offering a consistent second opinion. This suggests that clinicians account for the final diagnosis and justify it in relation to the patient's clinical manifestations, history, and professional judgement.

AI development challenges in relation to ethical values

To ensure AI model development is not manipulative or overrides human control, ethics are essential. AI development challenges involve clinicians, data and patients (Sitaras *et al.*, 2025). Hence, ethical considerations must address all aspects. For example, clinicians should be fair and trustworthy, using accurate data and

unbiased validation to ensure accountability and reliability. In addition, they should also uphold professional ethics by prioritising patient safety and rights. Furthermore, to collect more data for AI development, there may be a temptation to overprescribe radiological exposure in unnecessary cases, which sways clinicians' decisions rather than the patients.

Additionally, data screening and preprocessing are crucial, as imbalances and repetitive patterns exacerbate biases and overfitting, and need rigorous external validation on diverse datasets to demonstrate robustness and prevent diagnostic errors (Cross *et al.*, 2024; Shoorgashti *et al.*, 2025; Albalawi & Abalkhail, 2022; Gracea *et al.*, 2025; Kim *et al.*, 2024). AI pipelines demand excellent algorithms, where the integration of substantial volumes of high-quality, large datasets thus, precise annotations is indispensable for plausible models. In dental diagnostics, while two-dimensional (2D) and three-dimensional (3D) imaging modalities offer unique advantages, they also pose limitations. Specifically, 2D imaging, such as periapical and panoramic radiographs, is readily available and cost-effective. Still, it is often at risk of superimposition and a lack of depth perception, which can potentially lead to misinterpretations in complex anatomical regions (Mallineni *et al.*, 2024). However, 3D imaging of CBCT offers superior resolution for anatomical structures despite higher costs and radiation exposure (Gao *et al.*, 2025; Khattak *et al.*, 2025). Therefore, selecting image modalities must prioritise specific diagnostic requirements, balancing benefits against risks.

AI model evaluation emphasises performance metrics such as sensitivity, specificity, Area Under the Curve (AUC)and predictive values. Human oversight of high-accuracy models demonstrates high reliability and the potential for clinical workflow challenges, such as overfitting, biases from non-standardised data, and real-world limitations (Lal *et al.*, 2025). In essence, human justice confirms the reliability of using AI in diagnosis and being accountable in their clinical judgement, not solely depending on AI output (Albalawi & Albalkhail, 2022; Gracea *et al.*, 2025; Kim *et al.*, 2024; Koçak *et al.*, 2025).

In terms of patient-related ethical considerations, these align closely with standard clinical practice, with a strong emphasis on informed consent, data privacy, and autonomy. These principles are the foundation for fostering and sustaining patient trust in clinicians. First, patients must be well-informed regarding the use of their data, with confidentiality rigorously maintained throughout the AI development process. Furthermore, patients retain the right to withdraw consent or restrict their data's involvement in the data collection stage. For these reasons, upholding patient autonomy and privacy preferences is central to ethical data stewardship (Naeem *et al.*, 2023).

Islamic perspectives and AI in dental diagnostic

The integration of AI in healthcare, particularly in dental diagnostics, necessitates a comprehensive examination through the lens of bioethics principles, which provide a framework to guide AI advancement. However, from an Islamic perspective, the AI framework extends beyond solely technical efficacy to address issues of justice, beneficence, non-maleficence, and autonomy within AI applications. These principles serve as a moral compass, guiding the development and implementation of AI systems to ensure they align with religious values, human well-being, and societal interests, preventing the exacerbation of existing disparities (Kannike & Fahm, 2025).

Source: principles of Islamic ethics

The central sources of Islamic ethics are the Holy Quran and Hadith, which serve as the primary guiding texts for regulating a Muslim's daily life, including the use of AI in health applications. Although the Quran and Hadith contain no direct references to AI, especially a novel issue in the contemporary world, Islamic principles highlight two main

concepts: Tawhid and *Ihsan*. Tawhid, denoting the oneness of God, emphasises divine justice and precludes disruptions to social cohesion, exploitation of vulnerable groups, or ethical fragmentation (Mohammed *et al.*, 2025).

In the context of AI, *Ihsan* translates into the ethical imperative to develop AI systems characterised by fairness, transparency, and human-centred design. While these foundational principles offer a broad ethical framework, their practical application to specific AI dilemmas requires further interpretation and jurisprudential reasoning. Following the jurisprudential methodology (known as *Usul Fiqh*), the role of the Mufti and Fatwa comes into play, where they present arguments based on moral and contextual rationales. Further guidance is drawn from *Maqasid al-Shariah*, the five universal principles of Islamic law, which include the preservation of religion, life, intellect, progeny, and property. This offers a holistic perspective on AI's ethical implications. Collectively, these principles provide a robust ethical foundation, moving beyond jurisprudential rulings to foster a comprehensive, cross-cultural approach to AI ethics in healthcare (Mohammed *et al.*, 2025). Following this, *Maqasid al-Shariah* are the higher objectives of Islamic law. At the same time, there are *Al-Masadir al-Aqliyya* (rational sources) and *Al-Qawa'id al-Fiqhiyyah* (legal maxims) that offer additional layers of ethical analysis for complex AI applications. This is also known as the reason-based tools of Islamic jurisprudence, when considerations for rulings are not explicitly stated in the Holy Quran. These include *Qiyas* (analogy), *Istihsan* (preference), *Istishab* (presumption of continuity), *Maslaha* (public welfare), *Sadd al-dharai'* (blocking the means to evil end), and *'Urf* (customary traditions). As such, *Maqasid al-Shariah* serve as the ethical goals of Islamic law, whereas *al-masadir al-aqliyya* and *al-qawaid fiqhiyya* represent the rational mechanisms for implementing those goals in modern, complex contexts. Both *Maqasid al-Shariah* and *Al-Masdir al aqliyya* are pivotal in rationalising the application of AI technologies, as they provide a framework for moral judgements. This approach also prioritises human interests, known as *maṣlaḥa*, as the ultimate purpose of divine order, ensuring the well-being of humanity (Elmahjub, 2023).

Islamic ethics in the AI development for dentistry

As AI development continues to move forward, particularly in dental diagnostics, ethical frameworks must be reassessed to address the increasing use of patient data for training and validation, ensuring alignment with principles like *amanah* (trusteeship) and *maṣlaḥa* (public interest) (Ali *et al.*, 2025; Yunos & Hamdan, 2025). For instance, where patients provide explicit permission, whether informed or written consent, Islamic jurists regard clinicians as exempt from liability for any subsequent harm. Furthermore, the utilisation of patient data for ML training demands scrutiny, particularly emphasising the religious dimensions often absent from secular bioethical discussions. Nonetheless, these frameworks must balance technological advancement with the preservation of human dignity, such as justice (*'adl*), and welfare, to prevent AI from compromising humanity and promote *ihsan* (excellence in ethical conduct).

In addition, AI ethics in dentistry examines human-AI interactions from two key perspectives: firstly, the benefits and potential harms of AI to humans, whether AI improves diagnostic accuracy or raises any potential harm, such as risks of biases and errors (Cannarsa, 2021; Liu *et al.*, 2025). Second, human responsibilities toward these technologies, including equitable participation in AI development and oversight to uphold tawhid-inspired social protection (Yunos & Hamdan, 2025).

Despite these imperatives, AI adoption in diagnostic models faces substantial barriers, including ethical challenges such as algorithmic biases and adverse outputs (Kim *et al.*, 2024; Koçak *et al.*, 2025), legal implications on data privacy (Naeem *et al.*, 2023), and integration issues such as high costs and incompatibility with existing infrastructures (Cannarsa, 2021; Liu *et al.*,

2025). To prioritise patient safety and trustworthiness, the following four core guidelines, informed by Islamic ethical sources like *Maqasid al-Shariah* and trustworthy AI principles, are essential:

1. AI must not introduce new risks or compromise patient safety, prioritising *hifz al-nafs* (preservation of life) (Mohammed *et al.*, 2025; Yunos & Hamdan, 2025).
2. Continuously testing, validating, and monitoring algorithms to mitigate biases and errors that could harm outcomes, embodying *maslahah* (Cannarsa, 2021).
3. Transparent AI development processes to foster accountability and reduce harm, aligning with demands for explainability (Naeem *et al.*, 2023).
4. Adherence to patient autonomy and informed consent (*isti'zan*), ensuring willingness to participate without coercion (Yunos & Hamdan, 2025).

These guidelines provide a practical bridge between Islamic jurisprudence and the deployment of modern AI, necessitating interdisciplinary efforts for robust implementation. Building on this, a human-centred approach to AI systems is vital, ensuring that clinicians and patients are actively involved in the development and evaluation of these systems. We can conclude that these guidelines align with primary Islamic ethical considerations: *Isti'zan* (autonomy), *al-amanah* (act with integrity), *al-adl* (fairness), and *mas'uliyyah* (transparency and explainability).

Integration of AI in dental diagnostics and Islamic perspectives considerations

The integration of AI into dental diagnostics offers transformative opportunities alongside complex ethical challenges, necessitating rigorous evaluation through an Islamic moral framework. This involves scrutinising AI development and deployment in dentistry to ensure alignment with core principles. This includes Maqasid al-Shariah, data governance, research objectives, and societal outcomes, thereby preventing bias, ensuring equity, and upholding human welfare

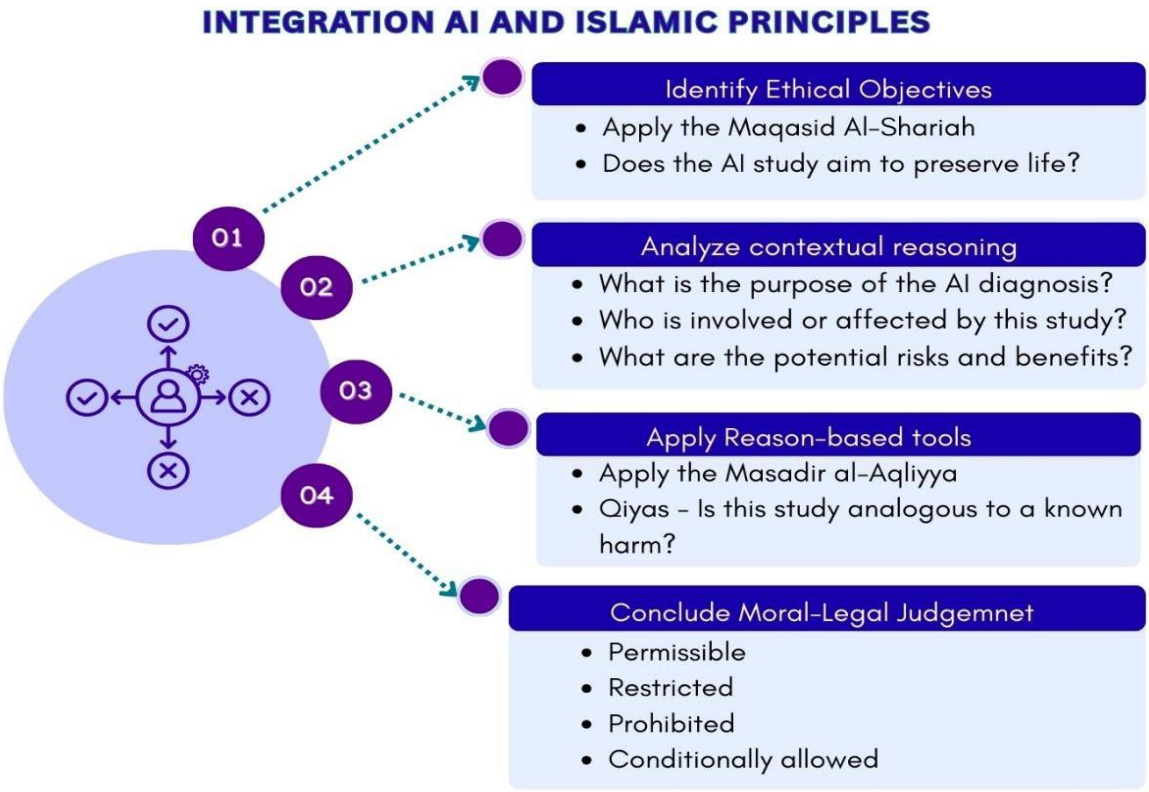

Figure 3. Islamic principles application in AI study.

There is a structured ethical framework (Figure 3) based on Islamic jurisprudence that can serve as a means to ensure that AI practices remain permissible (Ali *et al.*, 2025; Elmahjub, 2023; Yunos & Hamdan, 2025).

