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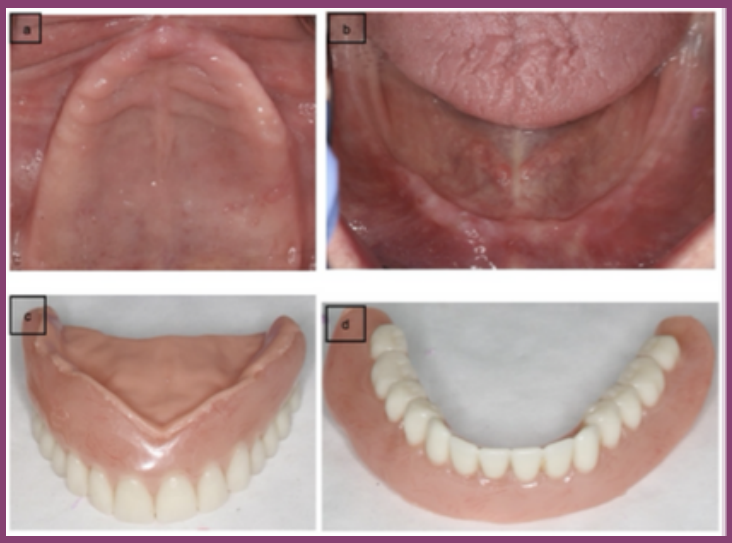
INTERNATIONAL ISLAMIC UNIVERSITY MALAYSIA
يونيورسيتي إسلام انتارابغسا ملسيا
Garden of Knowledge and Virtue

IJOHS

IIUM Journal of Orofacial and Health Sciences

A scientific journal
published by IIUM Press



eISSN 2735-0584

VOL. 6 ISSUE 2 2025

IIUM Journal of Orofacial and Health Sciences
Editorial Board

IIUM Journal of Orofacial and Health Sciences

Aims and scope

IIUM Journal of Orofacial and Health Sciences (IJOHS) is a peer reviewed biannual international journal dedicated to publishing high quality of 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 biomaterial, oral maxillofacial genetic and craniofacial deformities, dental public health and health sciences.

Publisher

IIUM Press

International Islamic University Malaysia (IIUM)

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EDITORIAL Open Access

To calm, to hold or to refer? When managing children becomes managing parents

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How to cite this article:
Ismail, A. F. (2025). To calm, to hold or to refer? When managing children becomes managing parents. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 160–162. https://doi.org/10.31436/ijohs.v6i2.412

Article DOI:
https://doi.org/10.31436/ijohs.v6i2.412

Received:
27 May 2025
Revised:
22 June 2025
Accepted:
8 July 2025
Published Online:
31 July 2025

Introduction

Paediatric dental care required clinicians to maintain a delicate balance between effective treatment and child cooperation. In recent years, however, this dynamic has become increasingly complex (Yuan *et al.*, 2021). There has been an increase in reports from dental practitioners that managing parental expectations and demands is as critical, if not more challenging, than managing the child's behaviour itself. The intersection of clinical judgement, parental pressure and medico-legal concerns has fostered a climate of uncertainty, particularly within general dental practice, where access to paediatric dental specialists may be limited.

This editorial article highlights the ethical and practical implications of behaviour management decisions within the Malaysian dental context, with a specific focus on sedation, physical restraint and referral protocols.

Behaviour management: techniques and tensions

Behaviour guidance in paediatric dentistry encompasses a variety of techniques, ranging from non-pharmacological approaches such as tell-show-do and voice control to pharmacological strategies including sedation and general anaesthesia. The primary objective is to deliver safe, efficient, and trauma-free dental care.

The clinical landscape is further complicated by absence of a national consensus on the appropriate use of behaviour management techniques, particularly in primary settings. In contrast, the American Academy of Paediatric Dentistry (AAPD) has established a comprehensive guideline that categorize behaviour guidance methods into basic and advanced interventions, with recommendations tailored to patient age, developmental status and medical history (AAPD, 2024). These guidelines emphasize the importance of informed consent and clinical documentation while reinforcing the clinician's authority to determine the most suitable method. However, such structured frameworks remain underutilized in Malaysia due to lack of equivalent local guidelines.

The Malaysian context: access, capacity, and compromise

A recent study conducted by Che Lah *et al.* (2024) underscores the importance of considering parental perspectives in the selection and application of behaviour management techniques while managing children. An increasing number of practitioners report experiencing resistance from parents, particularly regarding protective stabilisation and sedation. This resistance, while rooted in parental concern, has the potential to undermine clinical autonomy and heighten the emotional burden on practitioners.

The 2015 National Oral Health Survey of Preschool Children (NOHPS) reported that more than 70% of five-year-olds in Malaysia experience dental caries (Ministry of Health Malaysia, 2015). Given the significant treatment needs associated with this statistic, the burden placed on primary care providers is considerable. However, the availability of paediatric dental specialists is limited, and unevenly distributed between urban and rural areas. Consequently, general dental practitioners (GDPs) often find themselves responsible for managing complex cases that would typically warrant referral to specialists.

In this context, the pressure to satisfy parental expectation, particularly in the absence of specialist support, can lead to compromised care. Clinicians may be inclined to avoid necessary procedures, delay referrals or opt for less effective management strategies due to apprehension regarding potential complaints or confrontations.

These situations give raise to important ethical considerations. To what extent should parental opinion influence clinical decision-making? How can practitioners reconcile their duty of care to the child with the need to respect parental authority? Furthermore, how can the profession assist clinicians who make ethically sound yet potentially unpopular decisions?

Regulatory gaps and the need for structured support

The Malaysian Dental Council's Code of Professional Conduct (2022) provides broad ethical guidelines, but it does not furnish specific recommendations for managing uncooperative children or addressing parental refusal of clinically indicated interventions. In the absence of national protocols or legal safeguards, many practitioners express a feeling of vulnerability and a lack of support.

Moreover, behaviour management training within Malaysian dental curricula framework often lacks sufficient emphasis on medico-legal documentation, informed consent processes and managing parental expectations. Continuing professional development (CPD) programmes predominantly concentrate on enhancing clinical skills, often neglecting to adequately address communication strategies pertinent to conflict resolution and parental education.

Conclusion

Behaviour management in paediatric dentistry has evolved beyond mere clinical skills, it now encompasses ethical navigation, legal awareness and social diplomacy. In Malaysia, the escalating tension between parental expectations and clinical necessities highlight the need for clearer guidelines, enhanced training and substantial institutional support. Only through these measurers can the dental chair be restored to a space where treatment decisions are made in the best interest of the child, grounded in science and not swayed by pressure

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ORIGINAL ARTICLE Open Access

Prevalence of geriatric psychiatric cases in Malaysia and their association with clinical mental health workforce availability

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Abstract

The aging population presents a global challenge, with increasing attention on the mental health needs of elderly individuals. In Malaysia, the rising number of geriatric psychiatric cases emphasizes the urgent need for effective mental health care solutions. This study investigates the relationship between clinical staffing levels in psychiatric care and the management of geriatric psychiatric conditions. While previous research has established a link between staffing levels and care quality, this study provides specific insights into how workforce availability influences the management of elderly psychiatric patients in Malaysia. Given the growing prevalence of psychiatric disorders such as depression, anxiety, and dementia among older adults, this research addresses a critical gap in understanding the effects of staffing on mental health outcomes. Using descriptive and regression analyses, the study assesses data on psychiatric cases and clinical staffing across Malaysian states. The analysis reveals that higher clinical staffing levels significantly improve the management of geriatric psychiatric conditions. This evidence highlights the critical role that adequate staffing plays in enhancing psychiatric care for the elderly. The study underscores the importance of strategic investments in mental health services, offering insights for policymakers and healthcare planners as they strive to meet the increasing demand for mental health care in Malaysia. By optimizing staffing and resource allocation, the research contributes to better mental health outcomes for Malaysia's aging population, improving their quality of life.

Keywords: *clinical staffing, elderly population, geriatric psychiatry, health, psychiatric*

Received:
22 August 2024
Revised:
28 May 2025
Accepted:
28 May 2025
Published Online:
31 July 2025
How to cite this article:
Salwana, E., Ajit, K., Zaidi, Z. I., Zahren, M. I. S., Ismail, A., & Zulkifli, Z. (2025). Prevalence of geriatric psychiatric cases in Malaysia and their association with clinical mental health workforce availability. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 163–173. https://doi.org/10.31436/ijohs.v6i2.342
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.342
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Introduction

The global rise in the aging population has brought psychiatric care for older adults into sharper focus, revealing an urgent need to address mental health issues within this demographic. As the number of elderly individuals worldwide continues to grow, psychiatric conditions such as depression, anxiety, dementia, and schizophrenia are becoming increasingly prevalent among the elderly (World Health Organization, 2017). According to the World Health Organization, mental health disorders affect a significant proportion of older adults, impacting their

quality of life and overall well-being (World Health Organization, 2017). Depression, for instance, affects an estimated 7% of older adults globally, with factors such as chronic illness, social isolation, and loss of independence contributing to its rise (Chaurasia, 2020; Baiyewu *et al*., 2021; Raaj, 2021). Dementia, including Alzheimer's disease, is another critical concern, affecting approximately 5-10% of individuals aged 65 and older, with numbers expected to double by 2050 due to aging demographics (Coombs *et al*., 2021; Simon Long *et al*., 2023).

The COVID-19 pandemic has exacerbated these issues, leading to increased rates of anxiety, depression, and cognitive decline among older adults, partly due to heightened social isolation and disruptions in routine care (Bafail, 2022; Liu *et al*., 2022). Despite these challenges, there has been progress in understanding and addressing geriatric psychiatric conditions through improved diagnostic tools, treatment methods, and the integration of mental health services into primary care. However, gaps remain in access to care, with many older adults facing barriers such as stigma, lack of awareness, and inadequate resources (Cloak *et al.*, 2019; Dahlberg, 2023). Efforts to enhance mental health services for the elderly are crucial, emphasizing the need for comprehensive strategies to improve diagnosis, treatment, and support for this growing population.

These challenges are particularly pronounced in Malaysia, where the shortage of psychiatrists further complicates the ability to provide adequate mental health care for the elderly. According to recent reports, Malaysia has a low psychiatrist-to-population ratio, with only about one psychiatrist for every 200,000 people (Astro Awani, 2024**;** Selangor Journal, 2024**;** CodeBlue, 2021). This shortage is even more acute in rural areas, where access to specialized mental health services is severely limited. The lack of mental health professionals not only delays diagnosis and treatment but also places an overwhelming burden on the existing healthcare system, which is already stretched thin by the rising demand for services (Adams *et al*., 2024; Suhaimi *et al*., 2014; Dziedzic *et al*., 2023).

For the elderly, who are often dealing with multiple chronic health conditions alongside psychiatric disorders, this lack of specialized care can have devastating consequences. The limited availability of mental health professionals means that many elderly individuals are left untreated, leading to a decline in their overall health and quality of life. Furthermore, the stigma associated with mental health issues, particularly among older adults, often prevents them from seeking help (Teo *et al.*, 2022). In many cases, mental health problems are either ignored or misunderstood as a normal part of aging, which further exacerbates the situation (Cloak *et al*., 2019; Guan *et al*., 2018).

The Malaysian healthcare system is attempting to address these issues through various initiatives aimed at integrating mental health services into primary care (Ministry of Health Malaysia, 2023). This approach is intended to make mental health care more accessible, particularly for the elderly, by allowing general practitioners to play a larger role in diagnosing and managing psychiatric conditions. However, these efforts are still in their early stages, and there is a significant need for more comprehensive training for healthcare providers to ensure they are equipped to handle the complex mental health needs of the elderly (Ito *et al*., 2015: Hassan, 2018).

Additionally, cultural factors play a significant role in the treatment and perception of mental health issues in Malaysia. In many communities, mental health problems are still seen as a taboo subject, leading to a reluctance to seek treatment (Amin, 2024). This cultural stigma is particularly strong among the elderly, who may view mental health issues as a sign of weakness or a personal failing. Addressing these cultural barriers is essential to improving mental health outcomes for Malaysia's aging population. Public awareness campaigns and community-based interventions that focus on reducing stigma and increasing understanding of

mental health issues are critical components of this effort (Talib, 2020; Rosli *et al*., 2021; Hussein, 2021).

In conclusion, while there have been some advancements in addressing geriatric mental health issues in Malaysia, significant challenges remain. The shortage of mental health professionals, combined with cultural stigma and the increasing demand for services due to an aging population, creates a complex and urgent problem. To effectively meet the mental health needs of the elderly, Malaysia must continue to expand access to care, improve the integration of mental health services into the broader healthcare system, and address the cultural factors that prevent individuals from seeking help. Only through a comprehensive and multi-faceted approach can the country hope to provide the level of care needed to support its aging population and improve the overall well-being of its elderly citizens.

Thus, based on previous studies, this study aims to: (a) examine psychiatric cases by state and within the elderly category, and (b) assess the availability of treatment and psychiatric care specialists across Malaysia. These objectives are crucial for understanding the regional distribution of psychiatric issues among the elderly and identifying gaps in mental health services, which can inform targeted interventions and policy improvements.

Materials and Methods

The data used in this study were obtained from publicly accessible government sources. Specifically, geriatric psychiatric case data and staffing numbers were retrieved from the Ministry of Health Malaysia's official publications and the Health Informatics Centre (HIC), which publishes state-level health statistics. These data sets are available online and are collected by the Ministry as part of its national health surveillance system.

For this study, the inclusion criteria were:

- All reported psychiatric cases involving individuals aged 65 and above (geriatric age group).
- States and federal territories in Malaysia with complete data on both psychiatric cases and the number of clinical staff.

The exclusion criteria were any state or territory for which data on either psychiatric cases or clinical staffing were incomplete or unavailable (*e.g.*, Labuan, which reported no cases and had no staffing data).

As this study utilized secondary data obtained from publicly available government databases without any involvement of human subjects, individual identifiers, or patient-level data, formal ethical approval from MREC (Medical Research and Ethics Committee) or NMRR (National Medical Research Register) was not required. Nonetheless, ethical research practices were strictly adhered to by ensuring responsible data handling and reporting.

In this study, we employed both descriptive and regression analysis techniques to examine the prevalence of geriatric psychiatric cases and assess the availability of clinical staff in psychiatric care across Malaysia. For descriptive analysis, we began with numerical descriptive methods to calculate summary statistics such as the mean, median, and standard deviation. These metrics provided an overview of the average prevalence of psychiatric conditions among the elderly and highlighted the variability across different regions. Additionally, graphical descriptive analysis used visual tools such as bar charts and pie charts to represent the data. Bar charts displayed the number of geriatric psychiatric cases across various states, revealing regional disparities, while pie charts illustrated the proportion of different psychiatric conditions within the elderly population. These visualizations facilitated a clearer understanding of trends, patterns, and outliers in the data.

For the regression analysis, we explored the relationship between the number of geriatric psychiatric cases and the

availability of clinical staff in psychiatric care. In this analysis, the number of clinical staff served as the independent variable, while the number of geriatric psychiatric cases served as the dependent variable. We used simple linear regression to determine if there was a significant correlation between these two variables. The regression model helped identify whether an increase in clinical staff was associated with a reduction in psychiatric cases or if other patterns emerged. Key metrics such as the coefficient of determination (R^2) measured the proportion of variance in the number of psychiatric cases explained by the number of clinical staff, and regression coefficients indicated the strength and nature of the relationship. Significance tests, including p-values, assessed whether the observed relationships were statistically significant. A significance level of $p < 0.05$ was used to determine statistical significance for all tests conducted.

Results

Data in Figure 1 indicates that Johor has the highest number of cases, with 11,661 cases (17.87%), followed by Sarawak, Selangor, and Perak with 9,068, 7,510, and 7,501 cases respectively. Terengganu recorded the lowest number of cases with 447, while Labuan reported no cases. The average number of geriatric psychiatric cases is 4,078.44.

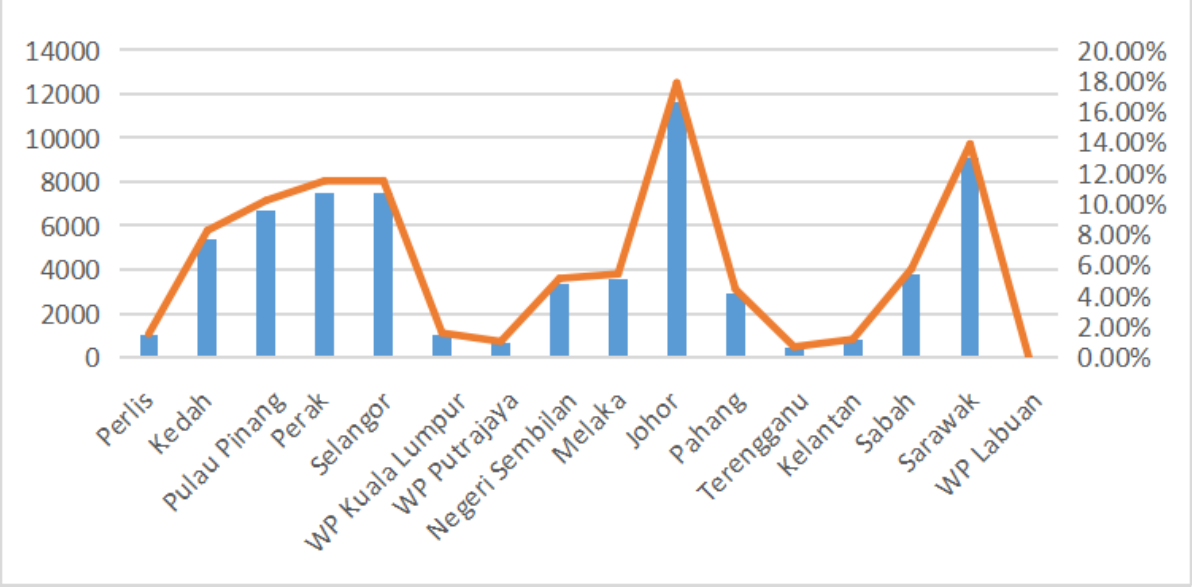

Figure 1. Number of geriatric psychiatric cases in Malaysia.

Figure 2 data shows that Perak has the highest number of psychiatrists, with 23, followed by Selangor, WP Kuala Lumpur, and Johor with 21, 19, and 18 respectively. This suggests that the availability of psychiatric care is generally good across states, although Labuan has no psychiatrists available. On average, there are 10.13 psychiatrists per state.

Regarding psychiatric nurses under the Ministry of Health Malaysia (MOH), Figure 3 shows Perak has the highest number at 336, followed by Johor, Sarawak, and Sabah with 266, 176, and 146 respectively. Labuan has no psychiatric nurses under MOH. The average number of psychiatric nurses under MOH is 77.94.

In terms of clinical workforce in psychiatric care, As shown in Figure 4, Perak again leads with 1,855 individuals, followed by Johor, Sarawak, and Sabah with 1,298 (23.53%), 559 (10.13%), and 474 (8.59%) respectively. Labuan has no clinical workforce in psychiatric care. The average number of clinical staff in psychiatric care is 344.81.

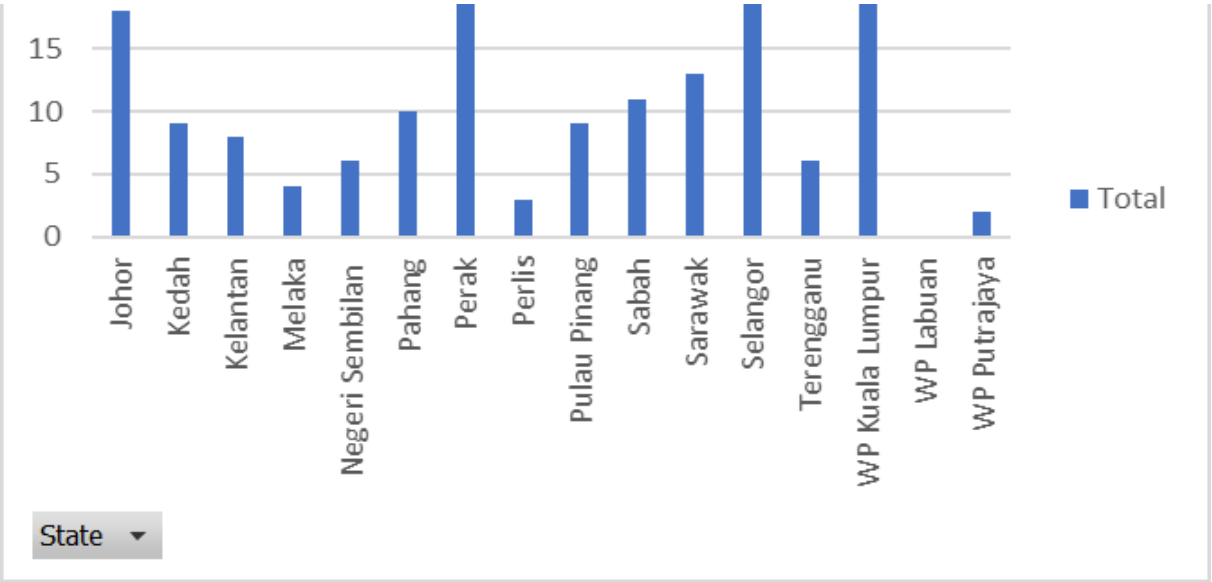

Figure 2. Number of psychiatrists in Malaysia.

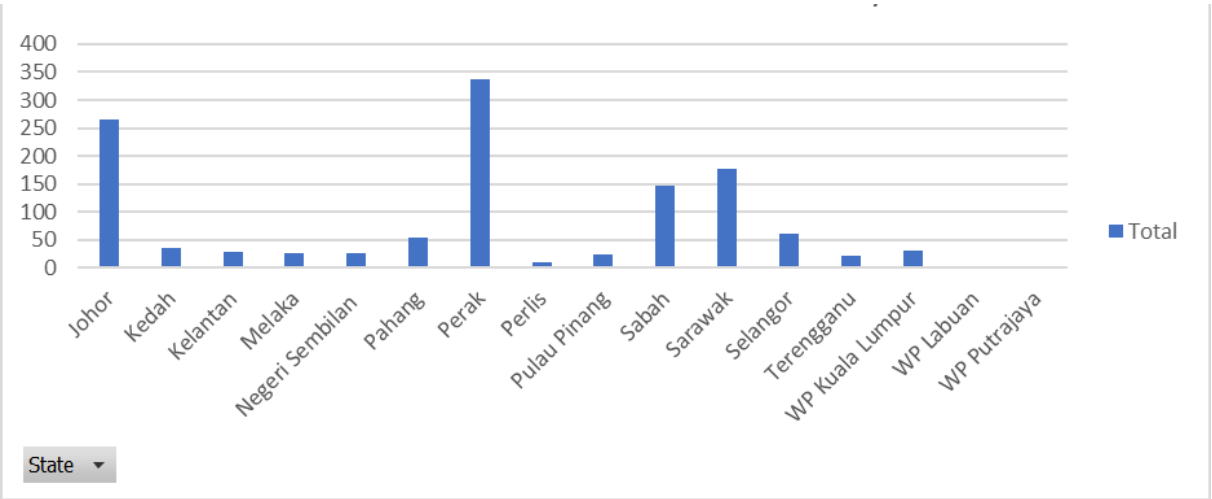

Figure 3. Number of nurses serving in the psychiatric sector under the Ministry of Health Malaysia.

Table 1 displays the results of an ANOVA (Analysis of Variance) test used to evaluate the relationship between the number of clinical staff (independent variable) and the number of geriatric psychiatric cases (dependent variable). The table includes key statistical measures: degrees of freedom (df), sum of squares (SS), mean square (MS), F-statistic, and significance level (p-value).

The degrees of freedom (df) indicate the number of values free to vary in the calculation. For regression, the df is 1, reflecting the inclusion of a single predictor variable. The residual df is 14, which represents the variability left unexplained by the model. The total df is 15, representing the total number of data points minus one. These values help in understanding how much of the total variability in the number of geriatric psychiatric cases can be attributed to the number of clinical staff.

The sum of squares (SS) measures the variability in the data. The regression SS is 83,183,333.69, representing the portion of variability in the number of geriatric psychiatric cases explained by the number of clinical staff. The residual SS is 104,605,210.30, reflecting the variability in psychiatric cases not explained by the clinical staff. The total SS of 187,788,543.90 is the sum of the regression and residual SS, capturing the overall variability.

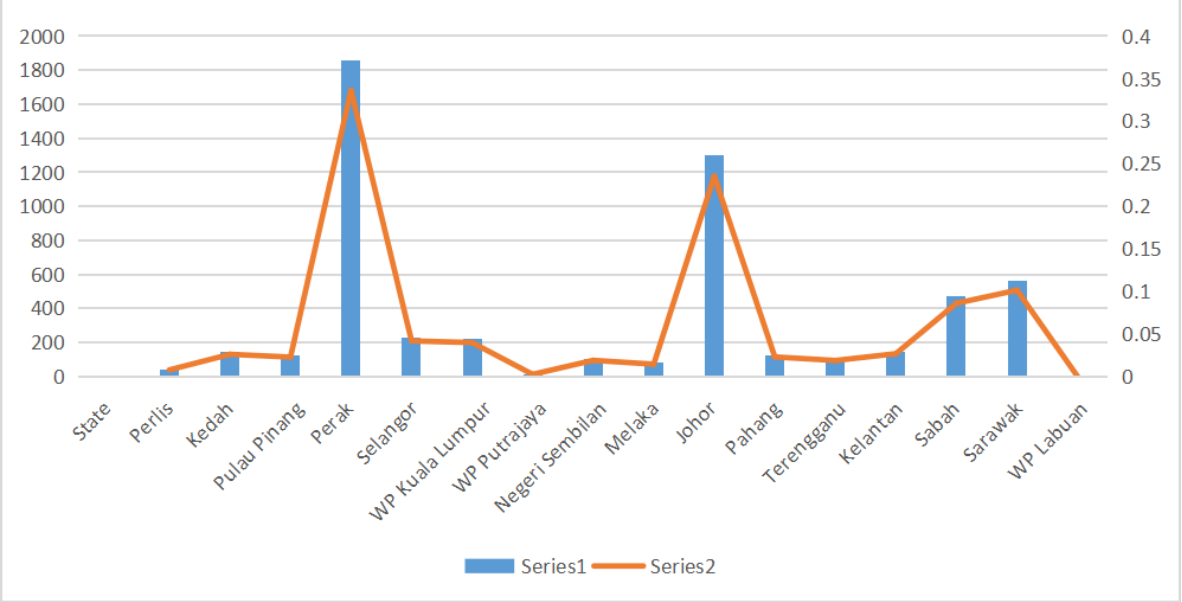

Figure 4. Number of clinical workforce serving in the psychiatric care sector.

Table 1. ANOVA analysis.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	83183333.69	83183333.69	11.13297004	0.00489259
Residual	14	104605210.3	7471800.732		
Total	15	187788543.9			

The mean square (MS) values are the average amount of variability. The regression MS, which is 83,183,333.69, is derived by dividing the regression SS by its df. The residual MS, 7,471,800.73, is calculated by dividing the residual SS by its df. The F-statistic of 11.133 is obtained by dividing the regression MS by the residual MS. This statistic assesses whether the predictor variable significantly explains the variability in the dependent variable.

The significance level (p-value) of 0.0049 indicates the probability that the observed relationship occurred by chance. Since this p-value is below the common significance threshold of 0.05, it suggests a statistically significant relationship between the number of clinical staff and the number of geriatric psychiatric cases. This finding implies that increasing the number of clinical staff can significantly influence the management of psychiatric cases among the elderly. Overall, the results underscore the importance of adequate clinical staffing in addressing and potentially reducing geriatric psychiatric issues.

Table 2 presents the results of the regression analysis that investigates the relationship between the number of clinical workforces in psychiatric care (independent variable) and the total number of geriatric psychiatric cases (dependent variable).

Table 2. Regression analysis.

Regression Statistics	
Multiple R	0.665554483
R Square	0.44296277
Adjusted R Square	0.403174397
Standard Error	2733.459481
Observations	16

The intercept value is 2499.02, which represents the estimated number of geriatric psychiatric cases when no clinical staff are present. This intercept is statistically significant, as evidenced by its t-statistic of 3.01 and a p-value of 0.009, indicating that the intercept is significantly different from zero. The 95% confidence interval for the intercept, ranging from 716.06 to 4281.98, provides a range within which we can be 95% confident that the true intercept value lies. This result underscores that even without clinical staff, there is a baseline number of cases, highlighting a potential level of cases that would exist due to other factors.

The coefficient for the number of clinical workforces is 4.58. This suggests that for each additional clinical staff member employed in psychiatric care, the number of geriatric psychiatric cases is expected to increase by approximately 4.58 cases. This coefficient is statistically significant, with a t-statistic of 3.34 and a p-value of 0.005, indicating a robust positive relationship between the number of clinical staff and the number of cases. The 95% confidence interval for this coefficient ranges from 1.64 to 7.52, showing that the effect of adding more clinical staff is likely to be between 1.64 and 7.52 additional cases, providing a clear indication of the magnitude and reliability of this relationship.

Table 3 presents the regression analysis examining the relationship between the number of clinical workforce in psychiatric care and the total number of geriatric psychiatric cases. The results reveal a statistically significant positive association, with a regression coefficient of 4.58 (p = 0.0049). This indicates that each additional clinical staff member is associated with an estimated increase of approximately 4.58 geriatric psychiatric cases. The 95% confidence interval for this coefficient ranges from 1.64 to 7.52, reinforcing the reliability of this association. These findings suggest that better staffing is linked to improved case detection and management.

Table 3. Statistical findings of regression analysis between the number of clinical workforces in the psychiatric care sector and the total number of geriatric psychiatric cases.

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	2499.01836	831.2987224	3.006161676	0.009435561	716.059927	4281.976793	716.0599267	4281.976793
Number of clinical workforces working in psychiatric care	4.580515903	1.372805072	3.336610561	0.004892585	1.636141186	7.524889948	1.636141859	7.524889948

Based on the analyses presented, a conclusion can be drawn regarding the relationship between the clinical workforce in psychiatric care and the number of geriatric psychiatric cases. The combined results from both the regression and ANOVA analyses underscore a clear and significant relationship between the number of clinical staff and the prevalence of geriatric psychiatric cases. The positive correlation indicates that as the number of clinical staff increases, so does the number of cases report. This relationship highlights the importance of adequate staffing in psychiatric care settings to manage and address the growing needs of the elderly population effectively. The findings suggest that increasing the clinical workforce could be a crucial strategy in improving the management of geriatric psychiatric conditions, thereby enhancing overall care quality and responsiveness to patient needs.

Discussion

The analysis reveals significant findings regarding the interplay between the clinical workforce in psychiatric care and the number of geriatric psychiatric cases. The regression analysis and ANOVA results together offer a nuanced understanding of how staffing levels impact psychiatric care for the elderly.

One plausible explanation for this relationship is that a larger clinical workforce enhances the capacity for diagnosing and documenting psychiatric conditions. More staff members may lead to improved detection of psychiatric disorders among the elderly, revealing cases that might otherwise remain undiagnosed. This enhanced detection capability could be particularly crucial in geriatric psychiatry, where symptoms can be subtle and complex. Alternatively, the increase in case numbers associated with a larger workforce could reflect a growing need for mental health services among the elderly. As clinical staffing increases, the healthcare system may be better equipped to address and manage the rising demand for psychiatric care. This scenario suggests that while the presence of more clinical staff leads to an increase in reported cases, it may also be indicative of a broader trend towards recognizing and addressing mental health issues within this demographic. This interpretation aligns with findings from recent studies. For instance, a 2024 study by Hu and Lee demonstrated that enhanced community mental health monitoring, facilitated by machine learning models, improved the detection of mental health issues among the elderly, underscoring the importance of adequate staffing and technological support in mental health services (Hu & Lee, 2024). Additionally, a systematic review and meta-analysis published in 2022 reported a global prevalence of depression in older adults at 28.4%, highlighting the substantial mental health needs within this population (Hu *et al.*, 2022). Furthermore, a Malaysian study in 2024 emphasized the significant burden on caregivers of persons with dementia, indicating that increased support and resources, including staffing, are crucial for managing the growing mental health demands of the aging population (Nasreen *et al*., 2024). These studies collectively support the notion that augmenting the clinical workforce not only facilitates the identification and reporting of geriatric psychiatric cases but also reflects an essential response to the escalating mental health needs of the aging population.

Overall, the analysis demonstrates a significant positive correlation between the number of clinical workforces in psychiatric care and the number of geriatric psychiatric cases. This implies that increasing clinical staff is associated with an increase in reported cases of geriatric psychiatric conditions. The results highlight the importance of adequate staffing in the psychiatric sector and suggest that managing the growing number of geriatric cases may require scaling up the clinical workforce to address the increasing demand for psychiatric care effectively.

The positive correlation between staffing levels and the prevalence of geriatric psychiatric cases underscores a critical need for sustained investment in mental health

services tailored to the elderly. This association is consistent with findings by Tan *et al.* (2021), who reported that the availability of mental health personnel significantly influenced detection rates of psychiatric conditions among older adults in Southeast Asia. In the context of Malaysia, states such as Johor, which recorded the highest number of geriatric psychiatric cases (11,661), may reflect not only a larger elderly population but also better availability of psychiatric services and infrastructure compared to other states. Johor's relatively higher concentration of health facilities and trained professionals could contribute to more effective detection and reporting of psychiatric conditions among the elderly.

Regionally, the prevalence of psychiatric disorders in the elderly across ASEAN countries varies but remains a growing concern. A recent meta-analysis by Vidyasagaran *et al.* (2023) found that depression affects approximately 20–30% of older adults in ASEAN nations, with dementia prevalence ranging from 6% to 10%, depending on urbanization, access to healthcare, and cultural perceptions. Compared to countries like Thailand and Indonesia, Malaysia demonstrates moderately high reporting rates, possibly due to growing awareness, national mental health campaigns, and expanded geriatric outreach services in recent years.

The role of clinical support staff—especially psychiatric nurses and allied health professionals—is crucial in the early identification, intervention, and follow-up care for elderly patients. However, despite progress, Malaysia still faces a shortage of geriatric-trained mental health personnel, particularly in rural regions (Guan *et al.*, 2018; Rosli *et al*., 2021). This shortage limits equitable access to psychiatric services and may contribute to underdiagnosis in less-developed states, suggesting that increased staffing alone does not guarantee improved mental health outcomes unless it is complemented by comprehensive training and distribution strategies.

While this study shows that greater staffing is associated with increased reported cases, it is essential to interpret this as an improvement in service outreach and case identification—rather than an actual surge in incidence. This phenomenon has also been observed in other studies, such as Bingham *et al.* (2022), which suggest that enhanced detection and reduced stigma can lead to increased service utilization, thus elevating reported case numbers.

Therefore, it is imperative that future policies not only focus on increasing the number of psychiatric professionals but also on equipping them with geriatric-specific training and ensuring equitable deployment across all Malaysian states. Further research should explore whether such staffing expansions directly contribute to improved clinical outcomes, or whether they primarily affect diagnostic coverage and health-seeking behavior among the elderly.

Limitations of the study

Despite the valuable insights provided, this study has several limitations that should be acknowledged. First, the analysis relies on secondary aggregate data, which limits the ability to account for individual-level variables or more granular determinants such as severity of psychiatric conditions, comorbidities, or treatment outcomes. Second, the study does not control for potential confounding factors such as socioeconomic disparities, access to healthcare facilities, population density, or levels of mental health awareness, which may influence both the number of reported cases and clinical staffing distribution across states. Additionally, the cross-sectional nature of the data restricts the ability to observe changes in psychiatric case trends over time or determine causality. Future studies should consider incorporating longitudinal datasets and multivariate models to better understand the complex interplay between mental health prevalence and healthcare workforce capacity.

Conclusion

This study reinforces the urgent need to expand the number of clinical staff in geriatric psychiatric care to meet the growing mental health demands of Malaysia's aging population. The findings demonstrate a significant positive association between the availability of psychiatric clinical personnel and the prevalence of diagnosed geriatric psychiatric cases, suggesting that improved staffing levels contribute to enhanced detection, diagnosis, and care delivery for elderly individuals with mental health conditions. In a context where psychiatric disorders among the elderly are on the rise, this underscores the importance of strategic workforce planning and targeted investments to strengthen mental health services at both state and national levels.

A key strength of this study lies in its empirical approach, combining descriptive and regression analyses to examine the relationship between staffing availability and psychiatric case prevalence across multiple states in Malaysia. This offers a valuable evidence base for policymakers to prioritize workforce development in mental health services, particularly in underserved regions.

However, the study also has limitations. It relies on secondary data that do not fully account for confounding factors such as differences in population size, socioeconomic status, healthcare access, or public mental health literacy across states. Additionally, the data do not include longitudinal trends, limiting the ability to assess changes over time.

Future research should adopt a more comprehensive and longitudinal approach, incorporating patient outcomes, qualitative insights from healthcare providers, and regional demographic factors. There is also a need to evaluate the impact of staff training quality, mental health policies, and community engagement initiatives in shaping psychiatric care outcomes among the elderly. Expanding the scope of analysis to include other ASEAN countries would provide useful comparative insights and further inform Malaysia's mental health planning.

In conclusion, addressing the shortage and distribution of trained clinical staff is a fundamental step toward improving geriatric psychiatric care. Ensuring both the quantity and quality of the psychiatric workforce will be vital to advancing mental health equity and well-being for Malaysia's elderly population.

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ORIGINAL ARTICLE Open Access

Potential of *Cananga odorata* and *Citrus limon* essential oils in modulating NOTCH1 signalling for non-melanoma skin cancer treatment

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Abstract

Natural products have drawn increasing attention as potential therapeutic agents, particularly for their anticancer properties. Essential oils (EOs) from *Cananga odorata* (CO) and *Citrus limon* (CL) are well-known for their antibacterial and antioxidant activities, yet their ability to suppress skin cancer cell growth remains uncertain. Whereas NOTCH1 signalling pathway plays an oncogenic role in cancer development due to uncontrolled cell proliferation. This study evaluates the antiproliferative effects of CO and CL EOs on skin cancer cells by examining their impact on NOTCH1 gene expression and protein secretion. Human foreskin fibroblast (HFF-1) and skin carcinoma (A431) cell lines were treated with DMSO-dissolved cisplatin and varying concentrations (125, 250, and 500 µg/ml) of CO or CL EO for 24 hours. Cellular morphology was observed under 20–40x magnification, while qRT-PCR and western blot analyses were conducted to measure NOTCH1 gene expression and protein secretion. In A431 cells, CO EO at 125 µg/ml significantly downregulated *NOTCH1* gene expression compared to untreated cells, with levels lower than those induced by cisplatin. In contrast, CL EO at the same concentration upregulated *NOTCH1* gene expression. At higher EO concentrations, both CO and CL EOs exhibited effects similar to cisplatin, with increased NOTCH1 protein secretion, likely resulting from apoptosis or necrosis-associated membrane leakage. These findings underscore the potential of natural products, particularly CO EO as an anticancer agent via modulation of NOTCH1 signalling. Further studies are essential to unravel the precise mechanisms by which these EOs affect A431 cells, advancing their potential use in skin cancer therapy.

Keywords: *Cananga odorata, Citrus limon, essential oil, NOTCH, skin cancer*

Received:
8 December 2024
Revised:
5 May 2025
Accepted:
13 May 2025
Published Online:
31 July 2025
How to cite this article:
Muzamil, M., Azzam, N. A., Mohd Radzuan, H., & Wan Omar, W. F. N. (2025). Potential of *Cananga odorata* and *Citrus limon* essential oils in modulating NOTCH1 signalling for non-melanoma skin cancer treatment. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 174–186. https://doi.org/10.31436/ijohs.v6i2.370
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.370
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Introduction

Skin cancer, although less common in Malaysia compared to Western countries, remains a significant health concern. Based on the most recent 2020 data from the World Health Organisation (WHO), Malaysia recorded 247 skin cancer-related deaths, accounting for 0.15% of all fatalities. With an age-adjusted death rate of 0.91 for every 100,000 individuals, Malaysia ranks 139th globally for skin cancer mortality (World Life Expectancy, 2020). Although it accounts for less than 1% of mortality, the rate probably may increase since the awareness of the disease is poor, even among the patients who were already under treatment (Bath-Hextall *et al.*, 2013). The spread and increment of the knowledge of the disease among the population will help to alleviate

the burden of treatment costs, and improve the quality of life (Gordon *et al.*, 2020).

Cancer is a condition where normal cell proliferation becomes uncontrolled with genome alteration (Rashid *et al.*, 2022). Skin cancers are categorized into two main types, which are non-melanoma skin cancer and melanoma. Non-melanoma skin cancers comprise basal cell carcinoma, making up 70-80% of this category, and squamous cell carcinoma (SCC), representing 20% of non-melanoma skin cancers. Even though melanoma only constitutes 4% of skin cancer cases, it is the deadliest type due to its high potential to spread rapidly and unpredictably, especially distanced metastases in advanced stages. It is responsible for 75% of all skin cancer fatalities (Al-Naggar, 2013). In addition, the NOTCH pathway regulates cell proliferation and differentiation, which has been implicated in the pathogenesis of cancer. Hence, hyperactivation of the *NOTCH* gene results in oncogenicity in a few types of cancers, such as breast cancer, T-cell acute lymphoblastic leukemia, SCC, and adenoid cystic carcinoma (Aster *et al.*, 2017).

Many studies reported that the *NOTCH1* gene is involved in skin cancer cells, but its treatment is not without side effects (Ansary *et al.*, 2022; Gellrich *et al.*, 2019). Cisplatin, a platinum-based chemotherapy used in advanced cutaneous SCC, has been associated with acute kidney injury in 20–35% of patients (Fang *et al*., 2021). Its prolonged presence in plasma, even decades after treatment cessation, contributes to mitochondrial dysfunction, necrosis, apoptosis, and oxidative stress (Ranasinghe *et al*., 2022). Whereas current studies do not support topical 5-fluorouracil (5-FU) as a standard treatment for cutaneous SCC. Existing reports are limited to case series for 5-FU, with inconsistent follow-up durations and histologic clearance. Moreover, 5-FU often causes prolonged skin irritation, which reduced patient compliance and compromised treatment efficacy (Kim *et al.*, 2018).

Recently, the exploration of natural products as therapeutic alternatives has become an area of interest, with essential oils (EO) demonstrating their potent anticancer properties (Osanloo *et al.*, 2021). For instance, *Cananga odorata* (CO), a naturally growing plant in Asian nations, exhibits antiviral (Nuning *et al*, 2024), antibacterial, antioxidant (Mrani *et al*., 2024), and soothing properties (Borgonetti *et al*., 2022). A recent study conducted revealed that the terpene β-caryophyllene, found in CO and other plants, has been recognised for its antitumor activity, particularly against prostate and breast cancers (Sedky *et al.*, 2023).

Similarly, the therapeutic and pharmacological effect of *Citrus* spp. essential oils have been widely reported as possessing antibacterial, antioxidant (Frassinetti *et al.*, 2011), anticancer, and anti-inflammatory properties (Rafique *et al.*, 2020). *Citrus limon* essential oil (CL EO) is proven to have antiproliferative effects, with studies highlighting its superior treatment efficacy against breast and cervical cancer cells compared to other EOs (Osanloo *et al.*, 2021; Othman *et al.*, 2022).

Despite the broad interest in studying essential oils' anticancer effects, the potency of CO and CL EO in inhibiting skin cancer cell proliferation is still lacking. Therefore, this study aims to determine the effect of CO and CL EO on the morphology of normal cell and non-melanoma skin cancer cells, and to investigate the effects of both EOs on *NOTCH1* gene expression and protein secretion in the same cells.

Materials and Methods

Materials

All reagents/instruments were available in the Microbiology-Pharmacology -Physiology (MPP) and Biochemistry Molecular & Proteomic (BMOLEP) laboratory, Department of Basic Medical Sciences, International Islamic University Malaysia (IIUM). Whilst all reagents/chemicals were purchased from Sigma-Aldrich, USA, unless stated otherwise.

Cell culture

The A431 squamous carcinoma and HFF-1 foreskin fibroblast cells were purchased from iCell Bioscience, Inc., Shanghai. These cell lines were cultured in high glucose Dulbecco's Modified Eagle's Medium (DMEM) (Biosera, France) supplemented with 10% foetal bovine serum (FBS) and 1% penicillin-streptomycin, and were grown in a 75cm^2 flask. The cells were incubated under 5% CO_2 at a temperature of 37^{o}C and subcultured when it was 80-90% confluent according to the standard method.