1. Objective Identification *via Maqasid al-Shariah*: Align AI applications with the preservation of life (*hifz al-nafs*), intellect (*hifz al-'aql*), and progeny (*hifz al-nasl*), prioritising human welfare (*maslahah*), and preventing harm (*la darar wa la dirar*), as emphasised in Islamic law's higher objectives (Ali *et al.*, 2025; Elmahjub, 2023; Yunos & Hamdan, 2025).
2. Contextual Analysis of AI Development: Evaluate data governance, including transparency, algorithm generalisation across diverse populations, and hyperparameter controls to mitigate biases and ensure fairness. This is particularly critical in dentistry, where unrepresentative training data can lead to discriminatory diagnostics (Koçak *et al.*, 2025; Naeem *et al.*, 2023; Yunos & Hamdan, 2025).
3. Implications Assessment Using Reason-Based Tools: Apply *Qiyas* (analogy), *Istihsan* (juristic preference), and other *al-masadir al-aqliyyah* (rational mechanisms) to any latest AI dilemmas, such as opaque decision-making or error-prone outcomes, adapting textual sources to modern contexts (Ali *et al.*, 2025; Yunos & Hamdan, 2025).
4. Final Moral Ethical Judgement: Identify AI's societal impact against *Tawhid*, *Ihsan*, and *maslahah*. This stage confirms no disruption to social cohesion or exploitation, deeming the study permissible only if it advances well-being without ethical fragmentation (Ali *et al.*, 2025; Elmahjub, 2023; Yunos & Hamdan, 2025).

This dynamic, multi-stage process bridges foundational texts, jurisprudential tools, and practical safeguards (Figure 4). It fortifies AI innovation in dentistry against ethical pitfalls, fostering trustworthy, human-centred technologies that align with Islamic imperatives (Cannarsa, 2021; Yunos & Hamdan, 2025).

Conclusions

This demonstrates that AI has reached a level of technical maturity that enables meaningful contributions to dental diagnostics. However, model development requires human oversight to ensure it remains tied to ethical conduct. Ultimately, AI models are operated and shaped by human adoption and decision-making. Therefore, human-centred tools must comply with specific ethical guidelines, which Muslim clinicians should oversee.

Thus, an integrated framework ensures continuous governance of AI development and clinical deployment in dental diagnostics, grounded in Islamic ethical principles. It begins with the acquisition of clinical data under *Isti'zan*, ensuring the ethical collection and preservation of patient dignity. Following this, AI data processing incorporates ethical safeguards based on *al-adl*, *al-amanah*, and *mas'uliyyah*, demanding balanced, high-quality datasets and ethical training to minimise bias and errors. In addition, generated diagnostic outputs require mandatory clinician review and adjustment, affirming human moral and professional accountability. It also concludes with an Islamic ethical appraisal that identifies pertinent *Maqasid al-Shariah*, assesses the clinical context, and applies rational sources (*al-masadir al-aqliyyah*) to inform judgments grounded in *Tawḥid*, *Iḥsan*, and *maṣlaḥah*. In summary, these principles position AI as a supportive tool within a human-centred, Shariah-compliant system that fuses technical efficacy with ethical duty. Overall, this operational integration harmoniously blends human and religious ethics, ultimately enabling the fulfilment of the commands of Allah and the human (*nas*).

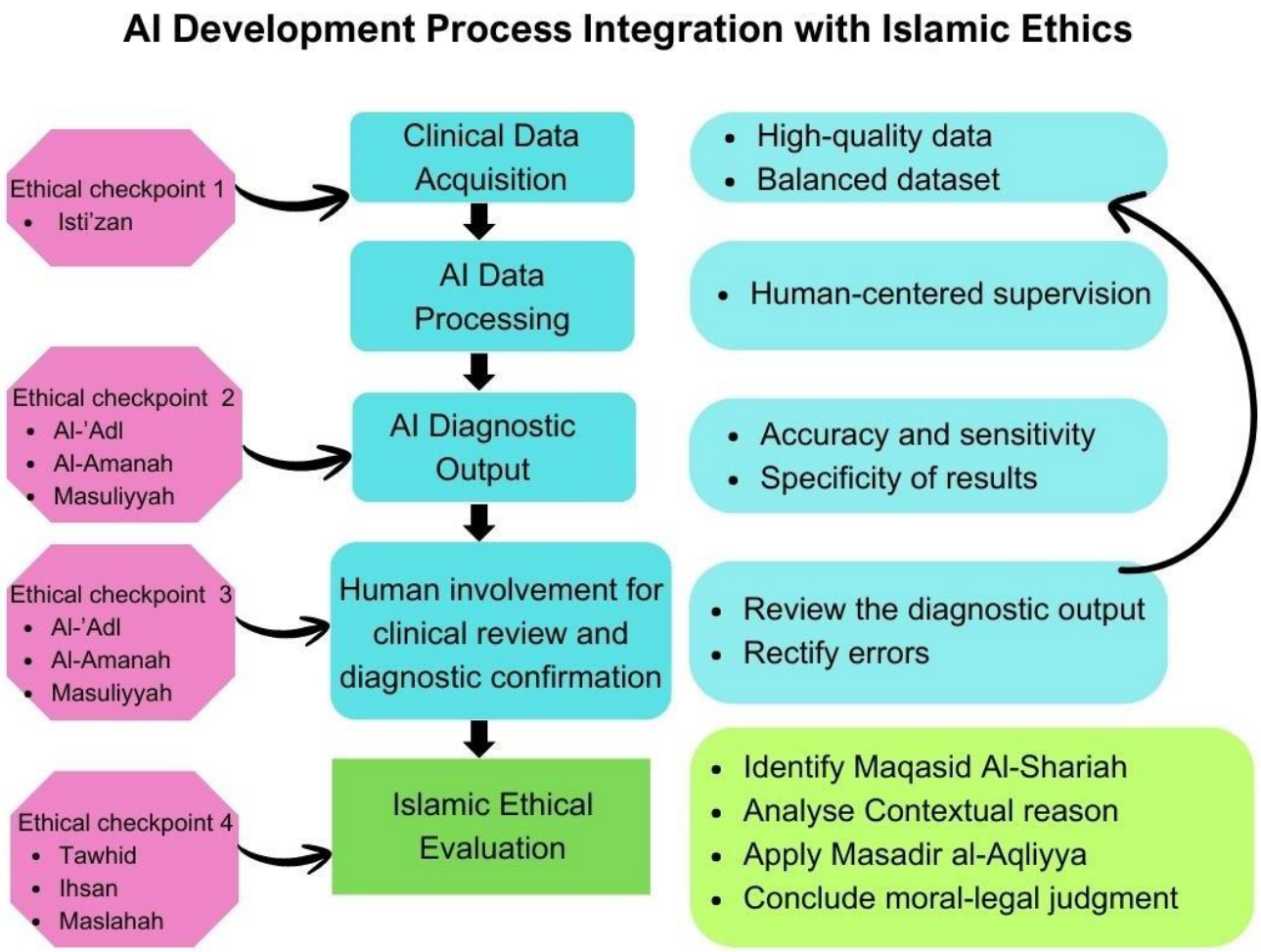

Figure 4. Islamic ethics application in AI development process.

Limitation of the Review

This review has several methodological limitations. As this narrative was intentionally designed as a structured review rather than a systematic review, thereby no formal risk-of-bias assessment was performed prior to article selection. Although a structured search strategy was fully followed, some relevant results may not have been captured due to differences in indexing systems and the constraints of a single reviewer

References

Akram, H. M. (2025). Artificial intelligence in dentistry: advancements in periodontology and other specialities, diagnosis, treatment planning, and ethical considerations. *Dentistry Review*, 5(2),1-8.

Albalawi, F., & Abalkhail, K. A. (2022). Trends and application of artificial intelligence technology in orthodontic diagnosis and treatment planning—A review. *Applied Sciences*, 12(22), 1-20.

Ali, F., Bouzoubaa, K., Gelli, F., Hamzi, B., & Khan, S. (2025). Islamic ethics and AI: an evaluation of existing approaches to AI using trusteeship ethics. *Philosophy and Technology*, 38(3), 1-34.

Alinazi, F. R., Althaqafi, G. K., Alaqidi, M. J., Aldossri, J. M., Alomayer, M. O., Alkallabi, S. A. *et al.* (2024). The impact of artificial intelligence on diagnostic accuracy and treatment planning in dentistry. *Journal of International Crisis and Risk Communication Research*, 7(S5), 16-22.

Bichu, Y. M., Hansa, I., Bichu, A. Y., Premjani, P., Flores-Mir, C., & Vaid, N. R. (2021). Applications of artificial intelligence and machine learning in orthodontics: a scoping review. *Progress in Orthodontics*, 22(1), 1-11.

Butnaru, O. M., Tatarciuc, M., Luchian, I., Tudorici, T., Balcos, C., Budala, D. G., *et al.* (2025). AI efficiency in dentistry: comparing artificial intelligence systems in assessing several periodontal parameters. *Medicina*, 61(4), 1-23.

Cannarsa, M. (2021). Ethics guidelines for trustworthy AI. *The Cambridge Handbook of Lawyering in the Digital Age*, Cambridge: Cambridge University Press, pp. 283-297.

Cross, J. L., Choma, M. A., & Onofrey, J. A. (2024). Bias in medical AI: implications for clinical decision-making. *PLOS Digital Health*, 3(11), 1-19.

da Andrade-Bortoletto, M. F. S., Jindanil, T., Fontenele, R. C., Jacobs, R., & Freitas, D.Q. (2025). Comparison of AI-powered tools for CBCT-based mandibular incisive canal segmentation: a validation study. *Clinical Oral Implants Research*. 36(9):1086–1094.

Elmahjub, E. (2023). Artificial Intelligence (AI) in Islamic ethics: towards pluralist ethical benchmarking for AI. *Philosophy and Technology*, 36, 1-24.

Ezhov, M., Gusarev, M., Golitsyna, M., Yates, J. M., Kushnerev, E., Tamimi, D., *et al.* (2021). Clinically applicable artificial intelligence system for dental diagnosis with CBCT. *Scientific Reports*, 11(1), 1-16.

Farook, T. H., Ahmed, S., Rashid, F., Sifat, F. A., Sidhu, P., Patil, P., *et al.* (2025). Application of 3D neural networks and explainable AI to classify ICDAS detection system on mandibular molars. *The Journal of Prosthetic Dentistry*, 133(5), 1333–1341.

Fontenele, R. C., Gerhardt, M. D. N., Picoli, F. F., Van Gerven, A., Nomidis, S., Willems, H., *et al.* (2023). Convolutional neural network-based automated maxillary alveolar bone segmentation on cone-beam computed tomography images. *Clinical Oral Implants Research*, 34(6), 565–574.

Gao, S., Wang, X., Xia, Z., Zhang, H., Yu, J., & Yang, F. (2025). Artificial intelligence in dentistry: a narrative review of diagnostic and therapeutic applications. *Medical Science Monitor: International Medical Journal of Experimental and Clinical Research*, 31, 1-15.

Ghods, K., Azizi, A., Jafari, A., & Ghods, K. (2023). Application of artificial intelligence in clinical dentistry, a comprehensive review of literature. *Journal of Dentistry*, 24(4), 356–371.

Ghorbani, Z., Mirebeigi-Jamasbi, S. S., Hassannia Dargah, M., Nahvi, M., Hosseinikhah Manshadi, S. A., *et al.* (2025). A novel deep learning-based model for automated tooth detection and numbering in mixed and permanent dentition in occlusal phtographs. *BMC Oral Health*, 25 (1), 1-14.

Gracea, R. S., Winderickx, N., Vanheers, M., Hendrickx, J., Preda, F., Shujaat, S. (2025). Artificial intelligence for orthodontic diagnosis and treatment planning: a scoping review. *Journal of Dentistry*, 152, 1-12.

Hasan, M. A., Abdullah, N. A., Rahman, M. M., Idris, M. Y. I. B., & Tawfiq, O. F. (2021). Dental impression tray selection from maxillary arch images using multi-feature fusion and ensemble classifier. *IEEE Access*, 9, 30573-30586.

Kabir, T., Lee, C. T., Chen, L., Jiang, X., & Shams, S. (2022). A comprehensive artificial intelligence framework for dental diagnosis and charting. *BMC Oral Health*, 22(1), 1-13.

Kannike, U. M. M., & Fahm, A. O. (2025). Exploring the ethical governance of artificial intelligence from an Islamic ethical perspective. *Journal Fiqh*, 22(1), 134-161.

Khattak, O., Hashem, A. S., Alqarni, M. S., Almufarrij, R. A. S., Siddiqui, A. Y., Anis, R. *et al.* (2025). Deep learning applications in dental image-based diagnostics: a systematic review. *Healthcare*, 13(12), 1-13.

Kim, P., Seo, B., & De Silva, H. (2024). Concordance of clinician, Chat-GPT4, and ORAD diagnoses against histopathology in odontogenic keratocysts and tumours: a 15-year New Zealand retrospective study. *Oral And Maxillofacial Surgery*, 28(4), 1557-1569.

Kim, D., Kim, J., & Choi, S. G. (2025). CNN-based remote dental diagnosis model for caries detection with grad-CAM. *Scientific Reports*, 15(1), 1-13.

Koçak, B., Ponsiglione, A., Stanzione, A., Bluethgen, C., Santinha, J., Ugga, L. *et al.* (2025). Bias in artificial intelligence for medical imaging: fundamentals, detection, avoidance, mitigation, challenges, ethics, and prospects. *Diagnostic and Interventional Radiology*, 31(2), 75-88.