Cell morphology study and cell harvesting

Cells were seeded at a density of 3.0×10^7 cells/well in 6-well plates in similar culture environment until approximately 90% confluence. The cells were then treated with commercially available CO and CL EO (Plant Therapy, USA) due to their standardized composition and batch consistency, supported by GC-MS profiling. This approach minimizes batch-to-batch variation and ensures reproducibility, which aligns with accepted practices in pharmacological research.

EOs were dissolved in dimethyl sulfoxide (DMSO) and applied at 125, 250, and 500 µg/ml for 24 hours in triplicates. These concentrations were based on previous studies showing cytotoxic effects of citrus EOs within 5–150 µg/ml (Borusiewicz *et al*., 2017). Whereas the in vitro antiproliferative potential of CO EO remains less extensively studied, necessitating broader concentration testing to evaluate its biological activity. The final concentration of DMSO in all treatment conditions was maintained at 0.1%, a level generally regarded as non-toxic for in vitro assays.

Using an inverted light microscope (Olympus, Japan), the morphology of the cells was recorded under 20–40x magnification. For studies on protein and gene expression, adherent cells were harvested using TRIzol (Thermoscientific, USA) and mechanical scraping (Biosera, France). These cell lysates were kept at -80°C. For the protein secretion study, the collected conditioned medium was kept at -20°C.

Total RNA extraction from cell lysate

The total RNA was extracted from HFF-1 and A431 cell lysates in TRIzol using the innuPREP RNA Mini Kit (Analytik Jena, Germany) according to the manufacturer's protocol. Elution buffer was added to the total extracted RNA and was kept at -80°C.

cDNA conversion

The concentration of RNA samples was verified by measuring its absorbance at 260 nm via NanoDrop 1000 Spectrophotometer (Thermoscientific, USA). Using a cDNA conversion kit from BioLine (UK), 1,000 ng of RNA was converted to cDNA and was kept at -20°C.

Quantitative Real-Time Polymerase Chain Reaction (qRT-PCR)

Predesign *NOTCH1* and *ACTB* primers and probes were purchased from IDTDNA, USA (Table 1). The procedure was performed in a 10 µl reaction composed of Mastermix 2x (IDTDNA, USA), cDNA (1:10 dilution), 20x primers and probes, and RNAse-free water. Samples without transcriptase were used as control reactions. The CFX96 qRT-PCR system (BioRad, USA) was used to conduct the suggested procedure, which involved polymerase activation: 95°C for 3 min; denaturation: 95°C for 15 sec; and annealing: 60°C for 1 min. The CFX96 setting (available from BioRad, USA) was programmed to repeat the amplification up to 50 cycles. All statistical results were analysed by the CFX96 qRT-PCR system. Data are presented as mean ± SEM. A p-value <0.05 was considered statistically significant.

Table 1. Primers Sequences for Quantitative Real-Time Polymerase Chain Reaction (qRT-PCR).

Gene	Primer Sequence		Probe
	Forward (5'-3')	Reverse (5'-3')	
NOTCH1	CGAGGTCAACACAGACGAG	ACAGATGCCCAGTGAAGC	ATGAGTTCCAGTGCGAGTGCCC
ACTB	ACAGAGCCTCGCCTTTG	CCTTGCACATGCCGGAG	TCATCCATGGTGAGCTGGCGG

Protein extraction from cell lysate

Cytosolic protein was extracted from the second filtrate acquired from the innuPREP RNA Mini Kit as described previously (Radzuan, 2020). Briefly, the filtrate was precipitated with 4 volumes of cold acetone at 4°C for 30 min. Protein pellets were obtained by centrifugation at 4000 rpm g at 4°C for 10 min. The supernatant was discarded and 400µl of 100% ethanol was added to the pellet and centrifuged again for 1 minute. The supernatant was removed, and the pellet was air-dried for 10 minutes and resuspended in RIPA extraction and lysis solution (Thermoscientific, USA) before being used for BCA assay. The protein samples were kept at -20°C.

Protein extraction from conditioned medium

The collected conditioned medium was added to four volumes of 100% cold acetone and incubated at -20°C for 1 hour as previously described (Radzuan, 2020). The protein extracts were centrifuged using an ultracentrifuge (Beckman Coulter Life Sciences, USA) at 13000 g, 4°C for 10 min. The supernatant was discarded and the protein pellet was air-dried. The final pellet was suspended in RIPA extraction and lysis buffer and kept at -20°C.

Western blot

Western blotting was used to determine the NOTCH1 protein expression and secretion from HFF-1 and A431-CO or CL EO-treated cells. The primary protein (NOTCH1: A-8, Santa Cruz Biotechnology, USA) and the reference protein (ACTB: C4, Santa Cruz Biotechnology, USA) antibodies were diluted at 1:100, while the secondary antibodies (m-IgGk BP- HRP: sc516102 and m-IgG Fc BP-HRP: sc525409, Santa Cruz Biotechnology, USA) were diluted at 1:1000 for this application. Equivalent concentrations of cytosolic and secreted proteins were denatured in 6x and 2x Laemmli buffer (BioRad, USA) respectively. These two groups of proteins were loaded and separated in 2 different 7% bis-acrylamide gels, with a protein molecular weight marker (BioRad, USA) in the first well of each gel. Electrophoresis was run at 100V for 10 min, followed by 120V for 1 hour.

Subsequently, the proteins were electro-transferred to the PVDF membranes using the Trans-Blot Turbo Kit (BioRad, USA) at 13V for 20 min. After the completion of protein transfer, the PVDF membranes were blocked using a 1% BSA at room temperature for 1 hour. Then, the PVDF membranes were soaked in a working solution that consisted of the primary and reference protein antibodies overnight at 4°C. The following day, the membranes were rinsed and incubated with secondary antibodies for 1 hour at room temperature. The signal development was carried out by using the Chemi-Lumi One Series for HRP (Nacalai Tesque, Japan). Quantification of Western Blotting was done using the

ChemiDoc Imaging System Machine and ChemiDoc XRS software (BioRad, USA).

Results

Cell morphology

Cell morphology was evaluated using light microscopy at two magnifications to optimize visual assessment. A higher magnification (40×) was used for untreated HFF-1 cells to provide a detailed baseline of individual cell morphology. These cells exhibited a typical spindle-shaped appearance, uniform distribution, high confluency, and healthy morphology (Figure 1a).

For the treatment groups, lower magnification (20×) was employed to allow broader visualization of cell population changes across larger areas, including alterations in density, distribution, and morphology. HFF-1 cells treated with DMSO and 125 µg/ml of either CO or CL EO maintained their spindle shape and cell density, indicating negligible or minimal cytotoxic effects at this concentration (Figure 1b, c, f).

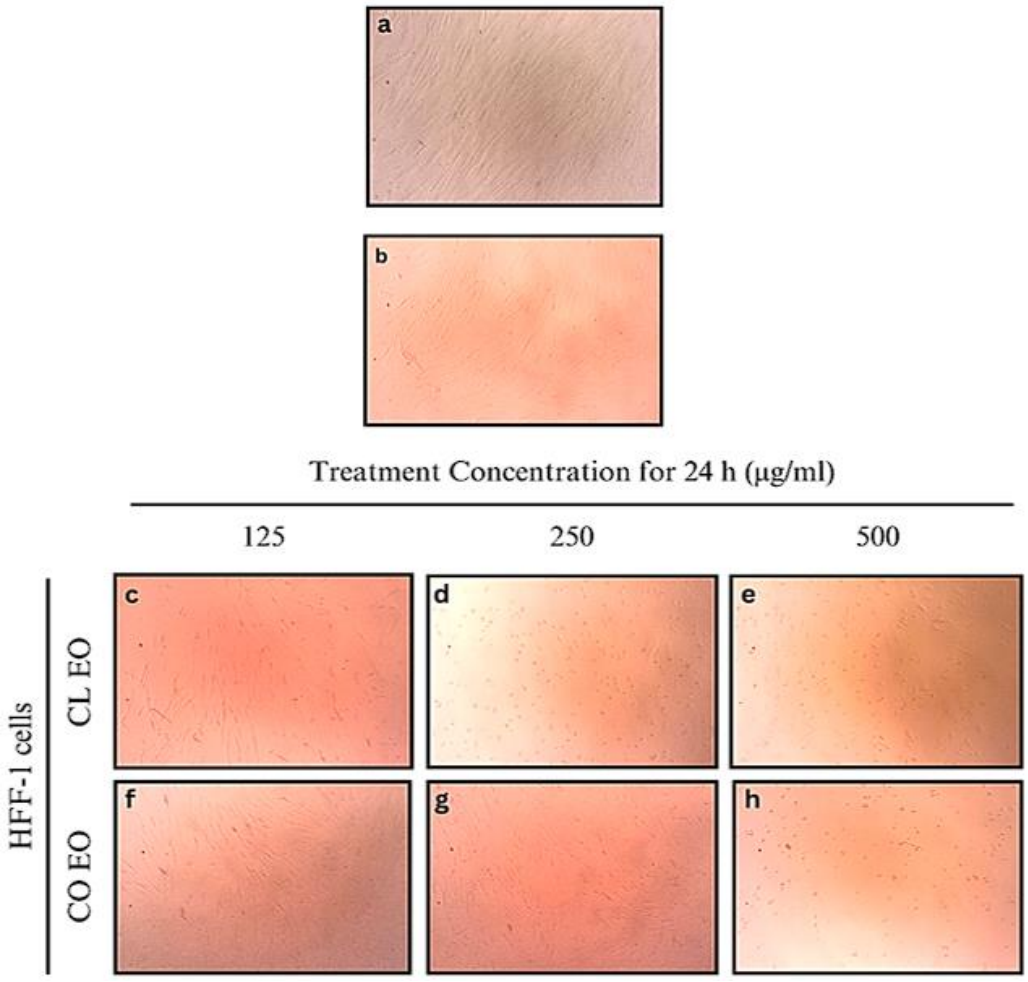

Figure 1. Morphological cell study of HFF-1 cell line. (a) Cells without treatment observed under 40x magnification. (b) Cells treated with DMSO, (c) 125 µg/ml of CL EO, (d) 250 µg/ml of CL EO, (e) 500 µg/ml of CL EO, (f) 125 µg/ml of CO EO, (g) 250 µg/ml of CO EO, and (h) 500 µg/ml of CO EO respectively, and observed under 20x magnification.

In contrast, treatment with 250 and 500 µg/ml of CL EO (Figure 1d, e) resulted in cells adopting a rounded morphology, with decreased cell-to-cell contact and reduced confluency, suggesting signs of cytotoxicity or apoptosis.

A similar response was observed in cells treated with 500 µg/ml of CO EO (Figure 1h), where cell rounding and sparse distribution were evident. These morphological changes indicate a dose-dependent effect of both EOs on cells viability and proliferation.

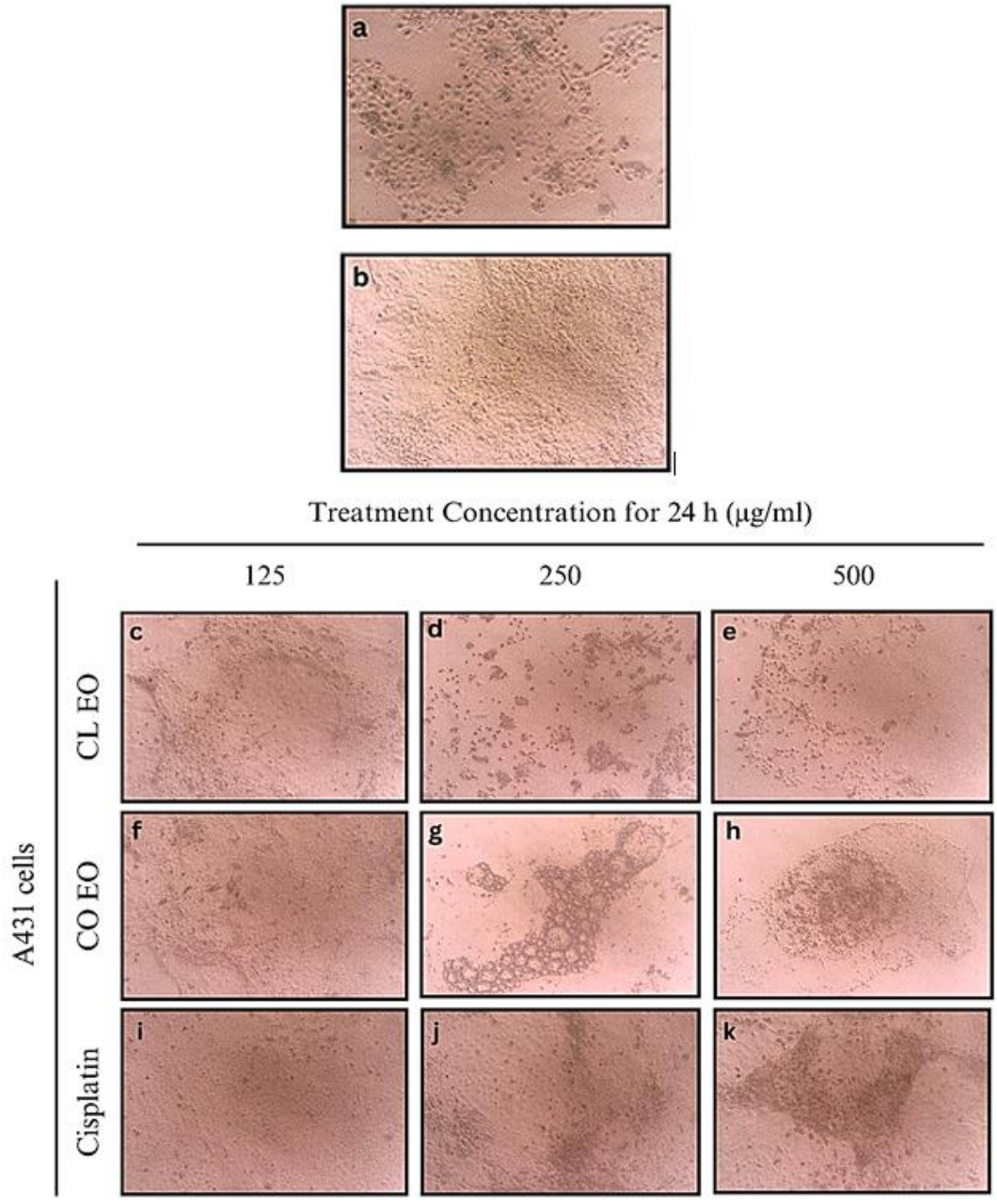

Figure 2. Morphological cell study of A431 cell line. (a) Cells without treatment observed under 40x magnification. (b) Cells treated with DMSO, (c) 125 µg/ml of CL EO, (d) 250 µg/ml of CL EO, (e) 500 µg/ml of CL EO, (f) 125 µg/ml of CO EO, (g) 250 µg/ml of CO E EO, (h) 500 µg/ml of CO EO, (i) 125 µg/ml of cisplatin, (j) 250 µg/ml of cisplatin, and (k) 500 µg/ml of cisplatin respectively, and observed under 20x magnification.

The initial morphology of the untreated A431 cells under 40x magnification appeared round shaped and grew in compact clusters with high confluency (Figure 2a). Morphological features remained unchanged following DMSO exposure, indicating vehicle tolerance (Figure 2b). For treatment groups, a lower magnification (20×) was particularly useful for A431 cells, which exhibit irregular cluster-based growth, enabling clearer visualization of treatment-induced detachment, aggregation, and cell loss.

With increasing concentrations of CL EO, cells exhibited clumped clusters with reduced confluency and cell density (Figure 2c–e). Similar alterations were observed in cells treated with CO EO, where dose-dependent effects included cell swelling, shrinkage, and isolation, particularly at 250 and 500 µg/ml (Figure 2f–h). These changes suggest membrane damage consistent with apoptotic or necrotic processes.

Cisplatin treatment (Figure 2i–k) elicited comparable morphological changes, including cell rounding, hyperpigmentation, and increased granularity. The 20× magnification provided an optimal field of view for evaluating these spatial and morphological alterations in A431 cells.

Gene expression

There is no significant molecular effect to the HFF-1 cells treated with 125 µg/ml CO and CL EO (Figure 3). Interestingly, in contrast to untreated A431 cells, those treated with CO EO showed marked downregulation of *NOTCH1* gene expression as compared to cells treated with 125 µg/ml cisplatin, although it is not statistically significant (p = 0.2) (Figure 4). However, cells supplemented with CL EO revealed insignificant upregulation of *NOTCH1* gene expression ($p > 0.05$), unlike the effects shown by former treatments.

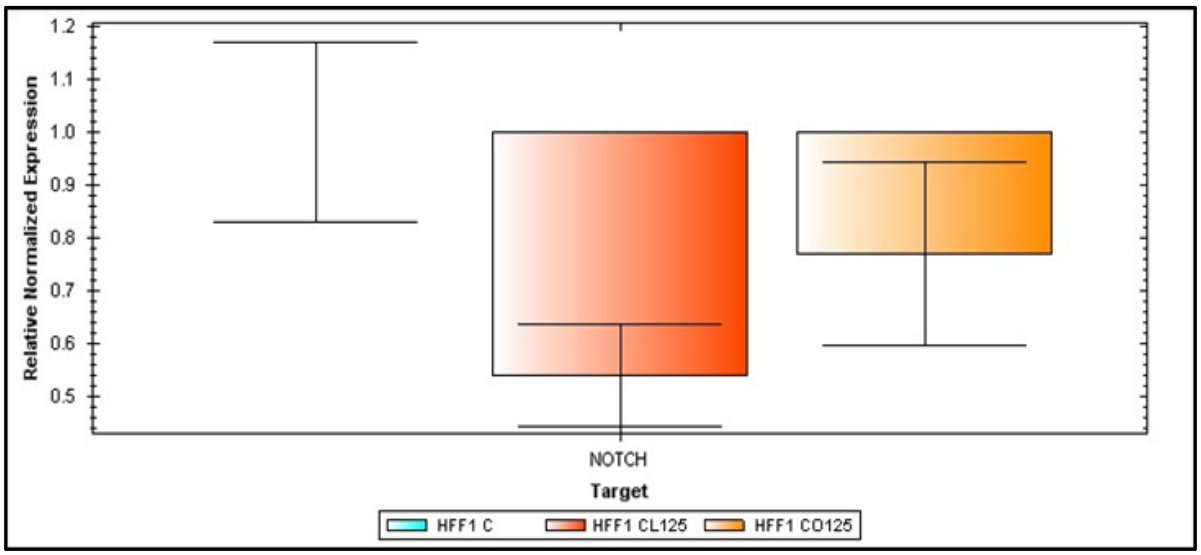

Figure 3. Relative normalized gene expression of NOTCH1 in HFF-1 cells after treatment with CO and CL EO at concentration of 125 µg/ml for 24 hours compared to control.

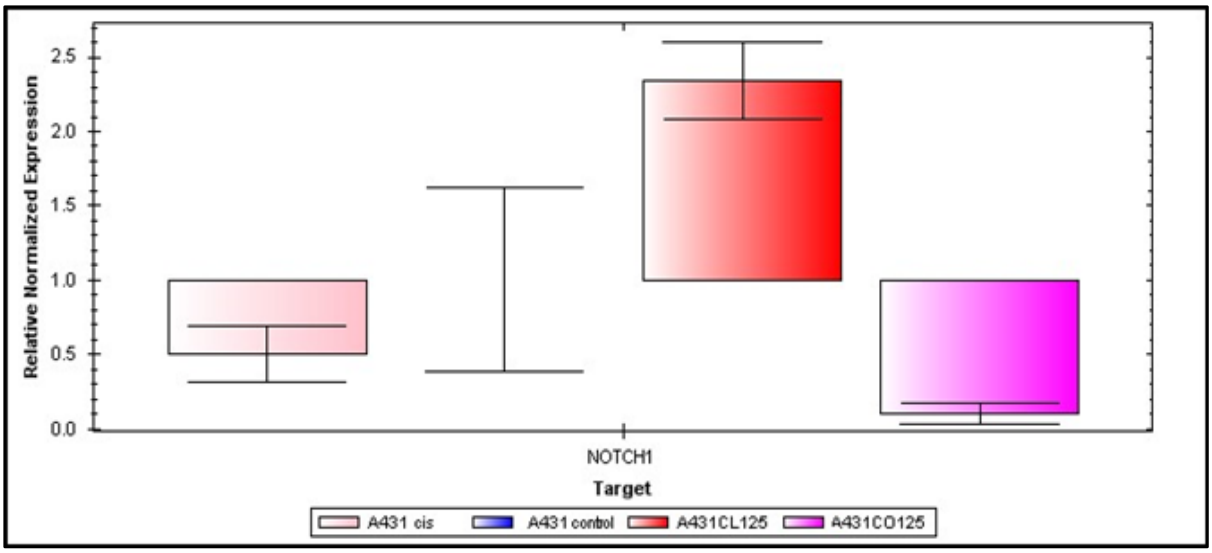

Figure 4. Relative normalized gene expression of NOTCH1 in A431 cells after treatment with cisplatin, CO, and CL EO at concentration of 125 µg/ml for 24 hours compared to control.

Protein expression and secretion

NOTCH1 protein expression could not be completed due to a very low concentration of cytosolic protein extracted from the same cell lysate (less than 0.3 µg/ml). Meanwhile, NOTCH1 protein secretion bands from A431 cells showed increasing intensity with increasing concentration of CO EO, which is almost similar to NOTCH1 protein secretion in cells treated with cisplatin. However, NOTCH1 protein secretion from A431 cells treated with CL EO showed lower protein band intensity (Figure 5).

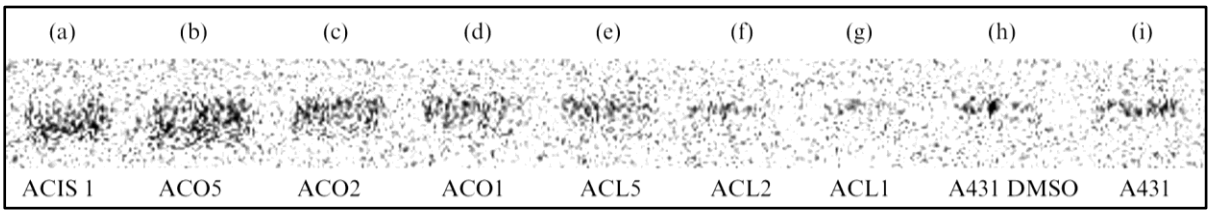

Figure 5. NOTCH1 protein secretion extracted from conditioned media of treated A431 cells. (a) 125 µg/ml cisplatin, (b) 500 µg/ml CO EO, (c) 250 µg/ml CO EO, (d) 125 µg/ml CO EO, (e) 500 µg/ml CL EO, (f) 250 µg/ml CL EO, (g) 125 µg/ml CL EO, and (h) A431 with vehicle (0.1% DMSO), respectively.

The quantitative values were generated by ChemiDoc XRS software and shown in Figure 6. A431 cells treated with 250 µg/ml and 500 µg/ml of CO EO showed marked upregulation of NOTCH1 protein secretion. The latter group displayed the highest NOTCH1 protein secretion, similar to those treated with cisplatin. While cells treated with 125 µg/ml and 250 µg/ml of CL EO showed downregulation of NOTCH1 protein secretion.

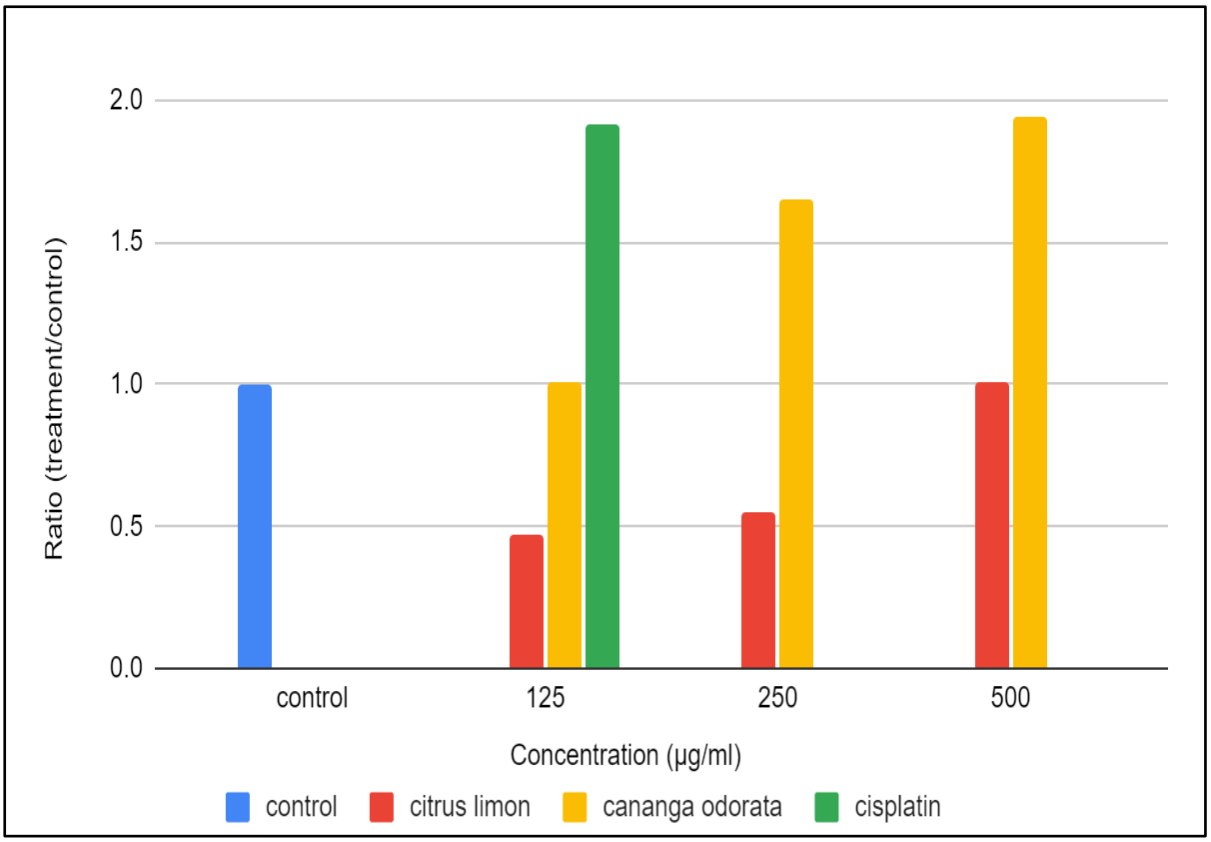

Figure 6. Ratio of NOTCH1 protein secretion on A431 cells.

Discussion

Plant essential oils have been extensively studied for their potential therapeutic properties, including their application in treating skin cancer**.** To understand the molecular mechanism underlying the effect of plant essential oil on normal skin and skin cancer cells, the morphological cell study, *NOTCH1* gene expression, and western blotting were analysed in this study.

Morphological observations in Figure 1 demonstrated the HFF-1 cells retained their characteristic spindle-shaped appearance when treated with CO and CL EOs at a concentration of 125 µg/ml, suggesting no significant impact on the morphology of normal cells at this level. However, exposure to higher concentrations (250 µg/ml or more) resulted in noticeable morphological changes. As the EO concentration increased, the fibroblast-like structure of the cells progressively transformed into a shrunk, rounded shape, indicating that higher concentrations of EOs disrupted the normal morphology of cells (Kang *et al.*, 2018; Montalvão *et al.*, 2023).

As shown in Figure 3, treatment of HFF-1 cells with 125 µg/ml CO and CL EO did not produce significant changes in *NOTCH1* gene expression compared to the untreated control. This finding, alongside the preserved spindle-shaped morphology and high confluency observed in Figure 1, indicates that low concentrations of CO and CL EOs did not adversely affect normal cells at the molecular or morphological level.

These results aligned with previous findings suggesting the relative safety of certain EO active components, particularly limonene and linalool, major constituents of CO and CL EOs. Herman *et al.* (2015) reported the anticancer potential of both compounds, while also noting their low toxicity profiles. Importantly, these constituents are recognized as safe by several international bodies, including the Research Institute for Fragrance Materials (RIFM) and the U.S.

National Toxicology Program (NTP). Compared to synthetic chemical enhancers, essential oils and their constituents generally present lower toxicity, supporting their potential application as safer transdermal drug delivery agents (Herman *et al*., 2015).

The absence of cytotoxic effects on normal cells is also consistent with studies by Galvão *et al.* (2012), who found no antiproliferative activity of other plant-derived EOs such as *Aloysia gratissima, Baccharis dracunculifolia, Coriandrum sativum*, and *Lippia sidoides*, on normal human cell lines (Galvão *et al*., 2012). Similarly, *Citrus medica* EO also exerted selective cytotoxic effects on human colon cancer cells without significantly affecting non-tumorigenic cells (Fitsiou and Pappa, 2019). These findings collectively support the selective action of certain EOs against cancerous cells, while preserving the viability and integrity of normal cell types.

Given the insignificant morphological and molecular impact of EOs at 125 µg/ml on HFF-1, this concentration was selected to investigate molecular changes in skin cancer cells. However, a precise range of compatible concentrations for normal and cancer cells should be determined before these EOs could be used as an alternative treatment for skin cancer.

Although the morphological appearance of A431 cells treated with 125 µg/ml of CO and CL EOs showed unremarkable changes than the untreated group as shown in Figure 2, this study reported promising findings via *NOTCH1* gene expression. Based on Figure 4, A431 cells supplemented with CO EO caused downregulation of *NOTCH1* gene expression, surpassing the effect observed with cisplatin. The antiproliferative effect shown by CO EO is similar to a study done by Gaafar et al. (2022), in which *Raphanus sativus* extract causes downregulation of *NOTCH1* expression in breast and colon adenocarcinoma cell lines, achieving greater reduction than cisplatin chemotherapy. Additionally, other genes associated with cell proliferation, such as *WNT1* and *SIX1*, were also downregulated, which supports antiproliferative properties of the extract (Gaafar *et al.,* 2022).

In our experiment, treatment with CL EO led to an unexpected upregulation of *NOTCH1* gene expression in cancer cells, despite its anticipated antiproliferative role. This observation could suggest that bioactive compounds of CL EO may modulate cancer cell behaviour through other mechanisms such as cell cycle arrest, induction of apoptosis and antiangiogenic effect (Mohamed Abdoul-Latif *et al*., 2023).

Supporting this, Murthy *et al.* (2012) found that citrus-derived flavonoids act as potent inhibitors of colon cancer cells by suppressing inflammatory markers and inducing cell cycle arrest (Murthy *et al*., 2012). Additionally, essential oil from *Citrus limetta* peel demonstrated anti-inflammatory effects towards skin cancer cells by downregulating cytokines such as TNF-α, IL-1β, and IL-6 (Kim and Hong, 2024). Collectively, these studies support the hypothesis that CL EO may influence cancer progression through multifaceted pathways, including modulation of inflammation and signalling pathway alterations, including but not limited to the NOTCH1 axis.

In Figure 6, A431 cells treated with cisplatin and higher concentration of CO EO exhibited an upregulation of NOTCH1 protein secretion. In contrast, A431 cells treated with lower concentration of CL EO demonstrated a downregulation of NOTCH1 protein secretion relative to the control. These results were inconsistent with the observed gene expression levels of *NOTCH1* in A431 cells.

A potential explanation for these discrepancies probably lies in post-transcriptional modifications. Processes such as mRNA stabilization, translation regulation, or protein stabilization could result in elevated or stable NOTCH1 protein levels despite transcriptional downregulation (Wang, 2011). These mechanisms may influence the accuracy of protein secretion data when compared to gene expression findings. Additionally, complex regulatory pathways might

enhance protein secretion to compensate for reduced intracellular NOTCH1 protein levels due to transcriptional downregulation (Su *et al*., 2024). To confirm whether this secretion involves active transport rather than passive leakage, future experiments incorporating brefeldin A, a known inhibitor of protein trafficking from the endoplasmic reticulum to the Golgi apparatus could provide additional clarity to this hypothesis.

Since the study could not determine cytosolic NOTCH1 protein levels, it remains unclear whether the increased secretion observed in A431 cells treated with CO EO is driven by enhanced synthesis, post-transcriptional regulation, or active secretion mechanisms. Alternatively, cell membrane leakage could be a plausible mechanism in response to treatment-induced stress. Cisplatin, a known chemotherapeutic agent, has been shown to induce both necrosis and apoptosis in cultured human lymphoma and renal tubule cells (Sancho-Martinez *et al.*, 2011). This stress response could result in dose-dependent reduction in protein expression, as reported previously (Rathinam *et al.,* 2015). Consequently, the elevated NOTCH1 protein "secretion" in cells treated with cisplatin and CO EO may reflect intracellular protein leakage into the media rather than active extracellular transport.

To distinguish between passive leakage and active secretion, assays such as LDH release to indicate cell necrosis or TUNEL assays to detect DNA fragmentation in apoptotic cells should be employed. Additionally, the presence of housekeeping proteins like GAPDH and actin in the culture media may suggest compromised cell membrane integrity.

Conclusion

This study showed the potential of CO EO as chemotherapy while maintaining the integrity of normal cell lines. In this study, 125 µg/ml concentration of CO and CL EO shown to have no effect on normal cell morphology and *NOTCH1* gene expression as compared to cancer cells. In addition, treatment of 125 µg/ml CO EO showed further downregulation of *NOTCH1* gene expression than 125 µg/ml cisplatin, which could be a potential alternative to current cancer treatment. However, optimization of methods must be done to produce consistent and reproducible results. Both EOs could be further investigated as a potential complementary therapy for cancer via NOTCH1 signalling, in view of their antiproliferative effect. Apart from LDH release and TUNEL assay, cell viability assay may be included in future research to obtain the cytotoxicity of CO and CL EOs on human cells and cancer cells.

Acknowledgement

The authors are thankful to the Department of Basic Medical Sciences, Kulliyyah of Medicine, International Islamic University Malaysia (IIUM) for providing continuous support, and funding via RMCG20-062-0062 during the course of preparation of this manuscript.

Conflict of Interest

The author declares that the manuscript produced in the absence of any financial or commercial relationships could be construed as a potential conflict of interest.

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ORIGINAL ARTICLE Open Access

A retrospective study on the evaluation, management, and outcomes of oral mucosal lesions in patients at the Oral Medicine Clinic

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Abstract

Oral mucosal lesions (OMLs) are prevalent across different populations worldwide, with varying frequencies in different regions. This study aims to evaluate the frequency of OMLs and analyse their distribution concerning age, gender, race, and systemic conditions. A retrospective cross-sectional study was conducted on patients who attended the Oral Medicine students' polyclinic, International Islamic University Malaysia, over a period of seven years. Data from a total of 85 patients were collected and analysed using descriptive statistical methods. The analysis included patient demographics such as age, gender, race, systemic diseases, as well as the types and sites of oral mucosal lesions (OMLs). OMLs were categorized into four main groups: ulcers, white lesions, infections, and others. Among the data collected from eighty-five patients, the prevalence of oral mucosal lesions was found to be higher in females than in males. The most common lesions were ulcers (65.9%), followed by infections (19.4%), white lesions (13.6%), and others (12.6%). Ulcers were predominantly found in individuals aged 15–30 years, whereas white lesions, infections, and other types were more frequent in the 31–60 age group. No significant association was found between systemic conditions and lesion types. Ulcers commonly appeared in multiple locations (37.5%), white lesions were most frequently found on the buccal mucosa (35.7%), infections were primarily observed on the hard palate (40.0%), and other lesions occurred most often on the labial mucosa (30.7%). Ulcers were the most prevalent type of oral mucosal lesions; however, no significant correlation was found between OMLs and systemic conditions.

Keywords: *evaluation, oral mucosal lesions, management, retrospective*

Received:
16 February 2025
Revised:
28 May 2025
Accepted:
28 May 2025
Published Online:
31 July 2025
How to cite this article:
Kashmola, M. A., Mustafa, N. S., Mohd Ibrahim, M. S., Jamhari, N. A., & Mat Daud, N. H. (2025). A retrospective study on the evaluation, management, and outcomes of oral mucosal lesions in patients at the Oral Medicine Clinic. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 187–198. https://doi.org/10.31436/ijohs.v6i2.387
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.387

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Introduction

The oral mucosa consists of three distinct parts: the masticatory mucosa, which includes the gingiva and the hard palate; the specialized mucosa covering the dorsum of the tongue; and the oral mucous membrane lining the rest of the oral cavity (Newman *et al*., 2018). Oral mucosal lesions (OMLs) refer to any abnormal changes in the surface, colour, texture, swelling, or integrity of the oral mucosa. These lesions can impact an individual's quality of life by causing difficulties in chewing, swallowing, and speaking due to symptoms such as burning, irritation, and pain (El Toum *et al.,* 2018).

An accurate and detailed description of an oral mucosal lesion (OML) is essential for its diagnosis and management, along with a brief patient history and clinical examination. The lesion should be documented based on the following ten characteristics look :

- size (length, width and height),
- number (single, multiple),
- outline (regular, irregular),
- surface (smooth, granular, verrucous, papillomatous, pebbly, cobblestone),
- base (pedunculated, sessile, nodular, dome-shaped),
- site (mucosal, intra-bony, dental),
- colour (red, pink, white, red-white combined, blue, purple, grey, yellow, black, brown),
- consistency (soft, hard, cheesy, firm, rubbery, fluctuant),
- origin acquired, non-acquired,
- morphology or clinical appearance primary lesions, secondary lesions) (Mortazavi *et al.,* 2019).

Although many OMLs are benign and do not require active treatment, some may present with significant pathology. Of particular concern are oral potentially malignant disorders (OPMDs), which have the potential to progress into malignancy (El Toum *et al.,* 2018).

However, epidemiological studies on oral mucosal lesions (OMLs) are still fewer than those on dental caries or periodontal diseases (Katiyar *et al.,* 2021). In the literatures, the prevalence of oral mucosa lesion in general population globally varies across different countries and areas, ranging between 10.8%-81.8% (Feng *et al.,* 2015; Chauhan *et al.,* 2018; Oivio *et al.,* 2020; Kansky *et al.,* 2018). This retrospective cross-sectional study aims to determine the frequency of oral mucosal lesions (OMLs) in patients who attended the Oral Medicine (OM) students' polyclinic at Kulliyyah of Dentistry (KOD), IIUM over a seven-year period, from January 2013 to December 2019. Additionally, the study evaluates the sites, types, management, and prognosis of OMLs, while also analysing their correlation with factors such as age, gender, race, and systemic conditions. Another objective is to establish a database of OML cases among patients visiting the OM clinic at KOD, IIUM. The OMLs in this study are classified according to Neville *et al,* (2018) in the Colour Atlas of Oral and Maxillofacial Diseases (Neville *et al.,* 2018) and are categorized into four groups: ulcerations, white lesions, infections, and others.

Materials and Methods

Study design

This study is a retrospective cross-sectional study design conducted among patients attending Oral Medicine (OM) Clinic, Kulliyyah of Dentistry, IIUM, within 7 years' duration starting from January 2013 to December 2019.

This retrospective cross-sectional study design was performed on patients attending Oral Medicine (OM) Clinic, Kulliyyah of Dentistry, IIUM, Kuantan, Pahang within 7 years' duration starting from January 2013 to December 2019. Prior to data collection, ethical approval was obtained from the International Islamic University Malaysia Research Ethics Committee (ID No: IREC 2020-014).

Sample size

Patient cases from the Oral Medicine (OM) poly Clinic at KOD, IIUM, between January 2013 and December 2019 were reviewed, and relevant data were extracted from patient records. The collected information included age, gender, race, chief complaint, history of the presenting illness, past medical history, smoking and tobacco use status, as well as the type, number, and location of oral mucosal lesions (OMLs). This data was systematically recorded in a data collection sheet.

The inclusion criteria for this study required a clear clinical and/or histopathological diagnosis of OMLs. Patients with incomplete or missing relevant information in their records were excluded from the study. The

classification of OMLs followed the system outlined in Neville *et al*., 2018) in the Colour Atlas of Oral and Maxillofacial Disease.

Data and statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) 25.0 software (SPSS Inc., Chicago, IL, United States). The collected data were analysed by using descriptive statistical analysis which includes the details of the patients such as age, gender, race, systemic disease, types and sites of oral mucosal lesions.

Results

This retrospective study explores the prevalence of oral mucosal lesions (OMLs) among patients attending the Oral Medicine (OM) poly Clinic at KOD, IIUM, Kuantan, over a seven-year period. A total of 85 patient records, from an initial 105 cases, met the inclusion criteria and were analysed. Among these patients, 55 (64.7%) were female, while 30 (35.3%) were male. The age range of the patients was between 11 and 74 years, with a mean age of 33.40 ± 15.743 years.

The majority of the sample falls within the age range of 15–30 years (n=49, 57.6%), followed by the 31–60 age group (n=29, 34.1%). A smaller proportion of patients belong to the age groups of under 15 years (n=1, 1.2%) and 60 years and above (n=6, 7.1%).

Over the seven-year study period (2013–2019), a total of 105 patients with oral mucosal lesions (OMLs) attended the Oral Medicine (OM) Clinic at KOD, IIUM. However, only 85 patients met the inclusion criteria and were included in the analysis. The demographic data, medical histories, and medication histories of the patients are presented in Tables 1 and 2.

Regarding systemic conditions, 9.4% of patients reported allergies (e.g., food allergies to seafood and nuts, latex allergy), 4.7% had hypertension, 1.2% had diabetes, 5.9% had asthma, and 2.4% had blood disorders such as anaemia and G6PD deficiency. Other conditions, including bronchitis, psoriasis, and scoliosis, were observed in 4.7% of patients, while 16.5% had multiple comorbidities such as hypertension, diabetes, hypercholesterolemia, thyroid disorders, and gout (Table 2).

In terms of medication use, 4.7% of patients were on antihypertensive drugs, 1.2% on antidiabetic medications, 2.4% on vitamins, 3.5% on anti-asthmatics, and 2.4% on anti-inflammatory drugs. Additionally, 14.1% of patients were taking multiple medications, and 3.5% were using other drugs such as oral contraceptive pills (Table 2).

For analysis, the study categorized OMLs into four subgroups: ulcerative lesions, white lesions, infections, and others (Table 4). Among these, ulcerative lesions were the most common, accounting for 54.4% of cases, followed by infections (19.4%), white lesions (13.6%), and other types of lesions (12.6%) (Table 3).

The distribution of types of oral mucosal lesion according to age groups as shown in Figure 1. The analysis showed a significant statistical difference between age-ulcer groups (p=0.000) and between age-infection groups (p=0.000). Ulcers are more prevalent in 15-30 year old (82%), whereas infections mostly occur in patients aged between 30-60 year old (70%) (Table 5).

Table 1. Demographic data of the patients attending OM Clinic, KOD IIUM.

Variables		*n*=85 (100%)
Age groups	Mean ± SD years, (range)	33.40 ± 15.7 (11-74)
	<15 years old	1 (1.2%)
	15 – 30 years old	49 (57.6%)
	31 – 60 years old	29 (34.1%)
	>60 years old	6 (7.1%)
Gender	Male	30 (35.3%)
	Female	55 (64.7%)
Race	Malay	79 (92.9%)
	Indian	1 (1.2%)
	Chinese	3 (3.5%)
	Other	2 (2.4%)
Systemic disease	Presence	38 (44.7%)
	Absence	47 (55.3%)

Table 2. Patients' medical and medications history (n=85).

	Frequency	Percentage (%)
Medical history		
Allergy	8	9.4
Hypertension	4	4.7
Diabetes	1	1.2
Asthma	5	5.9
Blood disorder	2	2.4
Other diseases	4	4.7
Multiple diseases	14	16.5
Medications		
Antihypertensives	4	4.7
Antidiabetics	1	1.2
Vitamins	2	2.4
Anti-asthmatics	3	3.5
Anti-inflammatories	2	2.4
Multiple medications	12	14.1
Others	3	3.5

Table 3. Distribution of types of oral mucosal lesion.

Type of lesions	Frequency	Percentage (%)
Ulcers	56	54.4
White lesions	14	13.6
Infections	20	19.4
Others	13	12.6
Total	103	100.0

Table 4. Distribution of types of oral mucosal lesions.