Lal, A., Nooruddin, A., & Umer, F. (2025). Concerns regarding deployment of AI-based applications in dentistry–a review. *BDJ Open*, 11(1), 1-6.

Lin, H., Chen, J., Hu, Y., & Li, W. (2024). Embracing technological revolution: a panorama of machine learning in dentistry. *Medicina Oral, Patología Oral y Cirugía Bucal*, 29(6), e742 -e749.

Liu, T. Y., Lee, K. H., Mukundan, A., Karmakar, R., Dhiman, H., & Wang, H. C. (2025). AI in dentistry: innovations, ethical considerations, and integration barriers. *Bioengineering*, 12(9), 1-21.

Makrygiannakis, M. A., Giannakopoulos, K., Kavadella, A., Paraskevis, D., & Kaklamanos, E. G. (2025). Diagnostic accuracy of an artificial intelligence-based software in detecting supernumerary and congenitally missing teeth in panoramic radiographs. *European Journal of Orthodontics*, 47(4), 1-8.

Mallineni, S. K., Sethi, M., Punugoti, D., Kotha, S. B., Alkhayal, Z., Mubaraki, S. *et al.* (2024). Artificial intelligence in dentistry: a descriptive review. *Bioengineering*, 11(12), 1-24.

Mendes, A. C., Quintanilha, D. B. P., Pessoa, A. C. P., de Paiva, A. C., & dos Santos Neto, P. D. A. (2025). Automated tooth detection and numbering in panoramic radiographs using YOLO. *Procedia Computer Science*, 256, 1318-1325

Morise Mahrous, M. M., Bin Dukhan, M., Ali, H., Ahmed, Y., & Ali Ahmed Fuoad Al Bayati, S. (2025). Artificial intelligence and its implications in the management of orofacial diseases: a systematic review. *The Open Dentistry Journal*, 19(1). 1-16.

Naeem, M. M., Sarwar, H., Hassan, M. T., Balouch, N. M., Singh, S. P., Essrani, P. D. *et al.* (2023). Exploring the ethical and privacy implications of artificial intelligence in dentistry. *International Journal Of Health Sciences*, 7(S1), 904-915.

Najeeb M, Islam S. Artificial intelligence (AI) in restorative dentistry: current trends and future prospects 2025 Apr. *BMC Oral Health* 18;25(1):592.

Negi, S., Mathur, A., Tripathy, S., Mehta, V., Snigdha, N. T., Adil, A. H. *et al.* (2024). Artificial intelligence in dental caries diagnosis and detection: an umbrella review. *Clinical and Experimental Dental Research*, 10(4), 1-13.

Samaranayake, L., Tuygunov, N., Schwendicke, F., Osathanon, T., Khurshid, Z., Boymuradov, S. A. *et al.* (2025). The transformative role of artificial intelligence in dentistry: a comprehensive overview. part 1: fundamentals of AI, and its contemporary applications in dentistry. *International Dental Journal*, 75(2), 383–396.

Samsudin, N. H. (2018). The application of *habluminallah* and *habluminannas* in the work motivation of the management. *International Journal of Academic Research in Business and Social Sciences*, 8(5), 1130-1139.

Shimizu, Y., Tanikawa, C., Kajiwara, T., Nagahara, H., & Yamashiro, T. (2022). The validation of orthodontic artificial intelligence systems that perform orthodontic diagnoses and treatment planning. *European Journal of Orthodontics*, 44(4), 436-444.

Sitaras, S., Tsolakis, I. A., Gelsini, M., Tsolakis, A. I., Schwendicke, F., Wolf, T. G. *et al.* (2025). Applications of artificial intelligence in dental medicine: a critical review. *International Dental Journal*, 75(2), 474-486.

Shoorgashti, R., Alimohammadi, M., Baghizadeh, S., Radmard, B., Ebrahimi, H., & Lesan, S. (2025). Artificial Intelligence models accuracy for odontogenic keratocyst detection from panoramic view radiographs: a systematic review and meta-analysis. *Health Science Reports*, 8(4), 1-14.

Shujaat, S. (2025). Automated machine learning in dentistry: a narrative review of applications, challenges, and future directions. *Diagnostics*, 15(3), 1-17.

Sributsayakarn, N., Intharah, T., Hirunchavarod, N., Pornprasertsuk-Damrongsri, S., & Jirarattanasopha, V. (2025). Automated age and sex estimation from dental panoramic radiographs. *International Dental Journal*, 75(6), 1-10.

Surdu, A., Budala, D. G., Luchian, I., Foia, L. G., Botnariu, G. E., & Scutariu, M. M. (2024). Using AI in optimizing oral and dental diagnoses—a narrative review. *Diagnostics*, 14(24), 1-16.

van Nistelrooij, N., Maier, E., Bronkhorst, H., Crins, L., Xi, T., Loomans, B. A. *et al.* (2024). Automated monitoring of tooth wear progression using AI on intraoral scans. *Journal of Dentistry*, 150, 1-7.

Yunos, A. S., & Hamdan, M. N. (2025). Managing the ethical implications of artificial intelligence in healthcare: An analysis from Islamic perspectives. *Ulum Islamiyyah*, 37(02), 2.

CASE REPORT Open Access

Root separation and resection of a tooth with class II subclass B2 furcation involvement in a periodontitis patient: a case report

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Abstract

Furcation involvement is a clinical condition resulting from severe attachment loss and consequently requires complex periodontal management. Successful furcation closure can be achieved through nonsurgical and surgical management, although this is limited to proper case selection. This is a case report of a periodontitis patient with class II subclass B2 furcation involvement associated with moderate attachment loss. Based on the amount of bone loss and depth of furcation involvement, root separation and resection were planned for tooth 27 aimed at eliminating furcation involvement and facilitate plaque control. Following comprehensive nonsurgical periodontal therapy and elective endodontic therapy root separation and resection were performed. Buccal furcation was eliminated with larger space existed for oral hygiene maintenance. The objective of this case report was to comprehensively discuss the management of furcation involvement which involve resection of the root that cause inaccessibility to plaque control. The prognosis and alternative options for such therapy are comprehensively discussed. The results of this case may help clinician to decide the best therapy for their patient.

Keywords: *furcation involvement, nonsurgical periodontal therapy, periodontal therapy, periodontitis, surgical periodontal therapy*

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Introduction

Periodontitis is a multifactorial and chronic disease of the tooth-supporting structures, known to affect 38% of the Malaysian population (Oral Health Division, 2020). Worldwide, 12.5% of the population are affected (Nascimento *et al.*, 2024). Periodontitis is characterised by gingival inflammation and bleeding, deep periodontal pockets, tooth mobility, and alveolar bone loss. Long-standing periodontitis may result in periodontal abscess and eventually, tooth loss.

The first line of therapy involves improving plaque control through oral hygiene education and motivation followed by professional removal of calculus by scaling and root surface debridement (Badersten *et al.*, 1984; Suvan *et al.*, 2020). However, several factors may limit the effectiveness of nonsurgical therapy such as noncompliance, presence of furcation, pocket depth (Heitz-Mayfield *et al.*, 2020), therapist experience and infrabony pocket (Greenstein *et al.*, 1992) which may subsequently necessitate surgical management.

Currently several surgical interventions are available for the management of residual pockets using advanced biomaterials including open flap debridement, guided tissue regeneration, and minimally invasive surgical techniques. Furcation involvements are managed using techniques such as furcation plasty, guided tissue regeneration, root resection and tunnelling. This is a case report of a patient with furcation involvement managed using root separation and resection technique.

Case Report

A 70-year-old female patient was referred by an undergraduate student due to the presence of furcation involvement. She complained of food impaction at the upper left posterior teeth and requested a crown. Previously, she had undergone multiple nonsurgical periodontal therapies by an undergraduate dental student. The patient reported having hepatitis B, but in a dormant stage. She has never taken any medication for the disease. The discovery was incidental and she has never experienced any consequences from the disease. She is otherwise healthy. The patient reported discomfort due to large spaces between her teeth and hopes that crowns can close these spaces.

Extraoral examination revealed no facial asymmetry, cervical lymphadenopathy, or other abnormalities. Intraoral examination showed moderate oral hygiene, with a 25% plaque score and a 35% bleeding score. Generalized probing depths of 3 to 4mm were observed, with localised deep pockets at teeth 26 and 27. For tooth 26, buccal probing depths were 7mm, 3mm and 7mm at mesial, midbuccal and distal respectively. Palatal probing depths were 5mm, 2mm and 5mm at mesial, midpalatal and distal surfaces. Class II furcation involvement was present at the buccal and distal aspects, while mesial furcation was not involved. Severe gingival recession of 6mm was noted at the midpalatal surface, and the tooth exhibited grade II mobility.

Intraoral examination at tooth 27 revealed 4mm, 4mm and 6mm probing depths at mesiobuccal, midbuccal and distobuccal respectively. Palatally, the probing depths are 3mm, 2mm and 5mm at mesial, midpalatal and distal surfaces respectively. Furcation assessment revealed class I furcation involvement at buccal and class II at distal, with no mesial furcation involvement. Gingival recession was 1mm at all buccal and palatal surfaces except for distopalatal surface, 2mm. There was no mobility tooth 27. The gingiva surrounding tooth 27 furcation area was firm but slightly edematous with bleeding on probing observed. Both teeth 26 and 27 were confirmed vital via electric pulp testing. Figure 1 shows the furcation involvement at tooth 27 as measured with a Naber's probe.

Periapical radiographs (Figure 2 and Figure 3a) show horizontal bone loss affecting half the root length at teeth 26 and 27. There was a secondary caries underneath the restoration and extending into dentine at distal of tooth 27. The furcation radiolucency was not clear. There was 70% bone loss surrounding the distobuccal root of tooth 27. The separation angle and divergence of the roots of tooth 27 were small (Figure 3b). Figure 3c shows the root trunk of tooth 27. The coefficient of separation is defined as the length of root cones divide by the length of root complex. The coefficient of separation for tooth 27 is 0.79 (Figure 3d).

Figure 1. Tooth 27 with furcation involvement.

Figure 2. Intraoral periapical radiograph of tooth 27.

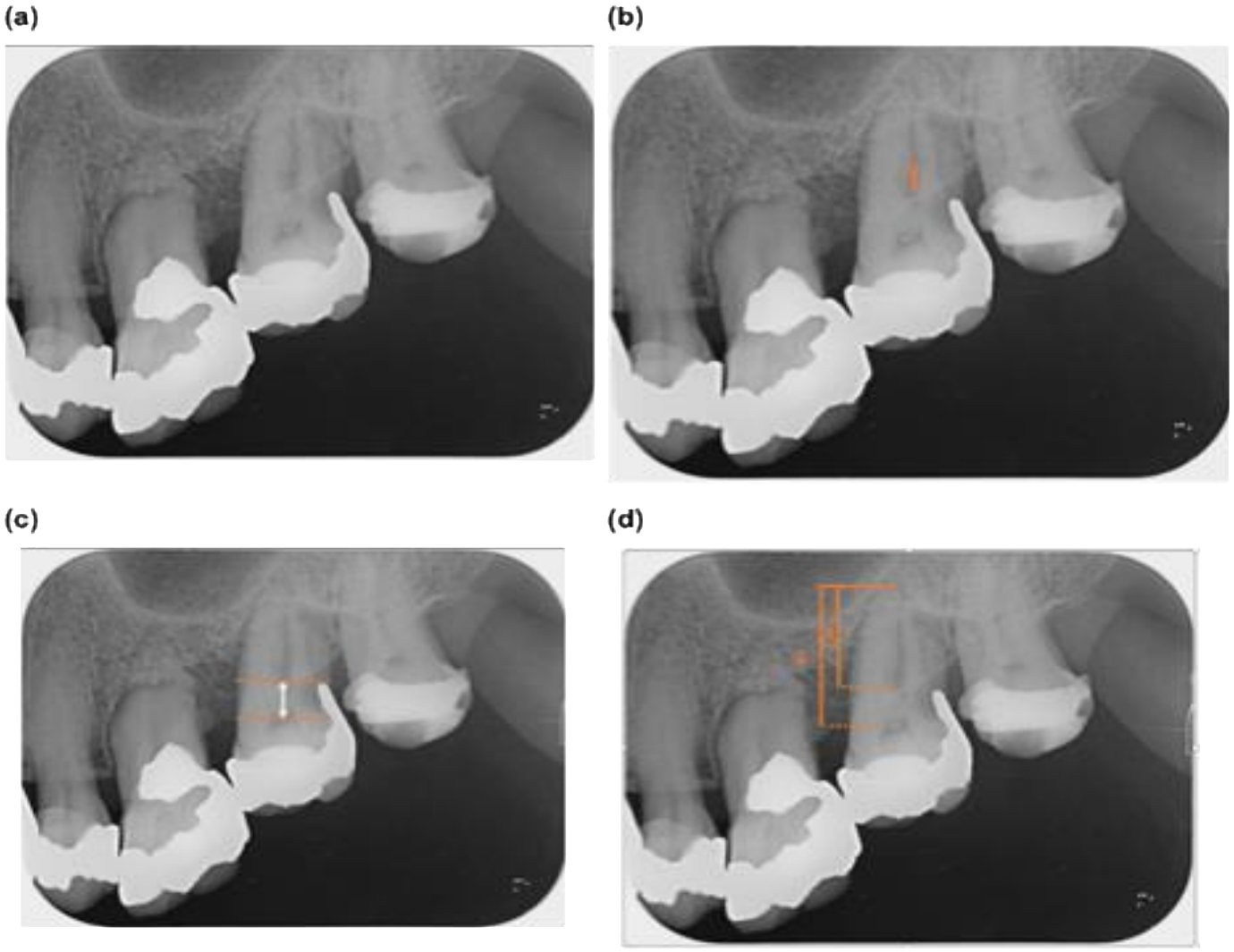

Figure 3. (a) Baseline radiograph. (b) Degree of separation. (c) Root trunk. (d) Coefficient of separation of the tooth 27.