Type of lesions	Frequency	Percentage (%)
Ulcers		
Minor RAU	25	24.3
Traumatic ulcer	21	20.3
Minor RAU & traumatic ulcer	10	9.8
Total	56	54.4
White lesions		
Nicotinic stomatitis	3	2.9
Geographic tongue	2	1.9
Leukoplakia	1	1.0
Lichen planus	2	1.9
Hairy tongue	1	1.0
Frictional keratosis	3	2.9
Smoker's keratosis	1	1.0
Multiple	1	1.0
Total	14	13.6
Infections		
Angular cheilitis	3	2.9
Denture stomatitis	12	11.6
Pseudomembranous candidiasis	1	1.0
Herpetic stomatitis	1	1.0
Herpes labialis	1	1.0
Multiple	3	2.9
Total	21	20.4

Others		
Reactive edematous tissue	1	1.0
Denture induced fibrous hyperplasia	4	3.8
Fibroepithelial hyperplasia	2	1.9
Fibroepithelial polyp	1	1.0
Exfoliating cheilitis	1	1.0
Allergic cheilitis	1	1.0
Multiple	2	1.9
Total	12	11.6

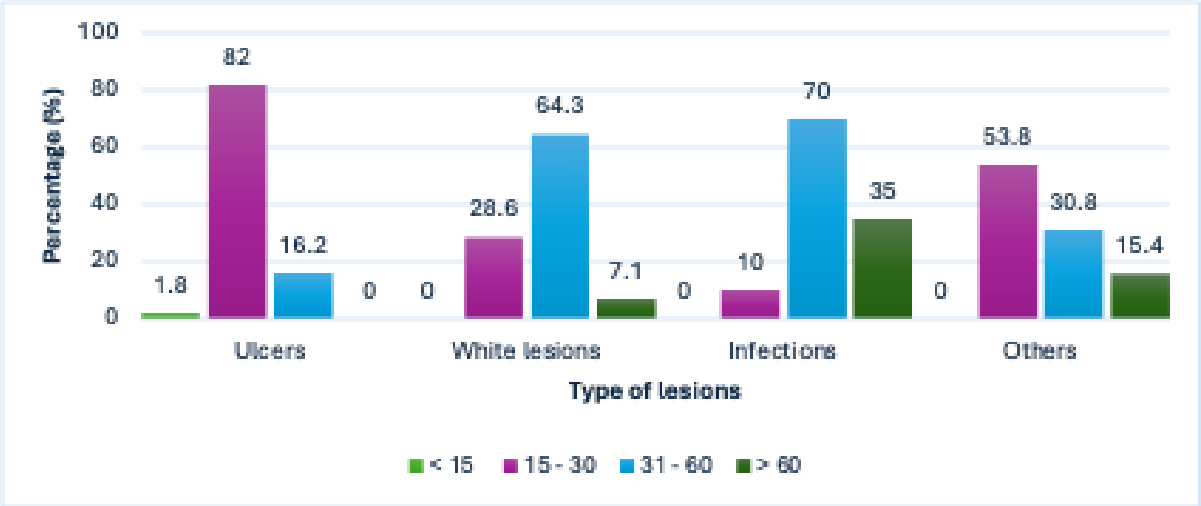

Figure 1. Distribution of types of oral mucosal lesion according to age range of patients

Table 5. Correlation between age groups and oral mucosal lesions

	Age groups *n* (%)				
	<15 years	**15-30 years**	**31-60 years**	**>60 years**	***p*-value‡**
Ulcers	1 (1.8%)	46 (82.0%)	9 (16.2%)	0	0.000
White lesions	0	4 (28.6%)	9 (64.3%)	1 (7.1%)	0.062
Infections	0	2 (10.0%)	14 (70.0%)	7 (35.0%)	0.000
Others	0	7 (53.8%)	4 (30.8%)	2 (15.4%)	1.137

The distribution of oral mucosal lesions according to gender as shown in Figure 2. The prevalence of oral mucosal lesions in relation to gender did not show a significant difference except for white lesions group (p=0.010) which male has more prevalence of presence of white lesion compared to female (Table 6).

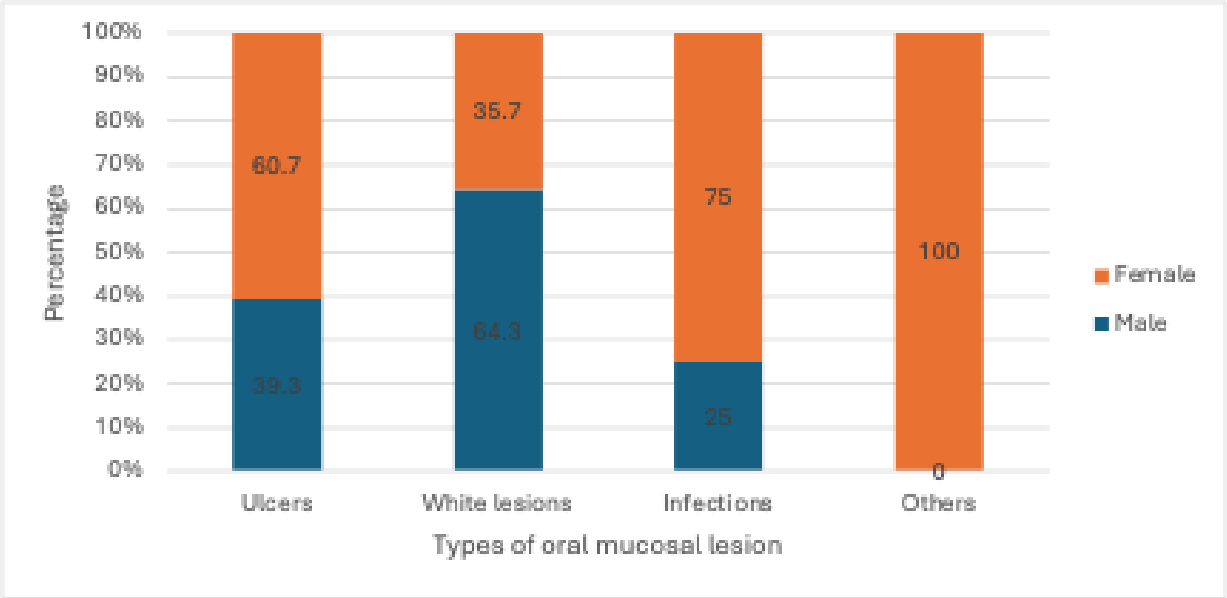

Figure 2. Distribution of types of mucosal lesion with genders.

Table 6. Correlation between gender and oral mucosal lesions.

	Gender *n* (%)		
	Male	**Female**	**p-value‡**
Ulcers	22 (39.3%)	34 (60.7%)	0.123
White lesions	9 (64.3%)	5 (35.7%)	0.010
Infections	5 (25%)	15 (75%)	0.496
Others	0	13 (100%)	0.537

‡Fisher's exact test

The correlation between OMLs and races and systemic diseases were not significant in this study because the sample does not represent the race distribution of the general population. Therefore, we did not include it in this study.

The distribution of oral mucosal lesions according to different sites of oral cavity was also recorded as shown in the table 7. Among these 4 groups of lesions, for ulcers, it mostly occurs in multiple locations about 37.5% followed by labial mucosa (17.9%) and buccal mucosa (16.0%). For white lesions the result showed that buccal mucosa is the common site to occur (35.7%) and the least to appear on hard palate and ventral of tongue (7.1%). Meanwhile, for infection group, the result showed higher percentage of occurrence on hard palate (40.0%) compared to other locations. For others, labial mucosa showed the most common site for lesion to occur which is about 30.7%.

Table 7. Distribution of oral mucosal lesions according to the locations.

	Frequency of OMLs, *n* (%)			
	Ulcers	**White lesions**	**Infections**	**Others**
Buccal mucosa	9 (16.0%)	5 (35.7%)	0	1 (7.7%)
Labial mucosa	10 (17.9%)	0	2 (10.0%)	4 (30.7%)
Hard palate	1 (1.8%)	1 (7.1%)	8 (40.0%)	2 (15.4%)
Tongue Dorsum	0	3 (21.5%)	0	0
Ventral	1 (1.8%)	1 (7.1%)	0	0
Floor of mouth	3 (5.4%)	0	0	0
Lips	5 (8.9%)	0	0	2 (15.4%)
Angle of mouth	0	0	3 (15.0%)	1 (7.7%)
Others (gingiva, alveolar ridge)	6 (10.7%)	3 (21.5%)	4 (20.0%)	2 (15.4%)
Multiple	21 (37.5%)	1 (7.1%)	3 (15.0%)	1 (7.7%)
Total	**56 (100.0%)**	**14 (100.0%)**	**20 (100.0%)**	**13 (100.0%)**

Discussion

The oral mucous membrane acts as the gateway to the human digestive system, and is often considered a reflection of both oral and general health (Goyal *et al.,*2016). Therefore, a thorough examination of the oral cavity is crucial for the early detection of various lesions that may arise. OMLs have diverse aetiologies including infections, local trauma or irritation, systemic diseases, autoimmune disorders and excessive consumption of tobacco, betel quid, and alcohol (Patel & Patel, 2011).

Understanding the prevalence and distribution of OMLs, as well as their association with factors such as age, gender, race, and systemic conditions, is essential for promoting primary prevention, effective management, and improved prognosis.

In the literature, epidemiological studies on oral mucosal lesions (OMLs) remain relatively scarce compared to reports on dental caries and periodontal diseases. In relation to general population, studies have reported the prevalence of OMLs have been reported 10.8% in China, 9.7% in Malaysia, 15.5% in Turkey, 25% in Italy 4 and 61.6% in Slovenia (Feng *et al.,* 2015; Zain *et al.,*1997; Cebeci *et al.,* 2009; Al-Mobeeriek & AlDosari, 2009). Studies have reported the presence of these lesions in 15% of dental patients in Saudi Arabia and 41.2% in India (Kovac-Kovacic & Skaleric, 2000; Mathew *et al.,* 2008).

Additionally, the prevalence of oral lesions has been documented across various countries, including Lebanon, Kashmir, and India (El Toum *et al.,* 2018; Patel & Patel, 2011). In Malaysia, population-based prevalence surveys on OMLs are limited but highly valuable, as they can provide an

accurate description of the epidemiology of OMLs in that area. While previous studies in Malaysia have been conducted, most have focused on specific groups of subjects (Taiyeb *et al.,*1995; Al-Maweri *et al.,* 2013) .To our knowledge, this is the first study to present epidemiological data on the prevalence and distribution of OMLs among the Kuantan population.

Regarding race and tobacco use, previous studies have shown a strong association between these factors and the prevalence and distribution of oral mucosal lesions (OMLs). However, in this study, the association between race, tobacco use, and the prevalence of oral mucosal lesions (OMLs) is less significant. This is primarily due to the sample size not accurately representing the racial distribution of the general population, making the findings prone to selection bias.

The majority of participants in this study were Malay (n=79, 92.9%). Out of 85 individuals, 75 (88.2%) had no history of tobacco use, while only 10 individuals (11.8%) reported either current smoking or a past smoking habit. A more extensive study with a larger population is necessary, as many studies have shown a strong positive association between smoking or tobacco use and the prevalence of oral mucosal lesions (OMLs) (Alshayeb *et al.,* 2019). One study also reported that 12.54% of total OML cases consisted of chemical burns, with 56.46% of those affected being cigarette smokers (Ain *et al.,* 2016).

The prevalence of OMLs was found to be higher among younger individuals compared to older ones, with the highest occurrence in the 15-30 age group, followed by the 31-60 age group. This trend is believed to be due to limited accessibility to dental services for older individuals in Kuantan, primarily because of physical and accommodation constraints. This result contradicts several studies. A study conducted in Lebanon found that the overall prevalence of OMLs was higher in the elderly than in younger age groups, attributing this finding to the habits of older individuals (El Toum *et al.,* 2018). Similarly, a study from Shanghai, China, supported this result (Feng *et al.,* 2015). However, a study conducted in the UAE reported no significant difference in OML prevalence based on age (Alshayeb *et al.,* 2019) . Additionally, this study found that the prevalence of OMLs was significantly higher in females than in males across all types, except for white lesions, which were more predominate in males.

Conversely, a study by (El-Hamd & Aboeldahab, 2018) found that OMLs were more common in men (52.8%) than in women (47.2%). This study attributed its findings to the higher prevalence of smoking among male participants (Ain *et al.,* 2016). While some studies reported no significant difference in the distribution of OMLs between males and females (El Toum *et al.,* 2018; Alshayeb *et al.,* 2019; Feng *et al.,* 2015), this study also found no significant relationship between systemic diseases and OML prevalence. This contradicts several previous studies that suggested a strong association between OML formation and systemic diseases (El Toum *et al.,* 2018) .This finding underscores the variability in the relationship between oral mucosal lesions (OMLs), gender, and systemic health across different populations. The absence of a significant association with systemic diseases in this study contrasts with earlier research, indicating that other factors such as genetics, lifestyle, and regional healthcare practices may have a greater influence on OML prevalence. Moreover, systemic diseases contribute to OMLs in two key ways: through direct oral manifestations of the disease and as side effects of medications prescribed for treatment. The dosage and duration of these medications should be carefully adjusted and monitored to minimize such complications. Further large-scale, well-controlled studies are essential to resolve these discrepancies and better understand the contributing factors. In this study, ulcers (54.4%) were the most common type of OML, followed by infections (19.4%), white lesions (13.6%), and other types (12.6%). Most participants had only one OML, although some exhibited multiple lesions simultaneously.

This study concluded that aphthous ulcers were the most frequently observed oral mucosal lesions, a finding supported by several previous studies (Goyal *et al.,* 2016; El-Hamd, & Aboeldahab, 2018; Amadori *et al.,* 2017; Verma *et al.,* 2019). Additionally, aphthous ulcers was found to be the most common lesions in their study, with prevalence rates of 44.5%, 14.68%, 18%, 22.4%, and 44.5%, respectively. Among all subjects diagnosed with aphthous ulcers, all cases were minor recurrent aphthous ulcers (RAU), with no instances of major or herpetiform types. Despite RAU being highly prevalent, its exact aetiology remains unknown.

Several predisposing factors have been associated with RAU, which can be categorized into three groups: antigenic sensitivity, thinned mucosa, and immune dysregulation (Neville *et al.,* 2018). Besides, a study that has been done mentioned that some possible factors associated with RAU which are allergic, local trauma, genetic, nutritional deficiencies, hematologic abnormalities, hormonal influence, infections and stress (Avci *et al.,* 2014). Furthermore, a study has identified various potential factors associated with RAU, including allergies, local trauma, genetic predisposition, nutritional deficiencies, hematologic abnormalities, hormonal influences, infections, and stress (Neville *et al.,* 2018). However, these factors have limited supporting evidence and require further investigation to establish a definitive correlation with RAU.

In this study, the majority of RAU patients were in the younger age group (15–30 years old), with prevalence decreasing as age advanced. This finding is supported by a study conducted by (Goyal *et al*., 2016). A cross-sectional study in Italy, which evaluated a large sample of adolescents and analysed the medical records of 6,374 participants (mean age 15.2 ± 1.7 years), revealed that recurrent aphthous stomatitis (RAS) was the most common type of OML observed among teenagers (n=278, 18%). The study also reported that females had a higher predisposition to RAS compared to males, aligned with our findings (Amadori *et al.,* 2017). This study showed that females have a higher predilection to RAU compared to males, a finding supported by several studies (Goyal *et al.,* 2016, Jabbar *et al.,* 2018).

The second most common lesion identified was traumatic ulcer, aligning with a study by Amadori *et al,* (2017) which reported that traumatic lesions were the second most frequently detected (14.3%), following recurrent aphthous stomatitis (RAS) (18%). Similarly, a study by Ali *et al*., (2013) found that traumatic ulcers were the most common ulcerative lesions, followed by recurrent herpes and aphthous ulcers (Ali *et al.,* 2013). Additionally, Amadori, *et al.,* reported that among 1544 adolescents, 36 types of oral mucosal lesions (OMLs) were detected, with aphthous ulcers being the most prevalent (n = 278; 18%), followed by traumatic ulcerations (n = 221; 14.3%) (Amadori *et al.,* 2017).

Neville *et al,* (2018) has also highlighted that traumatic ulcers can result from mechanical, chemical, or thermal injuries, with mechanical trauma being the most common cause. Furthermore, infections and white lesions were more frequently observed in older age groups. RAU and infections showed a higher prevalence in females, whereas white lesions were more common in males, possibly due to differences in oral hygiene habits. Notably, the incidence of RAU appeared to be lower in smokers compared to non-smokers (Jabbar *et al.,* 2018).

The third most common lesion identified was infections, specifically denture stomatitis (n=12, 14.1%). This condition was significantly more prevalent in the older age group, with the highest occurrence among individuals aged 31–60 years. It predominantly affected females, with the hard palate being the most common site.
These findings are supported by a study which reported that denture stomatitis is more common in females than in males, with a mean age of 54.00 ± 3.46 years (El-Hamd & Aboeldahab, 2018).

However, this study is limited by its retrospective nature, which may introduce information and classification biases, restricting the universality of the results. Future studies should include a larger sample size with a more diverse population to ensure more accurate and representative findings.

Conclusion

In conclusion, the prevalence of oral mucosal lesions varies depending on the general population of the studied areas and the authors' research focus. This study found that the most common type of oral mucosal lesions (OMLs) presented at the OM Clinic, KOD IIUM, were ulcerative lesions, followed by infections, white lesions, and other conditions. Ulcers were predominantly observed in younger adults, whereas white lesions, infections, and other conditions were more common in older patients. Among all these categories, ulcers were most frequently found in multiple locations within the oral cavity, including the buccal mucosa, labial mucosa, palate, tongue, and floor of the mouth.

Acknowledgement

The authors acknowledge the research project ID: SRCG20-012-0012 for the financial support.

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ORIGINAL ARTICLE Open Access

Antimicrobial properties of local Kelulut honey against selected oral pathogens

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Abstract

There are limited reports on the antimicrobial properties of Kelulut honey against oral pathogens. Hence, this study aimed to determine the antimicrobial properties of local Kelulut honeys obtained from the Malaysian Agriculture Research and Development Institute (MARDI) and Tangkak, Johor, Malaysia. The samples were mixed with sterile deionised water to obtain series of honey concentrations and evaluated against *Streptococcus mutans*, *Staphylococcus aureus*, *Candida albicans* and *Candida tropicalis* using agar well diffusion method. Bacteria *S. mutans* and *S. aureus* were grown anaerobically on Mueller-Hinton agar and incubated at 37°C for 24 hours, while fungi, *C. albicans* and *C. tropicalis* were grown on Sabouraud Dextrose agar at 25°C for 48 hours. Cultures were prepared in triplicates and adjusted to 0.5 McFarland standard (1 x 10^8 CFU/ml). Wells (6 mm diameter) were made on the agar, and 60 µl of honey at concentrations of 2.5, 2.0, 1.5, 1.0 and 0.75 g/ml were added onto each well. Sterile deionised water was used as negative control, and 0.2% chlorhexidine as positive control. Upon incubation, the zones of inhibition were measured using a digital calliper. Both Kelulut honeys exhibited zones of inhibition against *S. mutans* at 2.5, 2.0 and 1.5 g/ml whereas for *S. aureus*, the inhibition was noticed only at 2.5 and 2.0 g/ml. No inhibition zones were observed against *C. albicans* and *C. tropicalis* at any concentration. This study showed that both Kelulut honeys exhibited antibacterial properties against *S. mutans* and *S. aureus* but did not exhibit antifungal activity against *C. albicans* and *C. tropicalis*.

Keywords: *antimicrobial, antifungal, Kelulut honey, oral pathogens*

Received:
25 March 2025
Revised:
13 July 2025
Accepted:
14 July 2025
Published Online:
31 July 2025
How to cite this article:
Andek Jelantek, A. N. H., Mohd Noor, S. N., Mohamad, N. K., & Kannan, T. P. (2025). Antimicrobial properties of local Kelulut honey against selected oral pathogens. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 199–208. https://doi.org/10.31436/ijohs.v6i2.400
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.400
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Introduction

In general, the oral cavity is colonized with diverse of oral microbiota, composed of more than 700 microbial species (Guo *et al.*, 2014). Nonetheless, some of these bacterial species, including *Streptococcus mutans* (*S. mutans*) and *Streptococcus sobrinus* (*S. sobrinus*) (Bloch *et al.*, 2024), have been reported to cause oral diseases such as carious lesions and periodontal diseases (Godocikova *et al.*, 2025). *Porphyromonas gingivalis* (*P. gingivalis*) and *Fusobacterium nucleatum* have been indicated to be the main pathogens responsible for periodontal disease (Zhang *et al.*, 2022). Research have also shown that many oral microorganisms are also related to oral squamous cell carcinoma such as *P. gingivalis* (Wen *et. al.*, 2020) and *Treponema denticola* (Fitzsimonds *et al.*, 2020). Not only bacteria, but also oral *Candida*, a type of opportunistic fungus potentially can cause oral infections, for instance denture stomatitis (Yusoff *et al.*, 2016).

In order to eradicate the manifestations of oral pathogens in the oral cavity, oral hygiene practices are undeniably required. Mechanical brushing, interdental cleaning (Mandal *et al.*, 2017), and antiseptic mouthwashes (Brookes *et al.*, 2023) were some of the oral hygiene practices represented. However, among those practices, a great concern has been focused on antiseptic mouthwashes, whereby their application can be both advantageous and deleterious (Brookes *et al.*, 2023). Additionally, some research has suggested that mouthwashes, such as chlorhexidine may increase the risk of fatality among critically ill patients (Bellissimo-Rodrigues *et al.*, 2019). To address safety concerns about long-term use of mouthwashes, natural products such as honey containing various antimicrobial factors should be introduced. A prior study by Deglovic *et al*. (2022) found that honey not only has antibacterial properties but also inhibits the cariogenic process.

Honey, a supersaturated sugar solution that comes from the nectar of flowers collected by the bees is referred as one of the natural products that has long been recognized to have antimicrobial properties (Ogwu & Izah, 2025). Honey has been exploited for its nutritional and therapeutic benefits for millennia and exhibit powerful antibacterial effects against a range of infections, including methicillin-resistant *S. aureus* (MRSA) and *Pseudomonas aeruginosa* (Mandal & Mandal, 2011).

Kelulut honey, a type of honey produced by stingless bees of *Trigona* species. It contains trehalulose, which is a rare and healthy sugar, an isomer of sucrose with an unusual α-(1→1) glucose-fructose glycosidic linkage with known non-cariogenic and low glycaemic index properties (Fletcher *et al*., 2020) and hence suitable for individuals with diabetes. It contains high amount of glucose, fructose, sucrose and maltose, as well as gluconic acid, malic acid and citric acid (Mato *et al*., 2003; Haron *et al*., 2022). In addition to trehalulose, Kelulut honey is also rich in bioactive compounds such as flavonoids, glucose oxidase catalase, and phenolic acids (Zulkhairi *et al*., 2018) and exhibits high antioxidant (Liu *et al*., 2013; Ranneh *et al*., 2018), antimicrobial (Kateel *et al*., 2018) and wound healing properties (Adewumi & Ogunjinmi, 2011; Rashidi *et al*., 2016). *In vitro* studies have also proven its substantial antimicrobial activity against *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Escherichia coli*, *Salmonella typhimurium* and *P. aeruginosa* (Boorn *et al*., 2010).

The antibacterial properties of honey are primarily attributed to its acidity (Almasaudi, 2021), osmotic effect (Molan, 1992), and the presence of peroxide and non-peroxide compounds (Almasaudi, 2021). Honey typically has a pH between 3.2 and 5.4, resulting from enzymatic activity that produces gluconic acid during nectar ripening (Molan, 1992). This acidic environment inhibits bacterial growth, as bacteria generally thrive at a pH of 7.2 to 7.4 (Almasaudi, 2021). The honey's osmotic effect, caused by strong interactions between sugar and water molecules, limits the availability of water for microbial growth (Mandal & Mandal, 2011). Additionally, peroxide compounds, like hydrogen peroxide (H_2O_2), increase oxidative stress, aiding in the regulation of bacterial colonization (Brudzynski *et al*., 2011; Combarros-Fuertes *et al*., 2020). Non-peroxide antimicrobial activity is mediated by a range of compounds, including phenolic compounds (Kwakman & Zaat, 2012), leptosperin (Roberts *et al*., 2015), methylglyoxal (Girma *et al*., 2019; Nader *et al*., 2021), flavonoids, and antimicrobial peptides (Kwakman *et al*., 2011).

Even though numerous research has shown the antimicrobial properties of other honeys, such as Manuka honey and Slovak honey against oral and non-oral pathogens (Godocikova *et al.*, 2025), there is still a lack of information regarding these powerful properties of local Kelulut honey against oral pathogens. Further, the urge to use natural products possessing antimicrobial properties, such as honey, is worth exploring, as it has fewer risks to human health. Hence, by exploring these properties, it has broadened and shed some light on the beneficial values of Kelulut honey as well as

added value for the honey to be commercialized and known in the future. Therefore, this study aims to determine the antimicrobial properties of local Kelulut honey against selected oral pathogens, namely, *S. mutans*, *S. aureus*, *Candida albicans* (*C. albicans*) and *Candida tropicalis* (*C. tropicalis*) using agar well diffusion method. Two local Malaysian Kelulut honeys obtained from the Malaysian Agricultural Research and Development Institute (MARDI) and Tangkak, Johor, Malaysia was evaluated for their antimicrobial properties in this study.

Materials and Methods

Preparation of honey samples

Both the honey samples were mixed with sterile deionised water to produce honey solutions as described by Mohd-Aspar *et al*., (2023). They assessed a few types of honey from concentrations 30% to 90% (w/v) and the samples were prepared by weighing 3, 4, 5, 6, 7, 8 and 9 g of honey and mixing with deionised water making a final volume of 10 ml. However, the concentrations of the honey in current study were slightly different from the previous study. The stock solution concentration of 2.5 g/ml for both honeys was prepared by mixing 7.5 g of undiluted honey with 3 ml of sterile deionised water (w/v). The subsequent concentrations prepared from the stock solution are presented in Table 1.

The pH of stock solutions of each honey sample was then measured using microprocessor pH meter (Hanna Instruments, USA).

Table 1. Preparation of different concentrations of honey samples.

Volume of honey stock (ml)	Volume of deionised water (ml)	Final volume (ml)	Concentration (g/ml) (w/v)
0.8	0.2	1.0	0.8 x 2.5 g/1 ml = 2.0 g/ml
0.6	0.4	1.0	0.6 x 2.5 g/1 ml = 1.5 g/ml
0.4	0.6	1.0	0.4 x 2.5 g/1 ml = 1.0 g/ml
0.3	0.7	1.0	0.3 x 2.5 g/1 ml = 0.75 g/ml

Microbial inoculum preparation

The microorganisms used in this study were *S. mutans* (ATCC 25175, USA), *S. aureus* (ATCC 33862, USA), *C. albicans* (ATCC 10231, USA), and *C. tropicalis* (ATCC 1369, USA). Bacteria, *S. mutans* and *S. aureus*, both facultative anaerobic bacteria were maintained in anaerobic conditions and the microorganism preparation method was adapted from a study by Mohd-Aspar *et al*., (2023). Both the bacteria were cultured on Mueller-Hinton agar and incubated overnight at 37°C in a CO_2 incubator. Both fungi, *C. albicans* and *C. tropicalis* were cultured on Sabouraud Dextrose agar and incubated at 25°C for 48 hours. Agar plates were prepared in triplicates for all microorganisms to ensure the growth of at least one microbial inoculum. Microbial inoculum preparations were done by suspending *S. mutans* and *S. aureus* in sterile Mueller-Hinton broth, while *C. albicans* and *C. tropicalis* were suspended in Sabouraud Dextrose broth and adjusted to a concentration equivalent to 0.5 McFarland standard (1 x 10^8 CFU/ml).

Antimicrobial evaluation using agar well diffusion assay

Both Kelulut honeys were evaluated for their antimicrobial properties using the agar well diffusion assay as described by Yusoff *et al*., (2016) with slight modifications. In brief, a sterile cotton swab was dipped into the inoculum suspension and evenly spread on Mueller-Hinton agar for *S. mutans* and *S. aureus*, and Sabouraud Dextrose agar for *C. albicans* and *C. tropicalis*. Following inoculation, wells 6 mm in diameter were created on the agar surface using the bottom of sterile 20 µl pipette tips. Then, 60 µl of both Kelulut honeys at concentrations of 2.5, 2.0, 1.5, 1.0 and 0.75 g/ml (w/v) were loaded onto each well. A 60 µl volume of sterile deionised water was used as a negative control, and 0.2% chlorhexidine as a positive control. This test was conducted in triplicates for each sample. The agar plate was then placed in an incubator for 24 hours at 37°C for bacteria, and 48 hours at 25°C for the fungus. The zones of inhibition were measured in millimetres using a digital calliper.

Results

The pH of Kelulut honey from MARDI was 2.51 ± 0.01 and that of Tangkak was 2.62 ± 0.01. The zones of inhibition for the different microorganisms are presented in Table 2 and illustrated in Figures 1 and 2.

Discussion

The use and benefits of honey have been known since ancient times, largely due to its ability to prevent the growth of microorganisms in wounds (Kuropatnicki *et al*., 2018). Honey is also recognized for its bacteriostatic and bactericidal effects against a wide range of microbes, including both Gram-positive and Gram-negative bacteria (Mandal & Mandal, 2011). However, only a few honey varieties, such as Capilano Medihoney, Active Manuka honey, and Revamil honey, have been approved for therapeutic use (Omar *et al*., 2019). Recent studies have shown that honey from stingless bees has antibacterial properties against a variety of pathogens, indicating its potential as an antibacterial agent (Irish *et al*., 2008; Kimoto-Nira & Amano, 2008; Ewnetu *et al*., 2013; Zainol *et al*., 2013; Andualem, 2014; Eswaran *et al*., 2015).

In this study, the antimicrobial properties of Kelulut honey evaluated using agar well diffusion assay showed varying effects against bacteria and fungi. Based on the results, both the Kelulut honeys showed zones of inhibition against *S. mutans* at 2.5, 2.0 and 1.5 g/ml. However, the zones of inhibition for *S. aureus* were noticed only at 2.5 and 2.0 g/ml (Table 2). The findings of this study differ from those of Mohd Izwan (2016) who demonstrated that 25% Kelulut honey could inhibit *S. aureus*. However, our results were in line with a study by Ahmadi-Motamayel *et al*. (2013) who reported that honey at concentrations above 20% was effective against *S. mutans*. Moreover, our results also in line with a study by Badawy *et al*. (2004) which reported that the concentrations of honey significantly affect its antibacterial activity, with higher concentrations generally showing greater effectiveness.

Most types of honey release H_2O_2 when diluted due to the activation of glucose oxidase, which oxidizes glucose to gluconic acid and H_2O_2, contributing to their antimicrobial properties (Bang *et al*., 2003). In the current study, sterile deionised water was used as a honey diluent which facilitated the release of H_2O_2 (Kwakman & Zaat, 2012), potentially contributing to the observed zones of inhibition against both bacteria. The availability of water molecules from sterile deionised water was a vital component for the glucose oxidase-dependent catalysis (Brudzynski, 2020). Furthermore, the honey concentrations in this study, 2.5 to 0.75 g/ml (w/v) differed with the range of 30% to 50% (v/v) aqueous honey solution reported by Bang *et al*. (2003) where it was stated that this range was the optimal concentration for the highest buildup of H_2O_2.

Table 2. Antimicrobial effects of Kelulut honey from MARDI and Tangkak

	Zone of inhibition in mm (Mean ± SD)							
Microorganisms	***S. mutans***		***S. aureus***		***C. albicans***		***C. tropicalis***	
Samples	MARDI	Tangkak	MARDI	Tangkak	MARDI	Tangkak	MARDI	Tangkak
Negative control	-	-	-	-	-	-	-	-
Positive control	32.12 ± 0.12	33.37 ± 0.02	27.62 ± 0.07	27.31 ± 0.02	19.25 ± 0.36	20.43 ± 0.14	21.89 ± 0.24	22.72 ± 0.07
2.5 g/ml	15.26 ± 0.91	14.11 ± 0.09	10.48 ± 0.04	9.89 ± 0.1	-	-	-	-
2.0 g/ml	14.50 ± 0.17	9.91 ± 0.05	9.76 ± 0.05	8.73 ± 0.03	-	-	-	-
1.5 g/ml	13.68 ± 0.25	8.56 ± 0.04	-	-	-	-	-	-
1.0 g/ml	-	-	-	-	-	-	-	-
0.75 g/ml	-	-	-	-	-	-	-	-

Negative control = Sterile deionised water; Positive control = 0.2% chlorhexidine; '-' indicates no zone of inhibition

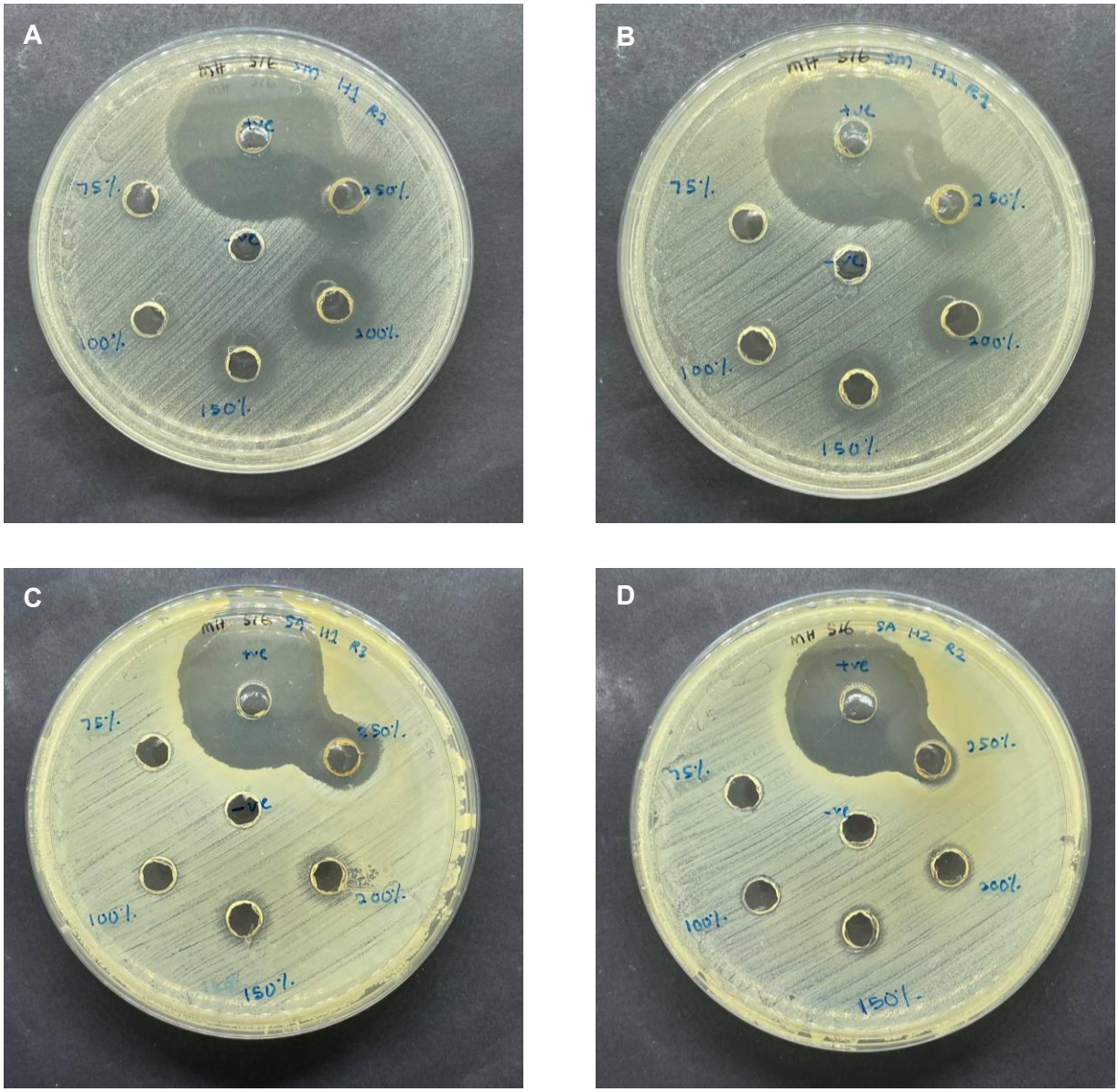

Figure 1. Zones of inhibition A. *S. mutans* (Kelulut honey from MARDI) B. *S. mutans* (Kelulut honey from Tangkak) C. *S. aureus* (Kelulut honey from MARDI) D. *S. aureus* (Kelulut honey from Tangkak).

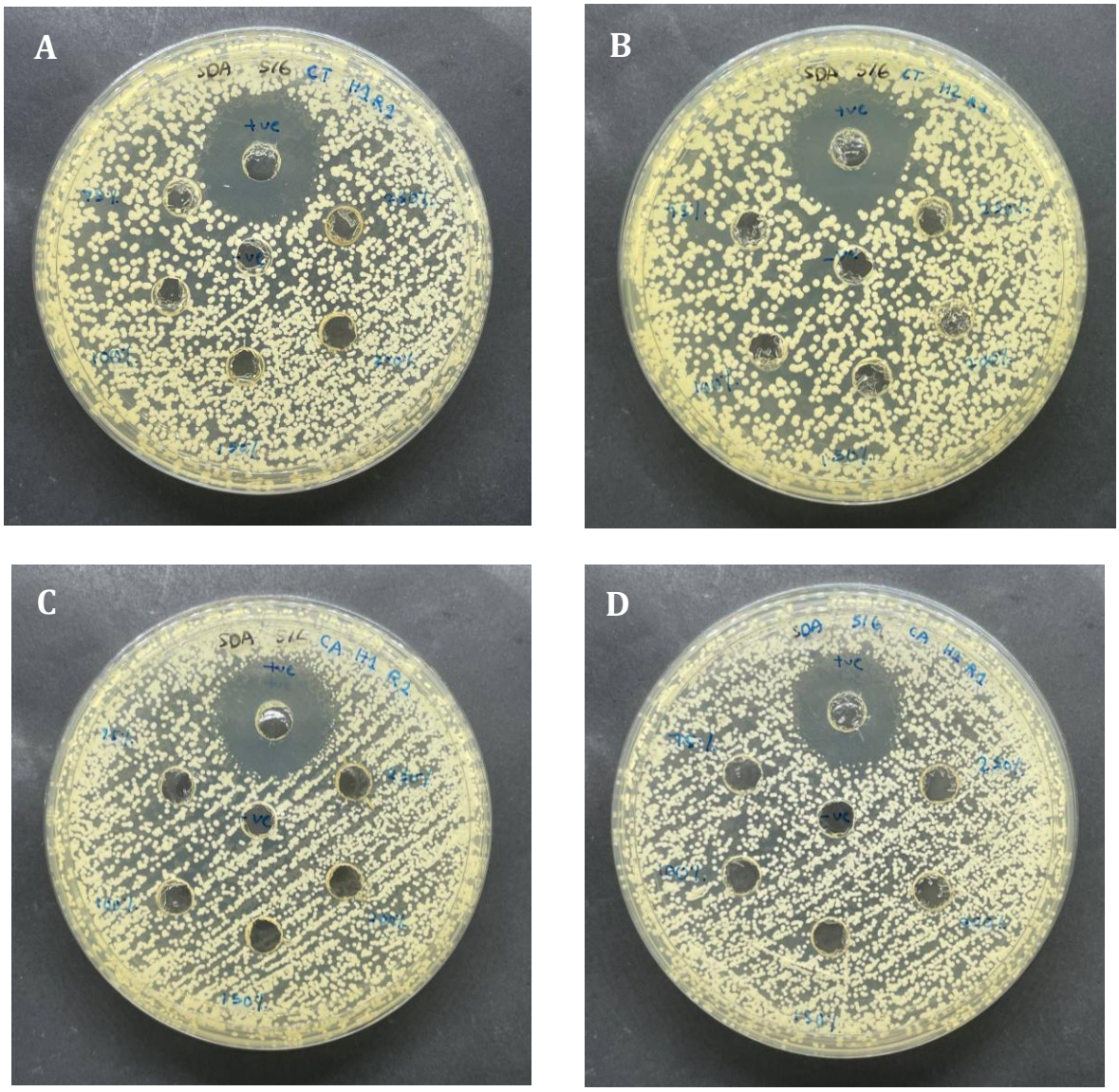

Figure 2. No zones of inhibition A. *C. tropicalis* (Kelulut Honey from MARDI) B. *C. tropicalis* (Kelulut Honey from Tangkak) C. *C. albicans* (Kelulut Honey from MARDI) and D. *C. albicans* (Kelulut Honey from Tangkak) except for the positive control (0.2% chlorhexidine)

Additionally, the antimicrobial potency of Kelulut honey in this study may also be linked to its acidic pH, recorded at 2.51 for Kelulut honey from MARDI and 2.62 for the sample from Tangkak, as well as the presence of polyphenolic compounds. The variations in pH values for both localities may be due to various factors including geographical area, nectar sources and environmental, as reported by Kaya & Yıldırım, (2021). In addition, common phenolic compounds in Kelulut honey include gallic acid, caffeic acid, catechin, apigenin, chrysin, kaempferol, *p*-coumaric acid and cinnamic acid. Among these, cinnamic acid is specifically noted for its antimicrobial properties in Kelulut honey (Zulkhairi *et al*., 2018).

In the current study, Kelulut honey did not inhibit the growth of *C. albicans* and *C. tropicalis* at any of the tested concentrations. This contrasts with the findings of Yusoff *et al*. (2016), who reported that Kelulut honey exhibited antifungal activity against *C. albicans* and *C. tropicalis* in its pure form, although the activity was lost upon dilution (1:1 and 1:2 with distilled water). Our results are also in contrast with the findings of Zubaidah *et al*. (2018), where Kelulut honey at concentrations of 10%, 15%, and 25% was able to completely inhibit *C. albicans* and showed stronger antifungal activity compared to Tualang and Acacia honey.

The results of this research suggest that Kelulut honey samples (MARDI and Tangkak) demonstrate antibacterial properties but not antifungal activity. The differences in their effectiveness against different oral pathogens may closely related to the osmolarity factor of the honey. Bacteria were susceptible to the high osmolarity of honey (Jia *et al*., 2020), while fungi were resistant to the honey's high osmolarity because of a particular high osmolarity glycerol (HOG) pathway (Hohmann, 2002). This pathway involves osmoadaptation of the yeast, a type of fungus, to adapt in high osmolarity conditions by sensing the osmotic changes and transmitting the signal to the transcriptional machinery for further responses of the yeast cells. Hence, the resistance of both the fungi in the current study could be attributed to this HOG pathway. Furthermore, the antimicrobial potency of honey can vary significantly, often by more than 100-fold, depending on factors such as geographical, seasonal, and botanical origins, as well as the conditions under which the honey is harvested, processed, and stored (Molan & Cooper, 2000). Key contributors to its antimicrobial efficacy include osmolarity, H_2O_2 content, low pH, and the presence of phenolic acids and flavonoids (Almasaudi, 2021). Among these, H_2O_2 plays a dominant role, and variations in its concentration across different honeys result in differences in their antimicrobial effectiveness (Almasaudi, 2021). Thus, while Kelulut honey's antibacterial activity is evident, its antifungal potential may require further exploration under different conditions or concentrations of these active components.

Conclusion

In conclusion, this study demonstrates that Kelulut honey exhibits antimicrobial activities towards different oral pathogens. Kelulut honey possessed potent antibacterial properties, effectively inhibiting the growth of *S. mutans* and *S. aureus* at higher concentrations. However, it did not exhibit antifungal activity against *C. albicans* and *C. tropicalis*. From the results, it can be inferred that Kelulut honey selectively inhibits the growth of certain oral pathogens, which drives its efficacy only against those certain pathogens. Further research on Kelulut honey's antifungal efficacy against other oral fungi pathogens is required to validate the properties as well as to improve our medical and dental understanding.