Based on the clinical and radiographic findings, the patient was diagnosed with localised periodontitis stage III grade B currently unstable with no risk factors (Caton *et al.*, 2018). Stage III was given due to moderate to severe bone loss at tooth 27 while grade B due to moderate rate of progression. Bone loss to age ratio for this patient is 1. The patient received one round of nonsurgical periodontal therapy under the care of a periodontist to remove any residual calculus. At re-evaluation, the furcation involvement persisted. Surgical periodontal therapy was planned with the objective to eliminate distal furcation involvement and facilitate plaque control. Due to severe bone loss and significant furcation involvement, root resective surgery was planned for the distobuccal root of tooth 27, with elective endodontic therapy to be performed beforehand. Open flap debridement will be performed along on tooth 26 during surgery.

Elective endodontic therapy was carried out by a restorative specialist. The completed endodontic treatment of tooth 27 is shown in Figure 4(a). Surgical consent was obtained prior to the surgery date. During surgery, a mucoperiosteal flap was elevated from teeth 25 to 27 (Figure 4b). Root debridement was performed and teeth 26 and 27. There was class II furcation involvement at the distal furcation of tooth 27 (Figure 4c). The distobuccal root was separated and its mobility assessed. The root alone was mobile grade II, with approximately 20% of alveolar bone remaining. The root was resected (Figure 4d). Root surfaces and surrounding bone were smoothened. The flap was repositioned and sutured using 4-0 vicryl suture. Post-operative instructions were given. Analgesics and chlorhexidine mouthwash were prescribed.

The patient was reviewed at one week for suture removal, and at two weeks, one month, and three months for post-operative care. At one-week post-surgery, the distal surface was restored using glass ionomer and composite resin. By the three-month review, the distal area of tooth 27 demonstrated complete healing with the gingiva fully covering the resected root area (Figure 5). Buccal probing depths were 4 mm at mesial, midbuccal and distal. Palatally, the probing depths were 4mm, 4mm and 5mm at mesial, midpalatal and distal. Buccal furcation involvement was eliminated by the removal of distopalatal root. There was a class II furcation involvement at distal with larger spacing and thus, more accessible oral hygiene compared to before root resection. The restoration surface was further smoothened using white stone bur. Fluoride was applied to the root of 27 to prevent root caries. Motivational advice was given to the patient regarding plaque control maintenance and frequent toothbrushing using interdental cleaning.

Discussion

Current evidence reports successful periodontal therapy following plaque control and non-surgical debridement (Suvan *et al.*, 2020; Albeshri & Greenstein, 2022). However, several limitations exist, including infrabony defect (Iorio-Siciliano *et al.*, 2025), furcation involvement (El Mobadder *et al.*, 2024), diabetes status (Hsu *et al.*, 2019), and the skill of the therapist, which contribute to the maintenance of the deep pocket following reassessment. In this case, the patient received several cycles of nonsurgical periodontal therapy which include oral hygiene education and motivation, scaling and root surface debridement by undergraduate student, supervised by periodontist. This is in line with the S3 level clinical practice guideline which involve supragingival dental biofilm control through behavioural change and professional mechanical plaque removal (PMPR) in the first step of therapy (Sanz *et al.*, 2020). The second therapy which is aimed at controlling subgingival biofilm and calculus are also delivered by undergraduate student through root surface debridement and reassessment.

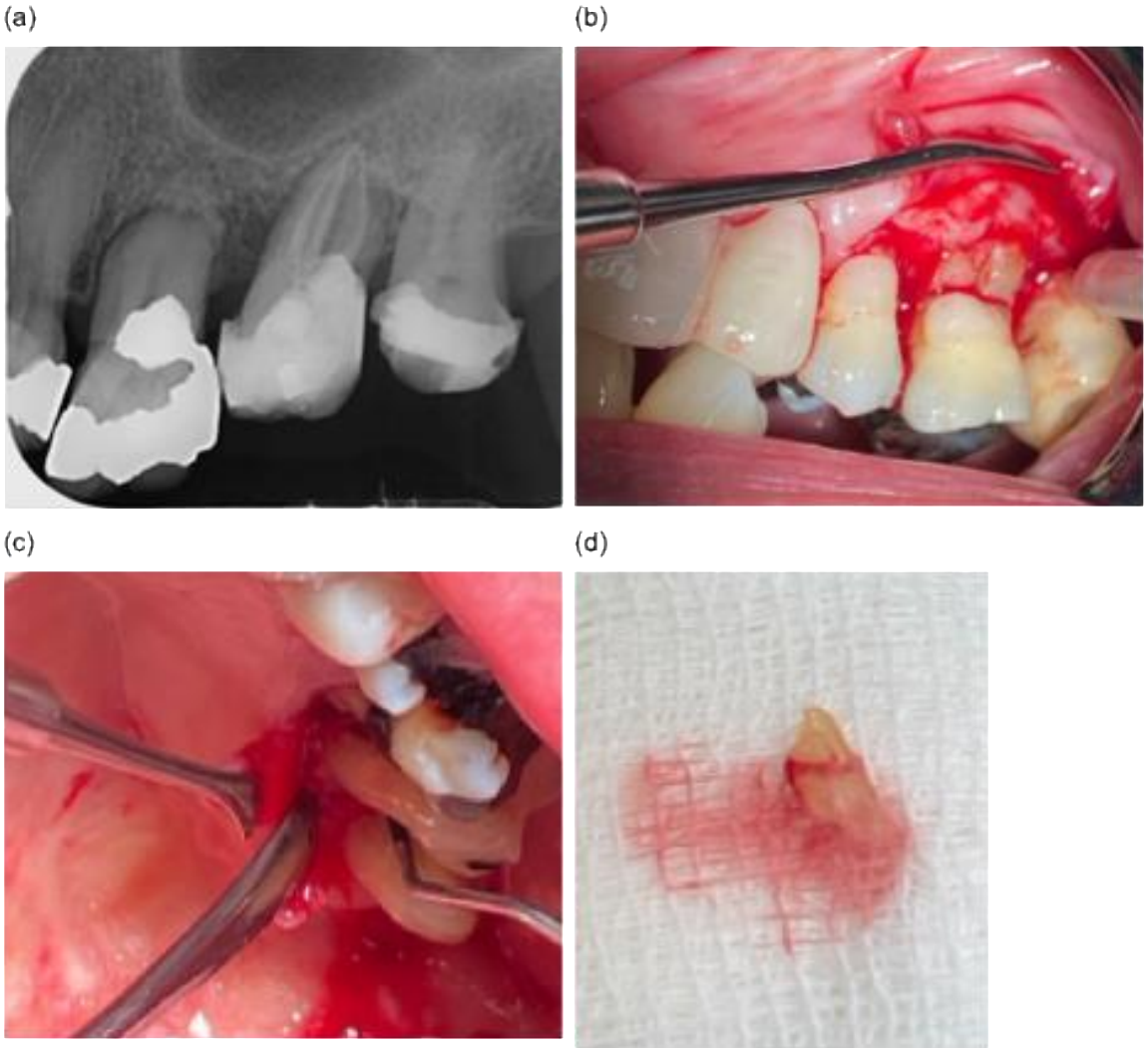

Figure 4. Intraoral periapical radiograph of obturated tooth 27, (b) mucoperiosteal flap elevation (c) class II furcation involvement of distal tooth 27 (d) resected distal root of tooth 27.

Figure 5. Post-operative review of tooth 27.

The goal of root surface debridement is to render the root free of microbial deposits and plaque-retentive factors such as calculus (Rateitschak-Pluss *et al.*, 1992). The hand instrument most suitable for subgingival debridement is the curette. Effective debridement depends on correct usage, with 80º being the optimal angle; too acute an angle results in inefficient calculus removal, while too obtuse an angle causes roughening of the surface. A finger rest enables the operator to achieve optimal angulation and allows wrist-forearm motion, as well as the use of different angles of debridement strokes to cover all aspects of the root surface (Lang & Lindhe, 2015). These correct debridement techniques must be practised and improved over time. Evidence shows a significantly inferior periodontal treatment outcome following therapy by undergraduate students compared to periodontal residents (Kozlovski *et al.*, 2018).

Nevertheless, several limitations exist independent of the therapist's level, such as bone irregularities, pocket depth (Heitz-Mayfield *et al.*, 2002), and furcation involvement, which require surgical management (Sekino *et al.*, 2022). The patient in this case has class II furcation involvement at teeth 26 and 27 at the time of referral. Class II is characterised by probable furcation involvement of more than 3 mm, but the involvement is not through and through (Hamp *et al.*, 1975). Several other classifications exist (Patil & Shetty, 2021) based on the anatomical area involved. Rasperini and colleagues introduced a decision guideline using two types of classification: horizontal and vertical criteria (Rasperini *et al.*, 2020). The vertical classification describes three subclasses: A, when bone loss extends to the coronal third of the root; B, when bone loss extends to the middle third; and C, when bone loss extends to the apical third (Tonetti *et al.*, 2017). The patient in this case has bone loss extending to the middle third at the mesial of 27, but at the distal area, bone loss extends nearly to the apical third of the root length. Therefore, subclass B2 was assigned.

Based on Sanz *et al.*, 2020, the third step of therapy is aimed at treating those areas of dentition non-responding adequately to the second step of therapy which may include interventions such as repeated subgingival instrumentations, access flap, regenerative and resective periodontal surgery (Sanz *et al.*, 2020). Several options are available in this case to eliminate the furcation involvement: furcation plasty, root separation and resection (RSR), and regeneration. Furcation plasty is not possible due to extensive bone loss. For

regenerative therapy to be successful, there should be a keyhole type of class II involvement to allow the membrane to be retentive. In addition, there were less favourable results following GTR in maxillary molars (Pontoriero & Lindhe, 1995). The decision regarding root separation and resection in this case was based on the aim to eliminate furcation involvement and facilitate plaque control. A short root trunk, wide divergence, and stability of individual roots are criteria that increase the success rate of such therapy. The distobuccal root of a maxillary molar is the shortest of the three roots; thus, the distal root has a small amount of bone support. Once separated, the individual root cone may exhibit increased mobility. The distobuccal root is often removed in root separation and resection cases (Ross & Thompson 1980).

However, the prognosis of such tooth following RSR remains questionable. The survival rates of a tooth following RSR depends on factor such as self-plaque control, remaining bone level and corrective therapy. Based on a systematic review on resective surgery, for class II furcation involvement, scaling and root debridement resulted in similar survival rate as root resection (Dommisch *et al.*, 2020). However, it was also reported that class II and III furcation involved teeth exhibits significantly higher risk of tooth loss compared to class I furcation involved teeth. Therefore, resective surgery is applied to improve long-term survival of these teeth (Dommisch *et al.*, 2020). In another retrospective study, only 3.5% of cases with class II furcation had furcation closure after nonsurgical periodontal therapy (Hamp *et al.*, 1975). Rasperini *et al.* stated that cases with C2 classification should be managed with advanced nonsurgical periodontal therapy and maintenance. Resective surgery was indicated only in Class III furcation, regardless of the level of bone loss (Tonetti *et al.*, 2017). When favourable root attachment is present, it is recommended to separate the crown from its respective portions by performing a bicuspidalisation procedure to eliminate the furcation area. Additionally, Carnevale reported a 93% survival rate for root-resected teeth in a 10-year longitudinal study (Carnevale *et al.*, 1998). Similar results were observed in another study in 2024 (Fugazzotto *et al.*, 2024).

In addition, retaining natural teeth is more cost-effective than implant tooth replacement therapy. When compared towards implant-supported crown, retained natural teeth with furcation management is less costly (Schwendicke *et al.*, 2014). Furthermore, when compared with most periodontal treatments, implant-supported crowns were retained for shorter time regardless of the degree of furcation involvement, the patient's age or profile (smoker) (Schwendicke *et al.*, 2014).

In general, teeth with a questionable prognosis require complex therapy to prolong their survival. It is crucial to consider every patient-related criterion before making any decision. The side effects and any required changes in oral hygiene must be discussed with the patient. Within the limitations of the present article, the author suggests a thorough anatomical assessment and prognostic evaluation prior to root resection to ensure a favourable outcome.