Acknowledgements

The authors acknowledge the Ministry of Higher Education Malaysia for the Fundamental Research Grant Scheme with Project Code: FRGS/1/2022/SKK10/USM/02/15 and the

staff of Craniofacial Science Laboratory, School of Dental Sciences, Universiti Sains Malaysia for the help rendered. The authors would like to extend gratitude to Mr. Kamarulzaman Bin Mahad for sponsoring the Kelulut honey from Tangkak, Johor, Malaysia.

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ORIGINAL ARTICLE Open Access

Development and validation of a questionnaire to assess the psychological impact and fearfulness of COVID-19 among Human Immunodeficiency Virus (HIV) patients

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Abstract

The outbreak of COVID-19 has led to a serious and uncertain condition, including an abrupt national economy and increased psychological distress especially among vulnerable population such as people living with HIV (PLHIV). Fear of infection, prolonged lockdown and isolation, and stigma merged with mental health burden for this group. This study aims to develop and validate a questionnaire assessing the psychological impact and fearfulness related to COVID-19 among HIV patients. The questionnaire was developed through a comprehensive literature review, followed by expert validation and statistical reliability testing. Content and face validity were conducted by medical, psychological, and public health professionals. Internal consistency and test-retest reliability were analysed using Cronbach's alpha and Spearman correlation. The final questionnaire included two domains: psychological impact (10 items) and fearfulness (14 items), each with a Scale-Content Validity Index (S-CVI) of 1.0. Face validity scores exceeded 90% in clarity, readability, and layout. Cronbach's alpha for psychological impact and fearfulness was 0.81 and 0.92, respectively. A test-retest correlation coefficient of 0.728 indicated strong stability. In conclusion, this validated questionnaire is a reliable tool for measuring psychological and emotional responses to COVID-19 among HIV patients, offering insight into their mental health needs during public health crises.

Keywords: *fearfulness, impact of COVID-19, mental health, psychological, questionnaire*

Received:
9 November 2024
Revised:
13 July 2025
Accepted:
14 July 2025
Published Online:
31 July 2025
How to cite this article:
Mohemmad Rizal, M. R., Zaini, S., AB Rahman, N. S., & Musa, R. (2025). Development and validation of a questionnaire to assess the psychological impact and fearfulness of COVID-19 among Human Immunodeficiency Virus (HIV) patients. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 209–215. https://doi.org/10.31436/ijohs.v6i2.365
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.365
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Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic, caused by the novel SARS-CoV-2 virus, first emerged in Wuhan, China, in late 2019. Characterised by both respiratory and non-respiratory symptoms, the virus rapidly spread across the globe, prompting the World Health Organization (WHO) to declare it a Public Health Emergency of International Concern (AlSamman *et al.*, 2020). As of May 2023, more than 687 million cases were reported worldwide, with approximately 6.87 million deaths (World Health Organization, 2022).

In Southeast Asia, Malaysia ranked among the highest in terms of COVID-19 cases and deaths (Shah *et al.*, 2020). To curb

transmission, the Malaysian government implemented strict public health measures including the Movement Control Order (MCO) and Conditional MCO (CMCO). While these interventions were essential to flatten the epidemiological curve, they also triggered profound socio-economic disruptions. Prolonged lockdowns led to business closures, job losses, and economic instability, particularly among vulnerable populations (Tzur Bitan *et al.*, 2020).

Beyond the economic impact, the pandemic had significant psychological consequences. Uncertainty, social isolation, and continuous exposure to distressing news created a climate of fear and stigma, particularly among unprepared communities (Brooks *et al.*, 2020; Liu *et al.*, 2021; Serafini *et al.*, 2020a). Individuals reported heightened anxiety, stress, irritability, and depression due to disruptions in daily routines, loss of income, and restricted access to social support and healthcare (Serafini *et al.*, 2020a; Shah *et al.*, 2020).

These challenges were especially severe for people living with HIV (PLHIV), who were already at risk of mental health issues due to stigma, treatment burden, and chronic illness (Hong *et al.*, 2023; Lusher *et al.*, 2023). The intersection of HIV and COVID-19 may have compounded psychological distress, yet there remains a lack of validated tools to assess these impacts(Ã & El-masri, 2005).

Therefore, this study aims to develop and validate a questionnaire to assess the psychological impact and fearfulness related to COVID-19 among PLHIV. Such an questionnaire is crucial to support targeted mental health interventions and inform public health preparedness in future crises (Armstrong, 2019).

Materials and Methods

Ethical approval and study design

This study was conducted over a six-month period, from November 2022 to March 2023, encompassing the development, validation, reliability testing, and distribution of the questionnaire. Ethical approval was obtained from the National Medical Research Register (NMRR) with ID NMRR-22-02745-2NM (IIR). A prospective cross-sectional survey design was employed to explore the psychological impact and fearfulness associated with COVID-19 among people living with HIV (PLHIV). Data collection was carried out using a validated, self-administered, closed-ended questionnaire.

Questionnaire development

i) Literature search

A systematic literature review was conducted between August and September 2022 using PubMed, Scopus, and ScienceDirect. Search terms included "COVID-19", "psychological impact", "fear", "mental health", and "people living with HIV (PLHIV)", using Boolean operators to refine results. The inclusion criteria encompassed studies published from 2019 to 2022, in English or Bahasa Malaysia, focusing on psychological or emotional impacts of COVID-19 among PLHIV. Exclusion criteria included articles not related to mental health or fear, and non-research materials such as commentaries or editorials.

From an initial pool of 124 articles, 42 were reviewed in full, and 15 were ultimately selected to guide the development of the questionnaire. Key psychological themes extracted included anxiety, depression, social isolation, stigma, and fear of infection. This led to the initial drafting of 18 psychological impact items and 20 fearfulness items. After iterative refinement, 10 psychological and 14 fear-related items were finalised.

ii) Face and content validity

Face validity was assessed among 15 individuals from various backgrounds to evaluate the questionnaire's clarity, feasibility, wording, and layout. Each item was rated using a 4-point Likert scale. The

psychological impact section received average scores of 93.7% for readability, 91.7% for feasibility, 92.1% for clarity, and 92.2% for layout. The fearfulness section scored slightly lower in clarity and layout (both 90.0%) but higher in feasibility (96.0%). Based on this feedback, two items were revised and one was removed. The overall scale-level face validity index (S-FVI) was 0.92, suggesting strong agreement on comprehensibility.

Content validity was evaluated by 15 experts in medicine, pharmacy, psychology, and HIV care. Using Lynn's (1986) method, each item was rated for relevance on a 4-point scale. The content validity index (CVI) reached 1.00 for both psychological and fearfulness domains, exceeding the minimum threshold of 0.78. Based on this process, four items were revised, two were removed, and a total of 24 items (10 psychological, 14 fearfulness) were finalised for the questionnaire.

iii) Questionnaire evaluation for reliability

The revised questionnaire was administered to 30 randomly selected PLHIV at Klinik Kesihatan Tanglin, Kuala Lumpur. Internal consistency was assessed using Cronbach's alpha. The psychological impact domain yielded a value of 0.81, while the fearfulness domain recorded 0.92, both indicating excellent reliability (Cortina Jose M, 1993).
Test-retest reliability was evaluated by re-administering the same questionnaire to the same participants after a three-week interval (3rd to 17th January 2023). Participants were identified and followed up via contact details gathered during the initial session. Spearman's correlation coefficient was used to assess temporal consistency, yielding a rho value of 0.728, indicating a moderate to strong positive correlation. The p-value was above 0.05, suggesting no significant difference between the two sets of responses, and confirming the questionnaire's temporal stability (Armstrong, 2019; Chen *et al.*, 2021).

Cross-sectional survey

A total of 250 PLHIV respondents were recruited from Klinik Kesihatan Tanglin and Klinik Kesihatan Petaling Bahagia. Eligible participants were adults (18 years and above) living with HIV, receiving treatment at the clinics, and able to understand either Malay or English. Those with severe psychiatric illness, cognitive impairment, or who declined to participate were excluded. Recruitment was conducted at the pharmacy counters, where patients were approached while waiting for their medication. The questionnaire was distributed in printed form and self-administered on-site. Data collection for this phase was conducted between February and March 2023.

Statistical analysis

Descriptive statistics were used to summarise demographic data and face/content validity results. Internal consistency was measured using Cronbach's alpha, while test-retest reliability was analysed with Spearman's correlation coefficient. To confirm construct validity, Confirmatory Factor Analysis (CFA) was conducted. CFA tested the model fit and factor structure of the questionnaire based on observed data. Key metrics including factor loadings, Average Variance Extracted (AVE), and fit indices were used to validate the hypothesised two-domain model of psychological impact and fearfulness.

Results

Demographic characteristics

A total of 250 respondents participated in this study. The majority of respondents were Malaysian citizens, consisting of 175 Malay respondents (70 percent), 40 Chinese respondents (16 percent), and 35 Indian respondents (14 percent). The respondents' ethnic backgrounds reflect the distribution in Malaysia. The mean age of respondents was 32.4 years (SD=6.7), with ages ranging from 17 to 67. The majority were male, 211 respondents (84.4 percent), and female, 39 respondents (15.6 percent).

In terms of employment status, the majority worked in the private sector/non-government, 168 respondents (67.2 percent), 25 respondents (10 percent) worked in the government sector, and 23 respondents (9.2 percent) were self-employed. The remaining respondents were unemployed, 18 respondents (7.2 percent), and 16 respondents (6.4 percent) were students. All respondents were HIV patients from Klinik Kesihatan Tanglin and Klinik Kesihatan Petaling Bahagia, Lembah Pantai, Kuala Lumpur. The median duration since diagnosis was 6 years and the median monthly income was RM 2700.00.

Descriptive analysis of psychological impact and fearfulness

A descriptive analysis investigated the distribution of responses to the psychological impact and fearfulness related to the COVID-19 pandemic. The questionnaire were assessed using a 6-point Likert scale ranging from 1 = Not at all to 6 = Always, allowing for a more detailed evaluation of the respondents' emotional, cognitive, and behavioral reactions in the week of the study.

i) Psychological impact

Findings from the ten item questionnaire provided significant insights into respondents health. The majority of respondents (58%, n = 145) said they occasionally found it difficult to focus on their work. The majority of respondents (64.0%, n = 160) said they could make decisions with reasonable ease. Significant emotional anguish was highlighted by the large majority (75.2%, n = 188) who said they frequently or always felt helpless to tackle their challenges. Although more analysis is required for a more accurate assessment, 55.2% (n = 138) of respondents stated that they had a moderate to high aptitude to handle difficulties.

Regarding emotional reactions, the majority of participants (60.8%, n = 152) said they felt glad occasionally to frequently when things were going well. Most respondents ranked their level of life satisfaction as moderate. Furthermore, over half (56.0%, n = 140) believed that their mental health was moderately to strongly impacted by a healthy physical environment.

But there were also indications of exhaustion and a lower standard of living. The fact that over half of the respondents (53.6%, n = 134) hardly ever had the energy to complete everyday tasks suggests that they were either physically or emotionally exhausted. The majority (60%, n = 150) also stated that they seldom ever had time for leisure activities. Besides, 46.0% (n = 115) of participants said they occasionally to fairly frequently had headaches.

ii) Fearfulness towards COVID-19

The results of the 14 questions indicated a rise in COVID-19-related anxiety and avoidance behaviour. The findings indicated that respondents' levels of fear and anxiety around the COVID-19 pandemic had increased. A sizable portion (75.2%, n = 188) reported feeling uneasy when thinking about COVID-19 frequently to continuously. Additionally, 57.0% (n = 142) exhibited bodily symptoms of anxiety, such as sweating palms, and 60.5% (n = 151) feared infection-related death. A significant number of respondents (80.0%, n = 200) reported feeling anxious when exposed to COVID-19-related news or stories on social media, indicating that outside information sources significantly influenced emotional states.

Physiological reactions were also frequent; among those who imagined being infected, 50.0% (n = 125) reported experiencing palpitations in their hearts. 65.2% (n = 163) of individuals reported sleep difficulties brought on by infection-related worry, while 68.0% (n = 170) reported social interaction anxiety. The most common concern, expressed by 85.2% (n = 213) of respondents, was the danger of infecting family members.

Moreover, 62.0% (n = 155) acknowledged that they frequently overthink the possibility of getting the virus, and 54.5% (n = 136) said they are afraid of getting infected when they go to clinics or hospitals for regular check-

ups. Concerns also included dangers associated with employment and vaccinations; 55.0% (n = 138) were concerned about losing their jobs, and 59.0% (n = 148) were reluctant to have the COVID-19 vaccine because of possible adverse effects. Furthermore, 61.0% (n = 153) were worried of developing a chronic illness following infection, and 63.5% (n = 159) were afraid of infection symptoms.

Content validation: Confirmatory Factor Analysis (CFA)

i) Psychological impact

The results of the Confirmatory Factor Analysis (CFA) indicate that the measurement model for the psychological impact of COVID-19 demonstrates a good model fit. All factor loadings exceeded 0.60, suggesting that each item strongly reflects the underlying construct. The Root Mean Square Error of Approximation (RMSEA) value was 0.066, which falls within the acceptable range (<0.08), indicating a reasonable approximation error. Additionally, both the Comparative Fit Index (CFI = 0.91) and Tucker-Lewis Index (TLI = 0.903) surpassed the minimum threshold of 0.90, suggesting a good fit of the model to the observed data.

The chi-square to degrees of freedom ratio (χ^2/df = 2.528) further supports the model's adequacy, as values between 1 and 3 are typically considered acceptable. Convergent validity was confirmed, with Average Variance Extracted (AVE) values exceeding 0.50 for all constructs. Furthermore, Composite Reliability (CR) values were above 0.60, indicating good internal consistency. These findings confirm that the questionnaire is both valid and reliable in measuring the psychological effects of COVID-19.

ii) Fearfulness towards COVID-19

The CFA results for the fearfulness dimension related to COVID-19 also indicate a strong and well-fitting model. All items demonstrated factor loadings above 0.60, supporting the one-dimensionality of the construct. The RMSEA value of 0.071 reflects an acceptable model fit. Moreover, the TLI (0.958) and CFI (0.965) both exceeded the stringent 0.95 threshold, indicating an excellent fit between the hypothesised model and the data.

The chi-square/degree of freedom value (χ^2/df = 2.545) was within the acceptable range, reinforcing the model's appropriateness. All AVE values surpassed the 0.50 benchmark, confirming good convergent validity. Additionally, the CR values exceeded 0.60, indicating strong internal reliability. Collectively, these CFA results validate the fearfulness subscale as a psychometrically sound measure of COVID-19-related fear.

Discussion

The COVID-19 pandemic has impacted vulnerable populations' mental health, especially people living with HIV (PLHIV) (Hong *et al.*, 2023; Serafini *et al.*, 2020b). A comprehensive tool to assess the psychological effects and fear associated with COVID-19 among PLHIV in Malaysia was designed and validated in this study (Ã & El-masri, 2005; Armstrong, 2019). The information including individual demographics, treatment history, stigma experiences, and mental health indicators, this questionnaire provides a clear picture of how the epidemic has affected this population everyday functioning and emotional health. The study done by Liu *et al.*, 2021 emphasised the necessity of comprehensive evaluations to address the particular challenges faced by PLHIV during emergencies.

The questionnaire's robust psychometric results are a testament to its meticulous design. Each item's strong relevance is confirmed by the perfect content validity index (S-CVI = 1.0), while face validity scores more than 90% indicate that respondents perceived the questions to be understandable and straightforward. When working with various populations, this degree of clarity is crucial to ensuring that replies are accurate and meaningful (Ã & El-masri, 2005).

From this, the results reveal alarming levels of psychological strain and fearfulness among respondents. Over 75 percent of participants reported feeling helpless in managing their challenges, while many experienced difficulty focusing, low energy, and reduced motivation to engage in leisure activities. These findings align with Serafini *et al.*, 2020b and Shah *et al.*, 2020, reported that prolonged lockdowns contributed to increased anxiety and depressive symptoms. Equally, this study reflects the finding by Hong *et al.*, 2023, which showed that the stigma and treatment difficulties faced by PLHIV have increased due to uncertainty, disruptions in daily routines, and worries associated with infection.

Based on these results, the confirmatory factor analysis (CFA) further supports the reliability of this tool in capturing two distinct but connected dimensions: the broader psychological impacts and the specific fears related to COVID-19. The high Cronbach's alpha values of 0.81 for psychological impact and 0.92 for fearfulness demonstrate excellent internal consistency, while the test-retest correlation of 0.728 confirms that the tool yields stable results over time. This level of consistency suggests the questionnaire can be confidently used in future monitoring or longitudinal studies to track mental health trends during and beyond major public health emergencies (Armstrong, 2019).

The degree to which COVID-19-related anxiety disrupted day-to-day functioning is indicated by the fear subscale. Many respondents noted physical symptoms including palpitations and disrupted sleep, postponed necessary healthcare visits, and expressed concern of spreading the infection to other members of their family. These result are consistent with the study finding by Brooks *et al.*, 2020, which showed that among high-risk groups, stigma, fear, and false information may hinder treatment compliance and interfere with public health initiatives.

By dealing with interrelated issues, this validated questionnaire equips researchers and policymakers with a practical and robust tool to identify individuals who may be more vulnerable and to design interventions that genuinely respond to their mental health needs. Informative campaigns, enhanced community support systems, and steps to lessen stigma for PLHIV are a few examples of mental health interventions. These measures are essential for protecting PLHIV's mental wellness during current and upcoming crises (World Health Organization, 2022).

However, this study has several limitations, as data collection was limited to urban clinics, which may not fully capture the perspectives of PLHIV in rural or underserved communities. Moreover, the cross-sectional design makes it impossible to demonstrate a causal relationship between psychological outcomes and pandemic-related issues. Future research should use long-term approaches and broaden its scope to encompass a variety of contexts to have a more precise measure of how these mental health impacts change over time.

Conclusion

A rigorous and reliable questionnaire has been developed and validated in this study for assessing the psychological effects and fearfulness of COVID-19 among PLHIV in Malaysia. Strong reliability and validity have been demonstrated by the questionnaire, indicating that it is appropriate for use in research and continuous mental health monitoring. For the purpose of protecting PLHIV during this and subsequent crises of public health, these tools assist policymakers and healthcare professionals to gather important information that may help them to develop effective policies and provide mental health services.

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ORIGINAL ARTICLE Open Access

Association of periodontal status and metabolic control in periodontitis patients with diabetes mellitus in Hospital Pakar Universiti Sains Malaysia

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Abstract

Evidence establishes diabetes mellitus (DM) as a significant risk factor for periodontitis. Periodontitis with DM patients exhibit more pronounced periodontal loss, elevated clinical attachment levels (CAL), and deeper periodontal pockets. This study aims to determine the association between periodontal status and metabolic control indicators in periodontitis with type 2 DM patients. A retrospective record review study was conducted from 2015 to 2024 at Periodontal Clinic, Hospital Pakar Universiti Sains Malaysia. All data of periodontitis with Type 2 DM patients were recorded and analyzed using SPSS 29.0. Demographic data was analysed descriptively and Fisher's exact test was used to evaluate the association between periodontal status and metabolic control indicators. Fourty two periodontitis patients were included with the mean (SD) age of 59.26 (9.97) years and male predominance (61.9%). Most patients were Malay (97.6%), and 28.6% had blood pressure of more than 140/90 mmHg. Periodontal status revealed 61.9% of patients were in stage 3 and 14.3% in stage 4 with grade B periodontitis was the most common (59.5%). Metabolic control indicators showed 64.3% of patients has HbA1c of ≥7.0%, 83.3% has fasting blood glucose of >6.0 mmol/L, and 54.8% with LDL of >2.6 mmol/L. Fisher's exact test analysis shows no significant association between periodontal severity and metabolic control indicators, including HbA1c (p=0.513), fasting blood glucose (p=0.539), and fasting lipid profiles (p≥ 0.05). The findings highlight a high prevalence of severe periodontitis among patients with poor glycemic control. However, no significant association of periodontal status and metabolic control indicators.

Keywords: *metabolic control indicators, periodontal severity, periodontitis, type 2 DM*

Received:
29 April 2025
Revised:
18 June 2025
Accepted:
18 June 2025
Published Online:
31 July 2025
How to cite this article:
Assmar, A. H., Taib, H., Mohamad, N., Awang Nawi, M. A., & Wan Mohamad, W. M. (2025). Association of periodontal status and metabolic control in periodontitis patients with diabetes mellitus in Hospital Pakar Universiti Sains Malaysia. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 216–224. https://doi.org/10.31436/ijohs.v6i2.408
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.408
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Introduction

Periodontitis is a chronic inflammatory disease that leads to the progressive destruction of the supporting structures of the teeth due to an immune response triggered by anaerobic Gram-negative microorganisms (Preshaw *et al.,* 2011). It is characterized by clinical attachment loss (CAL), probing depth (PD), bleeding on probing (BOP), and radiographic evidence of bone loss (Tonetti *et al.,* 2018). The classification of periodontitis is based on staging and grading system. Staging reflects the disease severity and complexity of the management, while grading is an indicator of periodontitis progression and influenced by risk factors such as smoking and diabetes mellitus (Papapanou *et al.*, 2018). According

to the National Oral Health Survey of Adults (NOHSA) conducted by the Ministry of Health Malaysia in 2020, 94.0% of Malaysian adults have periodontal disease with 48.5% of them having periodontitis. In fact, the prevalence of severe periodontitis was higher (18.2%), as compared to the global prevalence (Anuwar *et al.*, 2024). The prevalence of severe periodontitis has notably increased from 6.0% in 1990 to 17.8% in 2010 (Syakimah, 2013), highlighting the growing burden of the disease.

Diabetes mellitus (DM) is a metabolic disorder characterized by chronic hyperglycemia due to defects in insulin secretion, insulin action, or both (American Diabetes Association, 2009). Metabolic control indicators include glycated hemoglobin (HbA1c), fasting blood glucose (FBG), and lipid profiles. HbA1c reflects average blood glucose levels over the past two to three months, with levels above 7% indicating poor glycemic control (Eyth & Naik, 2022). Fasting blood glucose usually measured after an 8-hour fasting, should ideally remain below 5.6 mmol/L (Riley, 2023). Lipid profiles assess total cholesterol, triglycerides, low-density lipoprotein (LDL), and high-density lipoprotein (HDL) to evaluate cardiovascular risk in diabetic patients (Reddy *et al.,* 2022). DM is a well-established systemic risk factor for periodontitis. The prevalence of diabetes in Malaysia ranges between 7.3% and 23.8% (Akhtar *et al.,* 2022), with Type 2 diabetes mellitus (T2DM) being the most common form. Type 1 diabetes results from autoimmune destruction of pancreatic β-cells, leading to complete insulin deficiency (Sameer *et al.,* 2020), whereas Type 2 diabetes is characterized by insulin resistance and progressive β-cell dysfunction.