Conclusion

In conclusion, the management of deep periodontal pockets with furcation involvement, as illustrated in this case, highlights the limitations of nonsurgical therapy alone, particularly when performed by less experienced clinicians such as undergraduate students. While initial debridement achieved partial pocket reduction, persistent class II furcation with advanced vertical bone loss necessitated consideration of surgical intervention. Given the anatomical characteristics and

classification of the furcation defects, root separation and resection were deemed appropriate to improve access for plaque control and potentially enhance long-term tooth retention. However, the success of such procedures remains highly dependent on accurate diagnosis, proper case selection, and ongoing patient commitment to oral hygiene and maintenance. Therefore, comprehensive clinical evaluation and informed patient involvement are critical in managing teeth with a compromised prognosis.

Consent for Publication

Written informed consent was obtained from the patient prior to publication.

Competing Interests

The author declares that there are no competing interests.

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References

Albeshri, S., & Greenstein, G. (2022). Efficacy of nonsurgical periodontal therapy for treatment of periodontitis: practical application of current knowledge. *General Dentistry*, 70(5), 12-19.

Badersten, A., Nilveus, R., & Egelberg, J. (1984). Effect of nonsurgical periodontal therapy: II. Severely advanced periodontitis. *Journal of Clinical Periodontology*, 11(1), 63-76.

Carnevale, G., Pontoriero, R., & Di Febo, G. (1998). Long-term effects of root-resective therapy in furcation-involved molars: a 10-year longitudinal study. *Journal of Clinical Periodontology*, *25*(3), 209-214.

Caton, J. G., Armitage, G., Berglundh, T., Chapple, I. L., Jepsen, S., Kornman, K. S. *et al.* (2018). A new classification scheme for periodontal and peri-implant diseases and conditions–Introduction and key changes from the 1999 classification. *Journal of Periodontology*, 89, S1-S8.

Dommisch, H., Walter, C., Dannewitz, B., & Eickholz, P. (2020). Resective surgery for the treatment of furcation involvement: a systematic review. *Journal of Clinical Periodontology*, 47, 375-391.

El Mobadder, M., El Kontar, M., & Husseini, B. (2024). Minimally invasive non-surgical periodontal therapy and photoactivated disinfection for the treatment of furcation involvement. *Cureus*, 16(10).

Fugazzotto, P. A. (2001). A comparison of the success of root resected molars and molar position implants in function in a private practice: results of up to 15-plus years. *Journal of Periodontology*, 72(8), 1113-1123.

Greenstein, G. (1992). Periodontal response to mechanical non-surgical therapy: a review. *Journal of Periodontology*, 63(2), 118-130.

Hamp, S. E., Nyman, S., & Lindhe, J. (1975). Periodontal treatment of multi rooted teeth. Results after 5 years. *Journal of Clinical Periodontology*, 2(3), 126-135.

Heitz-Mayfield, L. J. A., Trombelli, L., Heitz, F., Needleman, I., & Moles, D. (2002). A systematic review of the effect of surgical debridement vs. non-surgical debridement for the treatment of chronic periodontitis. *Journal of Clinical Periodontology*, 29, 92-102.

Hsu, Y. T., Nair, M., Angelov, N., Lalla, E., & Lee, C. T. (2019). Impact of diabetes on clinical periodontal outcomes following non-surgical periodontal therapy. *Journal of Clinical Periodontology*, 46(2), 206-217.

Iorio-Siciliano, V., Blasi, A., Mauriello, L., Salvi, G. E., Ramaglia, L., & Sculean, A. (2025). Non-Surgical Treatment of moderate periodontal intrabony defects with adjunctive cross-linked hyaluronic acid: a single-blinded randomized controlled clinical trial. *Journal of Clinical Periodontology*, 52(2), 310-322.

Kozlovsky, A., Rapaport, A., & Artzi, Z. (2018). Influence of operator skill level on the clinical outcome of non-surgical periodontal treatment: a retrospective study. *Clinical Oral Investigations*, 22(8), 2927-2932.

Lang, N. P., & Lindhe, J. (Eds.). (2015). *Clinical Periodontology and Implant Dentistry, 2 Volume Set*. John Wiley & Sons.

Nascimento, G. G., Alves-Costa, S., & Romandini, M. (2024). Burden of severe periodontitis and edentulism in 2021, with projections up to 2050: the global burden of disease 2021 study. *Journal of Periodontal Research*, 59(5), 823-867.

Oral Health Division. (2020). National Oral Health Survey for Adults 2020. Page 9, Retrieved from: https://hq.moh.gov.my/ohp/index.php/ms.

Patil, A., & Shetty, S. (2021). Classification of furcation involvement-a literature review. *International Journal of Research and Review*, 9(3), 6-17.

Pontoriero, R., & Lindhe, J. (1995). Guided tissue regeneration in the treatment of degree III furcation defects in maxillary molars. *Journal of Clinical Periodontology*, 22(10), 810-812.

Rasperini, G., Majzoub, J., Limiroli, E., Barootchi, S., & Hill, R. (2020). Management of furcation-involved molars: recommendation for treatment and regeneration. *International Journal of Periodontics & Restorative Dentistry*, 40(4).

Rateitschak-Plüss, E. M., Schwarz, J. P., Guggenheim, R., Duggelin, M., & Rateitschak, K. H. (1992). Non-surgical periodontal treatment: Where are the limits? an SEM study. *Journal of Clinical Periodontology*, 19(4), 240-244.

Ross, I. F., & Thompson Jr, R. H. (1980). Furcation involvement in maxillary and mandibular molars. *Journal of Periodontology*, 51(8), 450-454.

Sanz, M., Herrera, D., Kebschull, M., Chapple, I., Jepsen, S., Berglundh, T., Sculean, A., Tonetti, M.S., & Wennström, J. (2020). Treatment of stage I–III periodontitis—the EFP S3 level clinical practice guideline. *Journal of Clinical Periodontology*, 47, 4-60.

Schwendicke, F., Graetz, C., Stolpe, M., & Dörfer, C. E. (2014). Retaining or replacing molars with furcation involvement: A cost-effectiveness comparison of different strategies. *Journal of Clinical Periodontology*, 41(11), 1090-1097.

Sekino, S., Wada, K., Sano, T., Inoue, Y., Komaki, R., Yabuki, K., Fukuda, T., & Numabe, Y. (2022). The effect of non-surgical periodontal therapy on furcation involvement: Retrospective study. *Journal of Interdisciplinary Clinical Dentistry*, 3(2), e002.

Suvan, J., Leira, Y., Moreno Sancho, F. M., Graziani, F., Derks, J., & Tomasi, C. (2020). Subgingival instrumentation for treatment of periodontitis. A systematic review. *Journal of Clinical Periodontology*, 47, 155-175.

Tonetti, M. S., Christiansen, A. L., & Cortellini, P. (2017). Vertical subclassification predicts survival of molars with class II furcation involvement during supportive periodontal care. *Journal of Clinical Periodontology*, 44(11), 1140-1144.

CASE REPORT Open Access

A case report of minimally invasive strategies for denture support in a geriatric patient with medical comorbidities

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Abstract

Geriatric patients in dentistry commonly present with medical comorbidities. It is necessary to thoroughly evaluate the patient's medical condition and then develop appropriate treatment plans, which provide greater benefits and help prevent medical complications. This case report describes the prosthodontic management of a geriatric female with partial edentulism, longstanding denture use, and systemic diseases, emphasising individualised care in a high-risk patient. A 69-year-old Chinese woman attending the Universiti Sains Islam Malaysia Polyclinic complained of a loose upper acrylic denture worn for 30 years, and presented with multiple caries, generalized recession and partial edentulism in both arches. She had a history of hepatitis B managed with medication and maintained follow-up, and shoulder cancer that finished chemotherapy 10 years ago. A black, purplish lesion on the left buccal mucosa adjacent to tooth 28 was detected during clinical examination. Strict infection control protocols were employed throughout treatment following her medical history. Pre-prosthetic procedures, including maintaining her oral hygiene, restoration, root canal treatment before denture construction, were done under proper management due to the patient's history of trismus. The case emphasized the challenges of prosthodontic management in geriatric patients with systemic disease and compromised dentition. The integration of restorative procedures and denture construction aimed to restore function and improve quality of life is discussed while considering the patient's systemic comorbidities.

Keywords: *dentures, geriatric, prosthodontics, root canal treatment, trismus*

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Introduction

According to the World Health Organisation, by 2030, one in every six individuals worldwide will be aged 60 years and above. The global population of the elderly is projected to increase from 1 billion in 2020 to 1.4 billion by 2030, and this figure is expected to double to approximately 2.1 billion by 2050 (World Health Organisation, 2024). The rapid growth of the ageing population has been accompanied by increasing awareness and demand for oral healthcare services among the elderly patients, also known as geriatric patients. This has brought better dental-educated geriatric patients with partial edentulism. On the other side, geriatrics are often presented with general health problems that are age-dependent, with specific dental problems of the remaining teeth (Sadatullah *et al.*, 2013). While in the prosthodontic management, the aim is to provide better masticatory functions as well as phonetics and aesthetics. However, significant

alterations in oral health due to aging can complicate the management. These problems require special skills on the part of the dentist to deal with aging dentitions (Zini and Pietrokovsky, 2006).

Geriatrics with partially edentulous requires proper assessments of the abutment teeth. The abutment condition offers the choice of both removable and fixed prostheses. Clinical presentation and various types of fixed or removable prostheses, alternatives and variations of design pose challenges in deciding a treatment plan (Sadatullah *et al.*, 2013). Furthermore, prosthetic design depends on the number and location of the abutments (Sadatullah *et al.*, 2013; Mericske-Stern, Taylor, & Belser, 2000).

Trismus or limited mouth opening poses significant challenges in dental management. It is a multifactorial etiology that may be derived from trauma, temporomandibular joint disorders (TMD), malignancies and radiation therapy (Mohammed *et al.*, 2024). Prosthodontic and restorative management need special consideration in terms of duration of procedures, application of rubber dam and impression taking procedures.

This case report will discuss strict infection control protocols employed throughout treatment following her medical history of Hepatitis B, followed by the pre-prosthetic procedures, including maintaining her oral hygiene, restoration, and root canal treatment of the left lower second molar, before denture construction, which were done under proper management due to the patient's history of trismus. The patient had consented

Case Report

A 69-year-old Chinese lady came to Dental Polyclinic Universiti Sains Islam Malaysia (USIM) with a complaint of loose upper acrylic denture and requested a new set of dentures. Her upper denture is loose due to the missing teeth. She had worn the upper denture for 30 years. She was diagnosed with hepatitis B in the past 4 years ago and is still on anti-viral medication, Ricovir® and follows up every 6 months. She also has a history of shoulder cancer 14 years ago and had undergone chemotherapy; the last cycle of chemotherapy was 10 years ago.

Upon examination, she presented with a black purplish lesion (5mm x 5mm) on the left buccal mucosa adjacent to tooth 28 (Figure 1). The surface of the lesion is irregular, and upon palpation, it is non-tender. Upon occlusion, there is no cheek biting or trauma on the lesion area. Further check-up with Oral Pathology Oral Medicine (OPOM) USIM specialist had been done, and the blanching test was negative. Upon examination, the differential diagnosis was haemangioma and oral varices. The lesion needs to be reviewed and observed for any changes in size or colour. The patient had been referred under the OPOM clinic for regular assessment of the lesion.

She also presented with multiple carious teeth and generalized recession with tooth surface loss and partially edentulous on the upper and lower arches, as presented in the intraoral photos of Figure 2 (a-c). (a)The maxillary residual ridge has mild resorption, regular shape with normal mucosal thickness. There is presence of unilobulated torus palatinus 5x5 mm with average depth of palatal vault. (b) The mandibular residual ridge it has a moderate ridge resorption and a regular shape with normal mucosal thickness. Both arches are U-shape. (c) Incisors and molars relationship were undefined with no severe tooth surface loss. Even though the patient had a history of chemotherapy, the saliva was of normal consistency.

Figure 1. Pre-operative- black purplish lesion on left buccal mucosa to tooth 28.

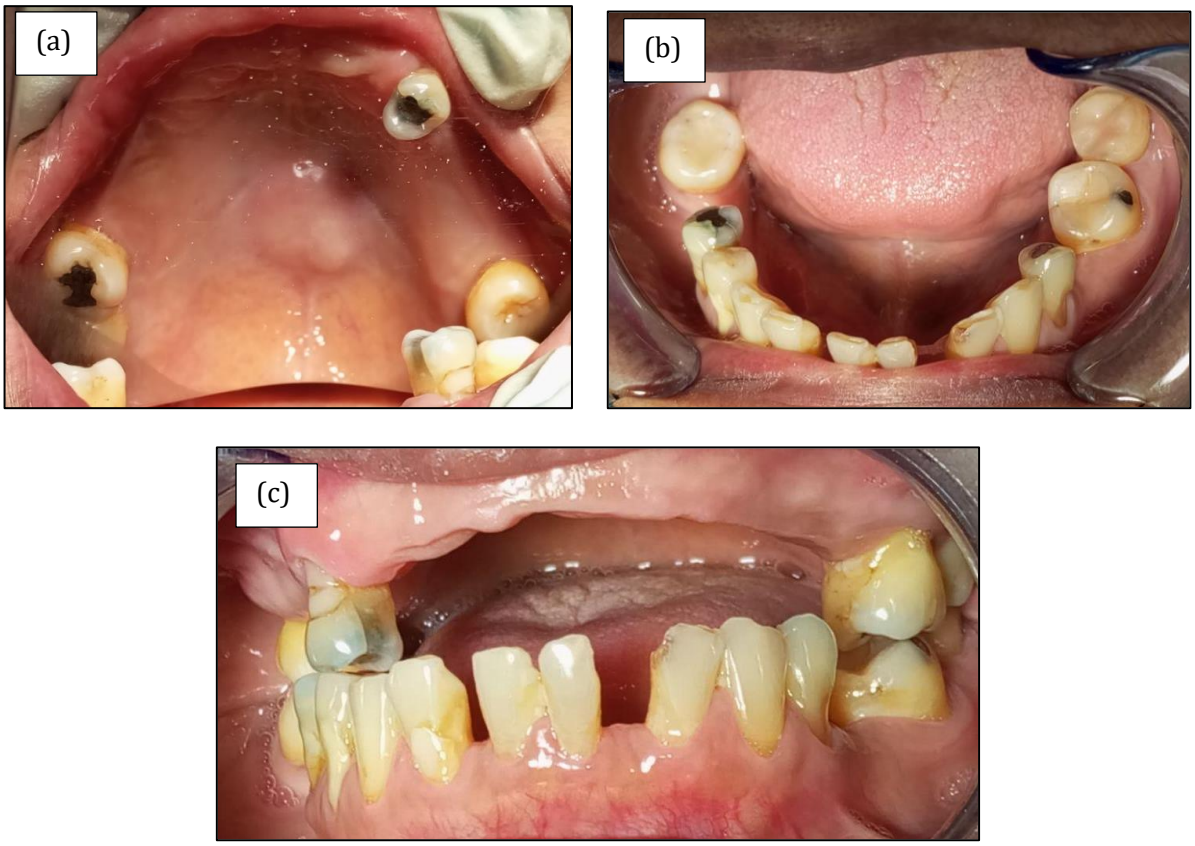

Figure 2. (a) Intraoral view of upper arch. (b) Intraoral view of lower arch. (c) Intraoral view during intercuspal position.

She also had history of open lockjaw due to trismus three times, which requires a proper precaution during a long duration of treatment, especially restorative part. Temporomandibular joint (TMJ) examination showed that there is clicking sound on the left TMJ without mandibular deviation.

Due to the blood-borne disease and high risk of infection, infection control is amplified by using full personal protective equipment (PPE) during treatment. Before denture construction, other treatments such as oral hygiene education, restoration of carious teeth, full mouth scaling and polishing were done. A metal onlay on tooth 37 was done as a definitive restoration after the root canal treatment. Root canal treatment on 37 was treated by a restorative specialist due to the severe apical root curvature of the tooth, shown in Figure 3 (a). There is present of radiopacity on occlusal of 37 extend until pulp chamber and presence of radiolucency at the apical area of the mesial root. The patient had undergone around three to four visits to complete the root canal treatment. She had a history of lockjaw once during the treatment. Due to the prolonged duration of treatment, her treatment duration was reduced.

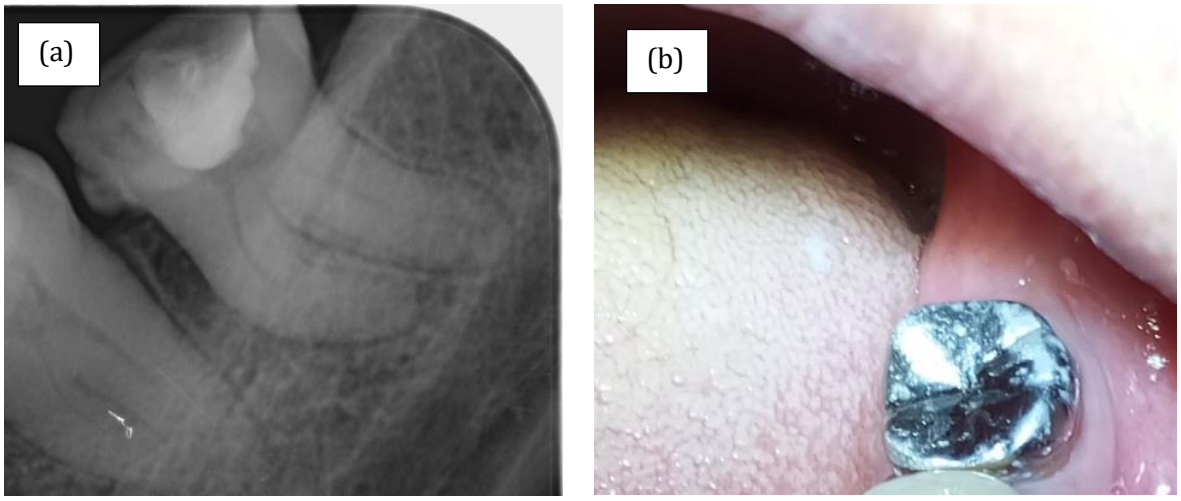

Figure 3. (a) Periapical of 37. (b) Full metal onlay on 37.

Metal onlay (Figure 3 (b)) was chosen as the definitive restorative material because 37 has a short crown height with loss of mesiolingual cusp. Therefore, to preserve the remaining sound tooth structure and durability of the tooth on occlusion, a metal onlay is the less invasive option compared to other materials such as zirconia or porcelain-fused-to-metal. One-millimeter occlusal reduction was done before chamfer margin was prepped one millimeter below occlusal surface. During the tooth preparation, to avoid recurrent lockjaw, the patient was instructed to open her mouth comfortably, and intermittent rest for the patient to close her mouth was provided. This aids in reducing over-exertion and strain towards the patient's TMJ and muscles. For aerosol procedures such as tooth preparation, an isolation room was booked prior to the appointment day to ensure infection control. Furthermore, full PPE and double gloving were practiced along with the usage of high-volume suction to reduce the risk of contamination. Disposable examination sets were used to avoid cross-contamination, and other dental instruments were soaked in a different disinfection solution that contains a higher concentration.

Upper and lower cobalt-chrome (Co-Cr) partial dentures were constructed for the patient to replace the missing teeth as presented in the intraoral photos of Figure 4 (a-c). A Co-Cr partial denture was chosen due to the lack of remaining teeth on the upper arch, which may compromise the retention of the acrylic denture. The palatal coverage of the denture was also taken into consideration, where acrylic dentures need full palatal coverage to increase retention, while Co-Cr dentures have less palatal coverage, i.e. horse-shoe shape major connector which aids in releasing the torus palatinus area. Moreover, Akers' clasp was

chosen as the design on 27 Distal and 28 Mesial to provide stability and bracing. The lower denture was designed with a lingual bar as the major connector. The denture was reviewed after 2 months due to the time restriction of the clinical schedule. Fortunately, the patient could eat and speak well with the denture, and there was no complaint of pain. However, there was slight discomfort in her lower denture, i.e. food stuck on the lingual bar. Upon examination, there is no gap at the lingual bar, and reassurance was given to the patient along with the denture hygiene instruction.

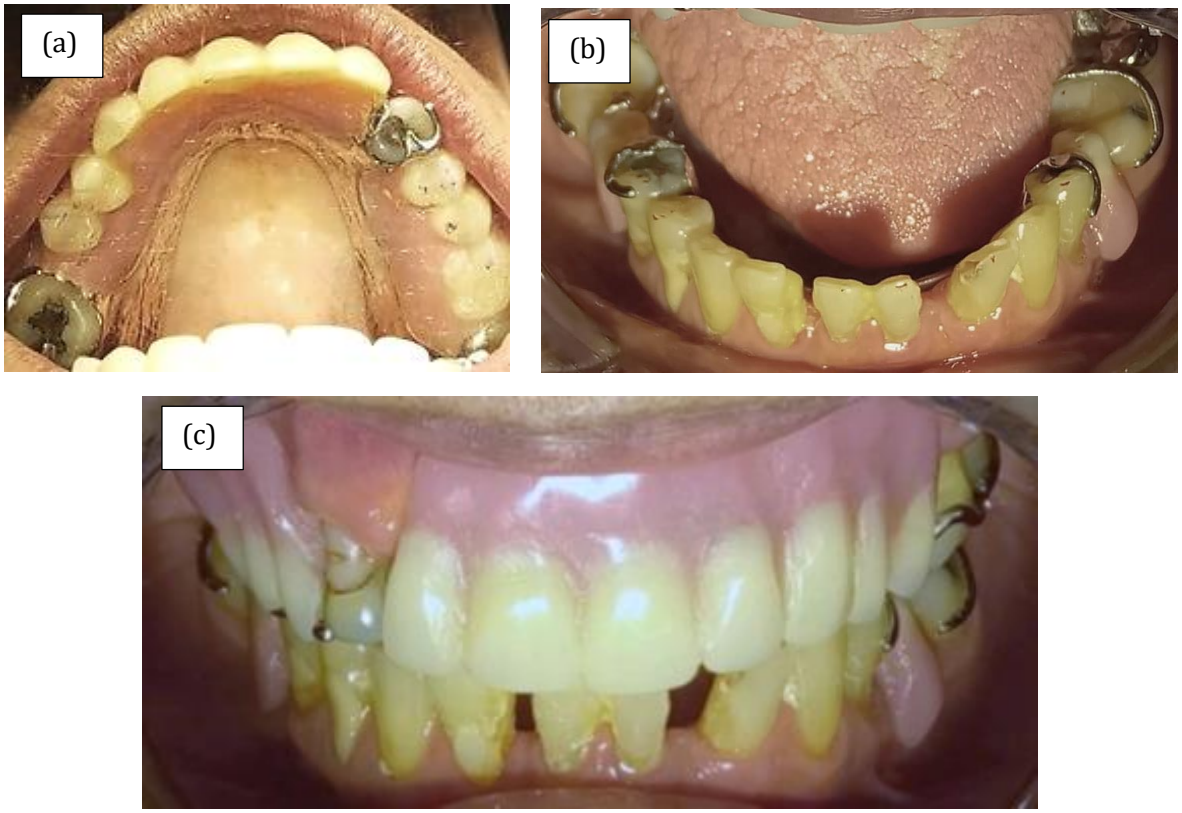

Figure 4. (a) Intraoral view of upper arch. (b) Intraoral view of lower arch. (c) Intraoral view during intercuspal position.

Discussion

This case study explained the complexity of managing a geriatric patient who has a history of hepatitis B, previous malignancy and TMD. It requires a multidisciplinary approach as the systemic comorbidities demand a beneficial prosthodontic rehabilitation as well as balancing the patient's medical risks by emphasizing a minimally invasive and functional restorative management with good infection control protocol.

1. Consideration of factors during treatment planning of a geriatric patient

A comprehensive dental treatment plan for geriatric patients requires holistic management that considers careful multiple connections with their health factors and a patient-centered approach (Ettinger *et al.*, 2021). Factors to be considered are the patient's cognitive status, functional ability, and psychological expectations (Ettinger *et al.*, 2021). Understanding the patient's expectations is important. In this case, even though patients request a denture, a comprehensive treatment needs to be handled before the denture can be

constructed. Managing a proper and correct dental need will help improve the patient's quality of life, thus improving patient satisfaction towards the given treatment. Apart from that, it is important to inform the patient regarding the treatment plan to align treatment goals with realistic expectations and to avoid any miscommunication.

Patients who have a history of TMJ problems, such as lockjaw, are also affected by procedural treatment. Stress may contribute to TMD, which is usually common in geriatric patients. The stress tolerance of each patient is varied, so the practitioner should identify their patient's stress tolerance towards dental treatment. Lockjaw or TMJ dysfunction may limit mouth opening, as in this patient's history, which may indicate that she has a progressive TMJ problem. Methods can be done to avoid TMJ problems during treatment, such as shortened appointment duration, muscle relaxation techniques and intermittent jaw rest, which was adopted in this case (Yadav *et al.*, 2018).

2. Prevalence of geriatric patients with medical comorbidities

A study conducted at King Saud Medical City reported a high prevalence of comorbidities among geriatric patients aged over 65 years. Among the total cohort of 5,874 patients, 2,394 individuals (40.7%) were diagnosed with a single disease, whereas 3,482 patients (59.3%) experienced more than one chronic illness. These findings highlight the substantial burden of comorbidity among the elderly population (Salem *et al.*, 2021).

Similarly, previous studies conducted in Malaysia have demonstrated that the prevalence of comorbidities among the elderly ranges widely from 15.8% to 83.0%, with a notably higher prevalence among individuals aged 75 years and above. In support of these findings, research by Shariff Ghazali *et al.* estimated that approximately 40.6% of Malaysians aged 60 years and older suffer from comorbid conditions. This evidence suggests that comorbidities represent a significant public health concern among the ageing population in Malaysia. (Shariff Ghazali *et al.*, 2021).

In addition, chronic infectious diseases continue to contribute substantially to the disease burden in Malaysia. It is estimated that approximately one million individuals in Malaysia are chronically infected with hepatitis B, accounting for nearly 75% of all viral hepatitis cases in the country. The prevalence of hepatitis B infection is reported to be higher among males, with a male-to-female ratio of 2:1. Ethnic disparities have also been observed, with incidence rates reported among Chinese, Malays, and Indians at 36%, 26%, and 15%, respectively. In the present case, the patient was a 69-year-old Chinese female with hepatitis B infection, which, concurrent with a previous study, has reported that hepatitis B has higher incidence rates observed among the Chinese population compared to other ethnic groups. Furthermore, data from the Malaysian Ministry of Health indicate that approximately 5% of Malaysians are affected by hepatitis B, while more than 80% of hepatitis B and hepatitis C patients are within the economically productive age group of 25 to 55 years (Raihan, 2016).

Moreover, a study by Ahmad identified several modifiable lifestyle and socioeconomic factors as important predictors of chronic and non-communicable diseases among the elderly population. These factors include diets high in saturated fats, tobacco consumption, physical inactivity, low socioeconomic status, and limited educational attainment (de Lima *et al.*, 2020).

3. Management and infection control of the medically compromised geriatric patient

This patient has a history of hepatitis B. It is important to manage patients with correct infection control protocol and enhance strict cross-infection control procedures. High-volume suction and proper personal protective equipment (PPE) will

significantly reduce the aerosol contamination during prosthodontic and restorative procedures. Adherence to the latest protocol of infection control, especially the post-pandemic infection control recommendations, is suggested. In the present case, the Infection Control Guideline v3 (4.0 FPG) was used in the management of high-risk patients, including those with Human Immunodeficiency Virus (HIV) infection, as well as patients with hepatitis A, B, and E, among others.

4. Endodontic and restorative treatment consideration in the geriatric patient

Ageing-related changes to dentition can significantly impact root canal treatment (RCT) in geriatric patients. Aging leads to calcification of canals, enamel wear, dentin sclerosis, and reduced pulpal volume, which complicate root canal procedures (AlRahabi, 2019). In this case, the decision to preserve tooth 37 with a metal onlay after endodontic therapy is aimed at the conservative approach that maintains occlusal function and improves prosthesis support, thus improving the patient's quality of life.

However, RCT in geriatric patients presents technical difficulties due to the calcification and reduced size of the pulp chamber, making access and instrumentation more complicated. In this case, referral to an endodontist may be necessary for the second or third molars if there is extreme inclination (>30°), as it can be highly complex and may require specialised expertise for successful treatment. Minimally invasive indirect restorations such as metal onlays are preferred in geriatric patients' dentition due to their longevity, marginal integrity, and reduced need for extensive tooth reduction. Hence, proper case selection and early referral can improve outcomes and ensure the best possible care for geriatric patients requiring endodontic therapy (AlRahabi, 2019).

5. Denture construction and the functional outcome in a geriatric patient

Denture construction in geriatric patients must provide good function, comfort and design to be able to maintain good oral hygiene. Furthermore, understanding patient preferences is essential, as some may have concerns about aesthetics, comfort, or functionality. Addressing their complaints and the purpose of requesting dentures while setting a realistic expectation to ensure their satisfaction is also important, as dentures may not fully replicate the feel and function of natural teeth.

Additionally, patient adaptation is also a key element, as elderly individuals may require time and guidance to adjust to their new prosthesis. A well-fitted partial denture is crucial, as shown in this study, to improve masticatory function and social confidence, thus quality of life. Furthermore, able to contribute to better nutritional intake and systemic health stabilization in geriatrics with medically compromised individuals (Friel and Waia, 2020). Proper counselling and follow-up appointments can enhance compliance and overall success in denture wear (Friel and Waia, 2020; Bellia *et al.*, 2023).

Conclusion

This study showed that proper planning of a holistic treatment plan may contribute to a good treatment outcome without compromising the geriatric patient's needs and expectations. Treatment for medically comorbid geriatric patients requires comprehensive assessment, strict infection control protocols and simple restorative and prosthodontic management to ensure good functional and aesthetic outcomes.

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Declaration of generative AI and AI-assisted technologies for grammar and style

refinement during the preparation of this manuscript. The intellectual content of the manuscript remains entirely the work of the authors. Furthermore, written informed consent was obtained from the patient for publication of this case report and accompanying images.

References

AlRahabi M. K. (2019). Root canal treatment in elderly patients: a review and clinical considerations. *Saudi Medical Journal*, 40(3), 217–223.

Bellia, E., Monagheddu, C., Notaro, V., Ceruti, P., & Bassi, F. (2023). Relationship between oral rehabilitation and nutrients intake in the independent elderly: a systematic review of the literature. *Journal of Gerontology and Geriatrics*, 71, 187-205.

de Lima, J. D., Teixeira, I. A., Silva, F. de O., & Deslandes, A. C. (2020). The comorbidity conditions and polypharmacy in elderly patients with mental illness in a middle income country: a cross-sectional study. *IBRO Reports*, 9, 96–101. https://doi.org/10.1016/j.ibror.2020.07.008

Ettinger, R., Marchini, L., & Hartshorn, J. (2021). Consideration in planning dental treatment of older adults. *Dental Clinics of North America,* 65(2), 361–376.

Friel, T., & Waia, S. (2020). Removable partial dentures for older adults. *Primary Dental Journal*, 9(3), 34–39.

Mericske-Stern, R. D., Taylor, T. D., & Belser, U. (2000). Management of the edentulous patient. *Clinical Oral Implants Research*, 11, 108-125.

Mohammed Binhuraib, H., Almousa, W. S., Nasser, T. M., Alwasifr, A. R., Almutawa, M. Y., Alsufyani, A. A. *et al.* (2024). Prosthodontic care for patients with trismus: a comprehensive review. *International Journal of Community Medicine and Public Health*, 12(1), 550–554.

Raihan, R. (2016). Hepatitis in Malaysia: Past, present, and future. *Euroasian Journal of Hepato-Gastroenterology*, 6(1), 52–55. https://doi.org/10.5005/jp-journals-10018-1167

Sadatullah, S., Al Moaleem, M., Assiry, A. and Eid, H. (2013). Full mouth rehabilitation of a geriatric patient. *Saudi Journal for Health Sciences*, 2(1), 67–72.

Salem Alsuwaidan, Abrar Algharbi, Shrooq Alyami, Norah Almukhlifi (2021). Prevalence of comorbidity among elderly. *Global Journal of Aging & Geriatric Research*, 1(4). https://doi.org/10.33552/gjagr.2021.01.000518

Shariff Ghazali, S., Seman, Z., Zainuddin, N. H., Omar, M. A., Sooryanarayana, R., Ariaratnam, S. *et al.* (2021). Prevalence and factors associated with multimorbidity among older adults in Malaysia: a population-based cross-sectional study. *BMJ Open*, 11(10), e052126. https://doi.org/10.1136/bmjopen-2021-052126

World Health Organization. (2024). Ageing and health. World Health Organization. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/ageing-and-health

Yadav, S., Yang, Y., Dutra, E. H., Robinson, J. L., & Wadhwa, S. (2018). Temporomandibular joint disorders in older adults. *Journal of the American Geriatrics Society*, 66(6), 1213–1217.

Zini, Avraham & Pietrokovsky, J. (2006). Gerodontology teaching program at the geriatric dental clinic in Yad Sarah. *Refu'at ha-peh ve-ha-shinayim* (1993). 24. 31-4, 73.

CASE REPORT Open Access

Unusual presentation of ameloblastoma and a review of its biological behaviour

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Abstract

Ameloblastoma is a benign odontogenic tumour occurring primarily in the mandible with rare occurrence outside the jaw. We report a case of an ameloblastoma presenting as a polypoidal mass in the right nasal cavity of a 72-year-old woman. She presented with progressive nasal blockage symptoms and examination revealed a mass occupying the right nostril. Initial tissue biopsy confirmed conventional ameloblastoma. Subsequent imaging study showed a mass involving the right maxilla. Primary tumour from the maxilla extending into the sinonasal tract was favoured over a much rarer primary ameloblastoma of the sinonasal tract, in view of the tumour bulk in the maxilla. Unfortunately, the patient defaulted her follow-up. Ameloblastomas are known to recur locally thus excision with clear margins is paramount. Recurrence is also influenced by factors such as the presence of B-Raf proto-oncogene (BRAF) and Smoothened, frizzled class receptor (SMO) genetic mutations, with SMO mutation found to be associated with maxillary location in the older age group. Ameloblastomas can metastasise without undergoing malignant cytological changes, with mandibular tumours being far more likely to do so. Long-term follow-up and regular computed tomography (CT) monitoring is required post excision.

Keywords: *ameloblastoma, maxillary tumour, nasal mass, odontogenic tumour*

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Introduction

Ameloblastoma is a benign odontogenic tumour of the jawbone predominantly occurring at the mandible with propensity for local extension if left untreated (Masthan *et al.,* 2015). It is often asymptomatic but may present with swelling and or pain in the jaw. Although they are benign tumours, ameloblastomas have a strong inclination of recurrence after treatment, with a rate of up to 90% (Goh *et al.,* 2021). We describe an unusual case of ameloblastoma presenting as a polyp within the nasal cavity.

Case Report

A 72-year-old woman presented with right nasal block with progressing severity over 1 year. It was associated with episodes of mucopurulent discharge of the same duration and a few episodes of self-limiting trivial epistaxis. Rhinoscopy showed a pink mass occupying the entire right nostril, remnant of head of inferior turbinate seen. The mass appeared to be friable and bled easily on touch during procedure, but the operator was unable to advance the scope to visualize posteriorly. On further examination, the oral cavity was found to be

fully edentulous. A small pink soft tissue mass protruded through a focal mucosal breach over the right gingivobuccal sulcus, representing the inferior extension of the same lesion that occupied the right nasal cavity.

A biopsy of the nasal mass was taken; macroscopic examination showed multiple pieces of brownish tissue measuring 10mm in aggregate diameter. Microscopic examination showed multiple fragments of tissue focally lined by stratified squamous epithelium. Most fragments are lined by palisading basaloid columnar epithelium arranged in anastomosing strands and islands. These columnar epithelia exhibited uniform elongated hyperchromatic nuclei, inconspicuous nucleoli and reversed polarity with presence of subnuclear vacuolation. The central stroma exhibited extensive squamous metaplasia with minimal areas of typical loose stellate reticulum-like cells (Figure 1). There was no dysplasia or evidence of malignancy seen. Immunohistochemically, the columnar epithelium and stellate reticulum were positive for CK19. The interpretation was that of an ameloblastoma.

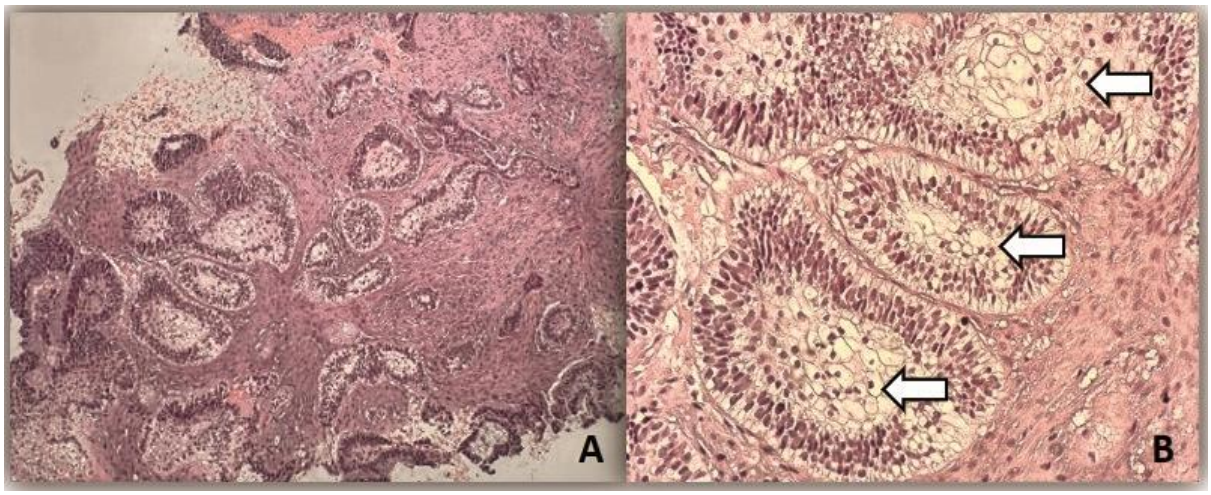

Figure 1. Histopathological examination, A (H&E, x100) and B (H&E, x400) of the mass showing fragments of tissue composed of palisading basaloid columnar epithelium with reversed polarity and loose stellate reticulum cells (white arrow).

Her subsequent CT scan 2 days later demonstrated that both the intranasal mass and the gingivobuccal lesion were contiguous extensions of a large heterogeneously enhancing tumour, centred within the right maxillary sinus. The mass measured 6.7 x 6.2 x 5.1cm (AP x W x CC) (Figure 2). The mass showed extensive destruction of the surrounding maxillary and nasal cavity walls with extension into the nasal cavity and infratemporal fossa. Areas of hypodensities within the mass seen, likely of necrotic areas. Multiple air pockets noted at the anterior and inferior aspects of the mass, which was likely from previous biopsy. Unfortunately, this patient was lost in follow-up.

Discussion

Ameloblastoma is the most common odontogenic tumour, apart from odontomas. It is a benign intraosseous progressively growing epithelial odontogenic neoplasm characterized by expansion and a tendency for local recurrence if not adequately removed. The peak incidence occurs in the 4th and 5th decades of life. Approximately 80% of all ameloblastomas are found in the mandible; they occur most often in the posterior region, followed by the anterior mandible, posterior maxilla and anterior maxilla (Hertog *et al.,* 2012; Siar *et al.,* 2012).

Figure 2. Sagittal (A), coronal (B) and axial (C) views showing a large heterogeneously enhancing solid mass (red arrow) occupying the right infratemporal space, with its epicentre at the right maxillary sinus. The tumour demonstrated extensive destruction of the maxillary sinus and nasal cavity walls with extension into the nasal cavity and infratemporal fossa. Areas of hypodensities within the mass seen likely of necrotic areas.

They are usually asymptomatic but may present with a painful or painless mass around the jaw region. Ameloblastomas are locally aggressive, invading from the bone to the surrounding soft tissues. They usually have a progressive growth with large local extension, bone destruction and dental resorption.

Ameloblastomas arising from sites other than normally situated odontogenic epithelium (extragnathic) is extraordinarily rare. Ameloblastoma of the sinonasal tract is included in these extragnathic ameloblastomas (Schafer *et al.,* 1998). As ameloblastomas are locally aggressive, a primary gnathic ameloblastoma with spread to the sinonasal tract should first be ruled out. These tumours usually come as painless swellings with possible concurrent loosening of teeth, malocclusion and altered sensation in the teeth and occasionally pain. Local extension of the tumour may erode and destroy the bone and subsequently spread to the adjacent soft tissues. Extensive local progression has been reported with one case seen extending up to the brain (Bettoni *et al.,* 2018). Our case could possibly be a right sinonasal ameloblastoma, metastasis from a previous tumour or a right maxillary ameloblastoma with intranasal extension. With the bulk of the tumour at the right maxillary sinus, and no prior history, the third option seems most likely.

Local recurrences of ameloblastomas show a marginal predilection to females with a ratio of 1:1.3. Reccurent ameloblastomas are seen in as many as 16.35% of cases to the mandible and 15.68% of cases to the maxilla (Goh *et al.,* 2021). Maxillary ameloblastoma is known to be more aggressive due to the cellular attributes of ameloblastoma and the character of bone in the maxilla (Darshani Gunawardhana *et al.,* 2010). The rate of local recurrence is increased 3.15 folds in cases with conservative treatment in contrast to radical treatment (Almeida Rde *et al.,* 2016). Therefore, in terms of patient management, most authors conclude that surgical excision with clear margins should remain the mainstay of treatment (Almeida Rde *et al.,* 2016; Hosalkar *et al.,* 2021; Pandiar *et al.,* 2021).

Metastasizing ameloblastoma is a distinct subtype in the WHO Classification of Head and Neck tumours and is differentiated from ameloblastic carcinoma by the absence of cytologic atypia. Metastatic deposits usually occur in the lungs, followed by the lymph nodes and bones (Tilakaratne *et al.,* 2023). Metastasis has been associated with poor patient outcome (Hosalkar *et al.,* 2021). Metastasizing ameloblastoma harbours BRAF p.V600E mutation similar to conventional ameloblastoma. Reported risk factors for metastasis include large size, rapid enlargement, prolonged clinical course, inadequate surgical excision, and multiple recurrences at the primary

site (Hosalkar *et al.,* 2021; Pandiar *et al.,* 2021).

The reason for metastasis in a benign entity such as ameloblastoma is not well-understood. It has been postulated that the basis may be similar to that seen in metastasis of other benign neoplasms such as benign metastasizing leiomyoma, giant cell tumour of bone and pleomorphic adenoma. The leading reason is due to incomplete removal with tumoural seeding during surgical removal. A higher frequency of surgical interventions due to multiple recurrences is associated with increased likelihood of metastasis (Hosalkar *et al.,* 2021). However, the authors also highlight that the flaw in this theory is that the immune mechanism is able to destroy distant seeding of benign tumour cells. Other routes of spread such as hematogenous, lymphatic and aspiration have been proposed with no exact mechanism established to date (Pandiar *et al.,* 2021).

A key factor in predicting metastatic behaviour is the tumour location. Mandibular ameloblastoma has been found to metastasise more frequently by virtue of being the primary location of most ameloblastomas (Pandiar *et al.,* 2021). Another factor is the histological subtype. Plexiform ameloblastoma has been associated with higher rates of metastasis. It has been theorized that the bud-like structures seen in this histological subtype are able to dislodge and become implanted at distant sites. In contrast, one review found that follicular subtype was the more commonly metastasizing subtype (Pandiar *et al.,* 2021). Other factors predicting higher likelihood of metastasis include male gender, large size of primary tumour, fast local spread and prolonged disease (Hosalkar *et al.,* 2021; Pandiar *et al.,* 2021).

Approximately 90% of ameloblastomas harbour mutations involving the MAPK signalling pathway, with BRAF V600E being the commonest alteration. In contrast, SMO mutations occur less frequently but have been shown to correlate with maxillary tumours arising in older patients, suggesting distinct molecular pathways according to tumour location (Sweeney *et al.*, 2014). Furthermore, tumours harbouring SMO mutations or multiple concurrent genetic alterations demonstrate a higher risk of recurrence compared with BRAF-mutated tumours (Gültekin *et al.,* 2018). Case series have demonstrated remarkable tumour regression following treatment with BRAF inhibitors such as dabrafenib, either alone or in combination with MEK inhibitors, particularly in unresectable, recurrent or metastatic BRAF-mutated ameloblastomas (Kaye *et al.*, 2014; Tilakaratne *et al.,* 2023; Grynberg *et al.*, 2024). These findings support the role of molecular profiling for prognostication and may guide targeted therapeutic strategies in selected patients (Brown *et al.*, 2014; Sweeney *et al.*, 2014; Gültekin *et al.*, 2018; Tilakaratne *et al.,* 2023; Grynberg *et al.*, 2024).

Although treatment outcome could not be assessed because the patient defaulted follow-up, this case remains educational because it illustrates an uncommon presentation of maxillary ameloblastoma masquerading as a benign nasal polyp. Recognition of this presentation is important to avoid diagnostic delay and to prompt appropriate cross-sectional imaging for assessment of the primary tumour.

Conclusion

Behaviour of ameloblastoma depends on its location, completeness of excision and presence of certain genetic mutations. Regional spread of ameloblastoma is more likely and need to be ascertained before interpreting an extragnathic primary, as this diagnosis affects prognosis. Targeted therapy for ameloblastoma may be contemplated in some cases.

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Competing Interest

The authors declare that they have no competing interests.

References

Almeida Rde A., Andrade E.S., Barbalho J.C., Vajgel A., & Vasconcelos B.C. (2016). Recurrence rate following treatment for primary multicystic ameloblastoma: systematic review and meta-analysis. *International Journal of Oral & Maxillofacial Surgery,* 45(3), 359-367. https://doi.org/10.1016/j.ijom.2015.12.016

Bettoni J., Neiva C., Fanous A., Olivetto M., Demarteleire C., Dakpe S., *et al.* (2018). Brain ameloblastoma: metastasis or local extension case report and physipathological reflexion. *Journal of Stomatology, Oral and Maxillofacial Surgery,* 119(5), 436-439. https://doi.org/10.1016/j.jormas.2018.04.017

Brown N.A., Rolland D., McHugh J.B., Weigelin H.C., Zhao L., Lim M.S., et al. (2014). Activating FGFR2-RAS-BRAF mutations in ameloblastoma. *Clinical Cancer Research.* 20(21), 5517-5526. https://doi.org/10.1158/1078-0432.CCR-14-1069

Darshani Gunawardhana K.S., Jayasooriya P.R., Rambukewela I.K., & Tilakaratne W.M. (2010). A clinico-pathological comparison between mandibular and maxillary ameloblastomas in Sri Lanka. *Journal of Oral Pathology & Medicine,* 39(3), 236-241. https://doi.org/10.1111/j.1600-0714.2009.00850.x

Kaye F.J., Ivey A.M., Drane W.E., Mendenhall W.M., Allan R.W. (2014). Clinical and radiographic response with combined BRAF-targeted therapy in stage 4 ameloblastoma. *Journal of the National Cancer Institute,* 107(1), 378. https://doi.org/10.1093/jnci/dju378

Goh Y.C., Siriwardena B.S.M.S., & Tilakaratne W.M. (2021). Association of clinicopathological factors and treatment modalities in the recurrence of ameloblastoma: analysis of 624 cases. *Journal of Oral Pathology & Medicine,* 50, 927–936. https://doi.org/10.1111/jop.13228

Grynberg S., Vered M., Shapira-Frommer R., Asher N., Ben-Betzalel G., Stoff R., *et al.* (2024). Neoadjuvant BRAF-targeted therapy for ameloblastoma of the mandible: an organ preservation approach. *Journal of the National Cancer Institute,* 116(4), 539-546. https://doi.org/10.1093/jnci/djad232. *Journal of the National Cancer Institute,* 116(4), 631. https://doi.org/10.1093/jnci/djad264

Gültekin S.E., Aziz R., Heydt C., Sengüven B., Zöller J., Safi A.F., et al. (2018). The landscape of genetic alterations in ameloblastomas relates to clinical features. *Virchows Archiv European Journal of Pathology,* 472(5), 807-814. https://doi.org/10.1007/s00428-018-2305-5

Hertog D., Bloemena E., Aartman I.H., & van-der-Waal I. (2012). Histopathology of ameloblastoma of the jaws; some critical observations based on a 40 years single institution experience. *Medicina Oral, Patologia Oral, Cirugia Bucal.* 17(1), e76-82. https://doi.org/10.4317/medoral.18006

Hosalkar R., Saluja T.S., Swain N., & Singh S.K. (2021). Prognostic evaluation of metastasizing ameloblastoma: A systematic review of reported cases in literature. *Journal of Stomatology, Oral & Maxillofacial Surgery.* 122, 192–198. https://doi.org/10.1016/j.jormas.2020.07.001

Masthan K.M., Anitha N., Krupaa J., & Manikkam S. (2015). Ameloblastoma. *Journal of Pharmacy and Bioallied Sciences,* Suppl 1, S167-S170. https://doi.org/10.4103/0975-7406.155891

Pandiar D., Anand R., Kamboj M., Narwal A., Shameena P.M., & Devi A. (2021). Metastasizing Ameloblastoma: A 10 Year Clinicopathological Review with an Insight Into Pathogenesis. *Head and Neck Pathology,* 15(3), 967-974. https://doi.org/10.1007/s12105-020-01258-5

Schafer D.R., Thompson L.D., Smith B.C., & Wenig B.M. (1998). Primary ameloblastoma of the sinonasal tract: a clinicopathologic study of 24 cases. *Cancer,* 82(4), 667-674. https://doi.org/10.1002/(sici)1097-0142(19980215)82:4<667::aid-cncr8>3.0.co;2-i

Siar C.H., Lau S.H., & Ng KH. (2012). Ameloblastoma of the jaws: a retrospective analysis of 340 cases in a Malaysian population. *Journal of Oral and Maxillofacial Surgery,* 70(3), 608-615. https://doi.org/10.1016/j.joms.2011.02.039

Sweeney R.T., McClary A.C., Myers B.R., Biscocho J., Neahring L., Kwei K.A., et al. (2014) Identification of recurrent SMO and BRAF mutations in ameloblastomas. *Nature Genetics,* 46(7), 722-725. https://doi.org/10.1038/ng.2986

Tilakaratne W.M., Odell E.W., Muller S., editors. (2023). Chapter 7: Odontogenic and maxillofacial bone tumours. In: *WHO Classification of Head and Neck Tumours*. 5th ed. IARC Publications; Lyon, France: 2023.

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  Ahmad, A., Husain, A., Mujeeb, M., Khan, S. A., Najmi, A. K., Siddique, N. A. *et al.* (2013). A review on therapeutic potential of *Nigella sativa:* a miracle herb. *Asian Pacific Journal of Tropical Biomedicine,* 3(5), 337-352. https://doi.org/10.1016/s2221-1691(13)60075-1

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