Epidemiological studies have consistently demonstrated that individuals with diabetes are approximately three times more susceptible to periodontitis. The US National Health and Nutrition Examination Survey (NHANES) III reported that adults with HbA1c levels exceeding 9.0% had a significantly higher prevalence of severe periodontitis compared to non-diabetics, even after adjusting for age, sex, smoking, and socioeconomic status (Preshaw *et al.,* 2011). Similarly, studies on the Pima Indian population showed that individuals with T2DM had an approximately threefold increased risk of developing periodontitis compared to those without diabetes (Preshaw *et al.,* 2011).

Despite strong evidence supporting the link between diabetes and periodontitis, there is limited local data assessing the association between periodontal status and metabolic control in Malaysian periodontitis with T2DM patients. Given the increasing prevalence of diabetes and periodontitis in Malaysia, therefore, it is a need for targeted research for better understanding on how metabolic control parameters influence the periodontal health. This study aims to address this gap by analysing the association between periodontal severity and metabolic indicators among periodontitis with T2DM patients at Hospital Pakar Universiti Sains Malaysia.

Specifically, this study aims to evaluate the periodontal status of T2DM patients, assess metabolic control indicators such as HbA1c, FBG, lipid profiles, and elucidate how these metabolic parameters influence the periodontal disease severity. By bridging the existing knowledge gap, this research will contribute to better periodontal disease management strategies for diabetic patients in Malaysia.

Materials and Methods

A retrospective record review was conducted from 2015 to 2024 at the Periodontal Clinic, Hospital Pakar Universiti Sains Malaysia (HPUSM), Kubang Kerian, Kelantan. Patients' folders were retrieved from Record Unit, HPUSM. Data were collected from patient records that fulfilled the inclusion and exclusion criteria.

The study population comprised of periodontitis patients with DM in Kelantan. The target population included patients diagnosed with both periodontitis and

T2DM who attended the Periodontal Clinic, HPUSM for treatment. The source population consisted of patients from the target group who fulfilled the inclusion and exclusion criteria, who had undergone treatment at HPUSM between 2015 and 2024.

Sample size was calculated for each objective. The largest sample size was derived from objective 1, to evaluate the periodontal status of periodontitis with T2DM patients, using single proportion formula with parameters set at Z=1.96, Δ=10%, power=0.95 (Singh *et al.,* 2019), n= 38+10% (drop out), yielding the total sample size of 42.

The sampling frame includes patients who met the study's inclusion and exclusion criteria. Patients eligible for the study include those were diagnosed with periodontitis with T2DM who had at least eight natural teeth, and had complete metabolic control status data including HbA1c, FBG, and lipid profiles results within the last six months from their periodontal clinic visit. Pregnant or lactating women, smokers, patients who had chronic liver disease, or were undergoing treatment that could potentially influence the study parameters such as antibiotics, immunosuppressants, antiepileptics, steroids, or non-steroidal anti-inflammatory drugs, were excluded from the study. This study was approved by Human Research Ethics Committee USM (USM/JEPeM/KK/24040307: Dated 2/6/2024).

Data entry and analysis

All data collection and analysis were conducted using SPSS 29.0. Demographic data was analysed using Descriptive method and Fisher's exact test was applied to evaluate the association between periodontal status and metabolic control indicators in periodontitis with T2DM patients. A *p*-value of less than 0.05 was considered as statistically significant.

Results

A total of 42 periodontitis patients with T2DM were included in this study. Table 1 shows sociodemographic data of the patients. The mean age of participants was 59.2 years (SD = 9.97). Majority of them were male (61.9%), and the predominant ethnic group was Malay (97.6%). Only one participant (2.4%) was Indian and no participant from Chinese or other ethnic groups. Regarding the blood pressure, majority of participants (71.4%) had blood pressure less than 140/90 mmHg, whereas 28.6% had elevated blood pressure, which is more than 140/90 mmHg.

The severity of periodontitis among participants was classified into four stages. None of the patients were classified in stage 1. Most patients (61.9%) were in stage 3, while 23.8% and 14.3% were in stage 2 and stage 4 respectively (Table 2).

Table 1. Sociodemographic data of periodontitis patients with type 2 diabetes mellitus (n = 42).

Sociodemographic data		n (%)
Age[a]		59.2 (9.97) [a]
Gender	Male	26 (61.9)
	Female	16 (38.1)
Race	Malay	41 (97.6)
	Chinese	0 (0)
	Indian	1 (2.4)
	Others	0 (0)
Blood pressure	<140/90mmHg	30 (71.4)
	>140/90mmHg	12 (28.6)

*a - Mean (SD)

Table 2. The periodontal severity in periodontitis with type 2 diabetes mellitus patients (n = 42).

Periodontal status	n (%)
Stage 1	0 (0)
Stage 2	10 (23.8)
Stage 3	26 (61.9)
Stage 4	6 (14.3)

Periodontal grading revealed that majority of patients (59.5%) were classified as grade B, while 35.7% and 4.8% of patients were in grade A and grade C respectively (Table 3).

Other parameters such as metabolic control indicators, which include HbA1c, fasting blood glucose, and fasting lipid profile, also were assessed (Table 4). Among participants, 64.3% had uncontrolled HbA1c levels (≥7.0%), and 83.3% had high FBG levels (>6.0 mmol/L). For fasting lipid profiles, 28.6% of participants had high total cholesterol (TC ≥ 5.2 mmol/L), 35.7% had elevated triglycerides (TG > 1.7 mmol/L), while 54.8% had high low-density lipoprotein (LDL > 2.6 mmol/L).

The association between periodontal severity and metabolic control indicators was determined and the results were shown in Table 5. No statistically significant association was found between periodontal severity and HbA1c (p = 0.513), FBG (p = 0.539), TC (p = 0.296), TG (p = 0.487), or LDL (p = 0.230) levels.

Table 3. The periodontal grading in periodontitis patients with type 2 diabetes mellitus (n = 42).

Periodontal grading	n (%)
Grade A	15 (35.7)
Grade B	25 (59.5)
Grade C	2 (4.8)

Table 4. The metabolic control indicators in periodontitis patients with type 2 diabetes mellitus (n = 42).

Metabolic Control Indicators	n (%)
HbA1c (%)	
• < 7.0 (control)	15 (35.7)
≥ 7.0 (uncontrolled)	27 (64.3)
Fasting blood glucose (mmol/L)	
• ≤6.0 (control)	7 (16.7)
>6.0 (uncontrolled)	35 (83.3)
Fasting lipid profile (mmol/L)	
• TC <5.2 (control)	30 (71.4)
≥5.2 (uncontrolled)	12 (28.6)
• TG ≤1.7 (control)	27 (64.3)
>1.7 (uncontrolled)	15 (35.7)
• LDL≤2.6 (control)	19 (45.2)
>2.6 (uncontrolled)	23 (54.8)

*HbA1c – glycated hemoglobin, TC - total cholesterol, TG – triglyceride, LDL- low density lipoprotein

Table 5. Association between periodontal severity and metabolic control indicators in periodontitis patients with type 2 diabetes mellitus (n=42).

Metabolic Control Indicators	Periodontal status		*p*-value
	Mild-Moderate (Stage 1 and 2) n (%)	Severe (Stage 3 and 4) n (%)	
HbA1c (%)			
• < 7.0 (control)	4 (26.7)	11 (73.3)	0.513
• ≥ 7.0 (uncontrolled)	6 (22.2)	21 (77.8)	
Fasting blood glucose (mmol/L)			
• ≤6.0 (control)	2 (28.6)	5 (71.4)	0.539
• > 6.0 (uncontrolled)	8 (22.9)	27 (77.1)	
Fasting lipid profile (mmol/L)			
• TC <5.2 (control)	6 (20)	24 (80)	
• ≥5.2 (uncontrolled)	4 (33.3)	8 (66.7)	0.296
• TG ≤1.7 (control)	7 (25.9)	20 (74.1)	
• >1.7 (uncontrolled)	3 (20)	12 (80)	0.487
• LDL ≤2.6 (control)	3 (16.7)	16 (83.3)	
>2.6 (uncontrolled)	7 (30.4)	16 (69.6)	0.230

*Interpretation is based on Fisher's exact test, Significant *p*-value < 0.05, HbA1c (glycated hemoglobin), TC (total cholesterol), TG (triglyceride), LDL (low density lipoprotein).

Discussion

This study aimed to evaluate the relationship between metabolic control indicators such as HbA1c, fasting blood glucose, and fasting lipid profile as well as the severity of periodontitis in periodontitis with T2DM patients. Both periodontitis and T2DM are chronic conditions with a well-established bi-directional relationship, where diabetes is known to increase the prevalence and severity of periodontitis, while advanced periodontitis is linked to poor glycemic control (Valentim *et al.,* 2022). However, in contrary to this expected association, the findings of this study revealed no significant association, despite most participants demonstrated poor glycemic control and severe periodontitis.

In a cross-sectional study conducted in North India, Preshaw *et al.* (2011) assessed the prevalence of periodontal disease among 427 patients with T2DM. They reported that more than 95% of diabetic patients exhibited some degree of periodontal destruction. They concluded that diabetes is a major risk factor for periodontitis, the susceptibility to periodontitis is increased by approximately threefold in people with diabetes. There is a clear relationship between degree of hyperglycemia and severity of periodontitis. Furthermore, a study conducted among Japanese individuals found that patients with T2DM were 1.17 times more likely to experience periodontal tissue destruction compared to healthy individuals (Morita *et al.,* (2011)). While periodontal status in non-diabetic individuals typically follows a normal distribution, the presence of diabetes shifts this distribution toward more severe stages of the disease (Battancs *et al.,* 2020). These findings are consistent with existing research indicating that diabetes accelerates periodontal tissue damage and contributes to disease progression. Consequently, it is reasonable to suggest that diabetes may play a role in both the onset and worsening of periodontitis (Battancs *et al.,* 2020). Given the well-established association between

diabetes and periodontitis, this hypothesis appears justified. However, the data from our study do not provide insight into the precise mechanism by which diabetes affects periodontal health, as no significant difference between periodontal severity and HbA1c as well as fasting blood glucose level.

The cross-sectional study conducted in South Jordan by Preshaw *et al.* in 2011 highlighted the well-established bidirectional relationship between diabetes and periodontitis. Diabetes not only elevates the risk and severity of periodontitis but also compromises the body's immune response, accelerating the progression of periodontitis. Conversely, periodontal inflammation can have a negative impact on glycemic control, creating a cyclical effect that further exacerbates both conditions (Preshaw *et al.,* 2011). This is proved by our data. In terms of the grading and progression of periodontitis, our results suggest that individuals with diabetes mellitus may have more progression in the severity of periodontitis as reflected by high percentage of individuals with grade B periodontitis (59.5%).

In our study, 64.3% of participants had uncontrolled HbA1c levels. Among those with controlled HbA1c level, 73.3% were diagnosed with stage 3 or 4 periodontitis, while 77.8% of participants with uncontrolled HbA1c levels fell into severe or advanced stages. However, this difference was not statistically significant (p = 0.513), suggesting that glycemic control status did not have a significant correlation with periodontitis severity in this population. Similarly, a study by Lim *et al.* (2007) explored the relationship between metabolic control and periodontitis severity in individuals with diabetes mellitus. Their findings indicated that poor metabolic control reflected by elevated HbA1c level, was associated with more severe periodontitis. Specifically, patients with poorly controlled diabetes exhibited greater clinical attachment loss and deeper probing pocket depths compared to those with better glycemic control. The discrepancy between our findings and those of Lim *et al.* (2007) might be due to differences in study design, sample size, or population characteristics. Additional factors, such as the duration of diabetes, compliance to the treatment, presence of comorbidities, and variations in oral hygiene practices may also influence the observed relationship between glycemic control and periodontitis severity.

Although our study did not find a statistically significant association between HbA1c level and periodontal severity, the higher prevalence of advanced periodontal disease among participants with uncontrolled diabetes suggests potential clinical relevance. While some studies (Morita *et al.,* 2011; Kim *et al.,* 2013) have demonstrated a positive correlation between poor glycemic control and worsening periodontitis, the findings have not been consistent across all populations. Therefore, further research is necessary to better understand the complex relationship between HbA1c level and periodontal health, taking into account for potential confounding factors and differences in population characteristics.

Moreover, we could not find a significant association between periodontal status and fasting blood glucose level. In the study by Kim *et al.* (2013), the relationship between various diabetes-related factors and periodontal health was examined among individuals with T2DM. The study found that periodontal parameters, including the number of missing teeth and papillary bleeding index, were significantly influenced by fasting blood glucose level. Specifically, higher fasting blood glucose level was associated with worse periodontal health outcomes (Kim *et al.,* 2013).

By contrast, our study observed that 71.4% of participants had controlled fasting blood glucose levels, while 77.1% had uncontrolled fasting blood glucose levels. However, there was no statistically significant association between periodontal severity and fasting blood glucose levels (p = 0.539). This discrepancy may be attributed to differences in study design, population characteristics, or other confounding factors that were not accounted in our analysis. In addition to glycemic control, factors such as diet, physical activity, drug susceptibility,

and access to professional medical care also play a crucial role in the progression of periodontitis (Kiedrowicz *et al.,* 2015).

Additionally, a study by Bridges *et al.* (1996) also found no association between glycemic control levels and periodontal disease parameters, including probing depth and clinical attachment loss. Similarly, research conducted in Poland by Krajewski *et al.* (2008) reported no significant differences in periodontal status between individuals with well-controlled diabetes (HbA1c ≤ 7.5%) and those with poor glycemic control (HbA1c > 7.5%) (Kiedrowicz *et al.,* 2015).

FBG is an important parameter for diagnosis of T2DM. Two readings of FBG more than 7.0 mmol/L is considered to confirm diagnosis of T2DM in asymptomatic individuals, while one reading of FBG more than 7.0 mmol/L is needed to confirm the diagnosis in symptomatic individuals (Clinical Practice Guideline Diabetes Mellitus, 2020). Understanding the potential mechanisms underlying the relationship between fasting blood glucose levels and periodontal health is crucial. Elevated fasting blood glucose levels can lead to the formation of advanced glycation end-products (AGEs), which initiate and propagate inflammatory responses, resulting in the degradation of periodontal tissues. Additionally, a hyperglycemic environment can impair the function of fibroblast, subsequently leading to increase susceptibility of collagen to degradation as well as hindering tissue repair and regeneration (Kim *et al.,* 2013). These pathophysiological processes may explain the association between poor glycemic control and periodontal disease progression.

Fasting lipid profile, a key metabolic parameter that may play a role in periodontal disease progression, was evaluated among the study groups. However, there was no statistically significant association between periodontal severity and fasting lipid profile, including total cholesterol (p = 0.296), triglycerides (p = 0.487), or LDL cholesterol (p = 0.230). Nevertheless, other studies (Lim *et al.*, 2007; Mirzaei *et al.,* 2022; Reddy *et al.*, 2022) reported there was a relationship between lipid metabolism and periodontal disease, suggesting that lipid profiles may be altered in individuals with metabolic disorders. However, their direct impact on periodontal severity remains uncertain.

Lim *et al.* (2007) explored the effect of hyperlipidemia on periodontal inflammation and reported minimal influence on gingival inflammation severity. Their study suggested that the widespread use of statins among participants could have mitigated the expected effects of hyperlipidemia on periodontal outcomes. Additionally, they also observed that individuals with poor glycemic control (HbA1c > 8%) had higher LDL cholesterol and triglyceride levels compared to those with better metabolic control. This finding reinforcing the relationship between diabetes, lipid metabolism, and inflammatory responses. They further proposed that elevated cholesterol levels could contribute to periodontal inflammation by triggering bacterial endotoxin-induced cytokine release, which alters lipid metabolism by increasing LDL cholesterol and reducing HDL cholesterol level.

In contrast to Lim *et al.*'s findings, our study did not establish a statistically significant correlation between lipid profiles and periodontal severity. This discrepancy may be attributed to differences in the study population, the use of lipid-lowering medications, or variations in glycemic control. Despite the lack of statistical significance, the trend of higher lipid levels in the uncontrolled metabolic group suggests that metabolic dysregulation may still influence the periodontitis progression. Additionally, a systematic review and meta-analysis conducted by Mirzaei *et al.* (2022) further supports the link between dyslipidemia and periodontal disease. Their study found that periodontitis increased the odds of dyslipidemia by 15.0% and the likelihood of low HDL by 32.0%. Furthermore, a significant positive association was identified between periodontitis indices and mean triglycerides, LDL, and total cholesterol levels, while HDL exhibited a protective effect against

periodontitis. These findings highlight the complex interplay between lipid metabolism and periodontal health.

One of the limitations of this study was the sample size, which was restricted to a specific geographic area, limiting the generalizability of the findings. Additionally, the retrospective nature of the record review posed a challenge, as only a limited number of patients met all the necessary inclusion criteria. Since our study did not find a significant statistical correlation, larger-scale studies may provide further insight into the potential impact of dyslipidemia on periodontal disease. Further research with controlled variables, such as statin use, might help to clarify this relationship. Other limitation was the lack of clarity regarding the smoking history of participants due to missing data. Similarly, incomplete weight records prevented the assessment of body mass index, an important parameter for its association with obesity and increased risk of insulin resistance. Future studies should consider incorporating these parameters as potential risk factors for diabetes mellitus.

Conclusion

Metabolic control indicators such as HbA1c, fasting blood glucose, and lipid profiles showed no significant correlation with periodontal severity in individuals with T2DM. In future study, there is a need for comprehensive approach to take into account additional factors such as systemic health conditions, oral hygiene practices, and lifestyle behaviors in managing periodontal health among diabetic patients. Emphasizing glycemic control, routine periodontal care, and patient education on oral health may play a crucial role in preventing diabetes-related complications and improving overall quality of life of the patients.

Future research should be conducted on a larger sample size with a diverse study design to establish a temporal relationship between periodontal health and T2DM. It is crucial to investigate why some individuals with poor glycemic control do not develop periodontitis-related complications, while others with well-controlled diabetes exhibit both micro- and macrovascular complications along with more severe periodontitis.

Acknowledgements

The authors would like to express gratitude towards all staff of School of Dental Sciences, Universiti Sains Malaysia and individuals who were directly or indirectly involved in this research.

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REVIEW ARTICLE Open Access

Integration of Islamic principles in healthcare delivery: a narrative review

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Abstract

The integration of Islamic principles in healthcare services offers several benefits. This approach fosters a more inclusive healthcare environment by recognizing and respecting the cultural and religious values of both Muslim and non-Muslim patients. However, the extent to which Islamic principles have been integrated into healthcare services remains unclear. This review aims to collate and analyse existing evidence on the implementation of Islamic principles within the healthcare delivery system. Relevant literature was identified through databases including IIUM Research Repositories (IREP), ScienceDirect, ResearchGate, SCOPUS, ProQuest, Emerald, PubMed, and BMJ. Search terms included combinations of the following keywords: Clinical, Shariah-compliant, Muslim, Religion, Medical, Muslim-friendly, Cultural competence, and Spiritual care, using Boolean operators "AND" and "OR." The search was limited to articles published in English, Malay, and Indonesian. Each article was reviewed, and relevant information extracted from them was incorporated into this review. The review found that integrating Islamic principles into healthcare services is complex and influenced by various factors, including understanding religious beliefs, adherence to Islamic teachings, and the interaction of cultural norms within healthcare. Three key components related to Islamic healthcare services were identified: (a) global healthcare service management, (b) patient satisfaction with service delivery, and (c) the behaviour of healthcare professionals. In conclusion, there remain gaps and disparities in integrating Islamic principles into healthcare services. Further research is recommended to explore the integration of Islamic principles in healthcare services globally.

Received:
18 September 2024
Revised:
6 March 2025
Accepted:
7 March 2025
Published Online:
31 July 2025
How to cite this article:
Suhaimey, S. S., Saidi, S., & Mohd Yusof, N. (2025). Integration of Islamic principles in healthcare delivery: a narrative review. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 225–235. https://doi.org/10.31436/ijohs.v6i2.351
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.351

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Keywords: *clinical, Muslim, medical, religion, shariah-compliant*

Introduction

Muslims are obligated to follow the Shariah in all parts of their lives, which encompasses a comprehensive set of Islamic principles and guidelines. However, the provision of Shariah compliant healthcare services is sometimes overlooked, particularly within the healthcare sector (Windasari *et al.,* 2024). Studies on Shariah compliant healthcare have primarily focused on service quality (Ratnawati *et al.,* 2020), emphasizing the importance of delivering healthcare services that meet the expectations and requirements of Muslim patients.

Islamic principles that should be integrated into healthcare delivery systems include the preservation of life, ensuring that all medical interventions prioritize saving lives while adhering to Islamic ethics. Ensuring halal compliance is another essential aspect, covering the provision of halal medications,

food, and medical products. Observance of modesty in patient care is crucial, particularly in gender-sensitive medical procedures where same-gender healthcare providers should be prioritized whenever possible. Facilitating acts of worship such as prayer and fasting for Muslim patients, while accommodating their medical conditions, is also an important consideration. Additionally, healthcare services should respect Islamic end-of-life care, including proper handling of the deceased and adherence to religious rites. These principles collectively contribute to a holistic and Shariah-compliant approach to healthcare.

Masud *et al.* (2021) stated that The Islamic Hospital of Jordan served as the foundation for the Ibadah Friendly Hospital (IFH) and the Shariah compliant Hospital (SCH). The overall performance of the Islamic Hospital of Jordan greatly encouraged the establishment of Al-Islam Specialist Hospital Kuala Lumpur in 1996. Al-Islam Specialist Hospital was founded with the goal of establishing a hospital based on Islamic principles and incorporating Islamic values into its operations. However, in Malaysia, Hospital Universiti Sains Malaysia (HUSM), a government teaching hospital, was the first to introduce the term "IFH" in 2004, as part of their process of integrating Islamic values into hospital operations.

Md Shariff (2022) mentioned that Shariah compliant hospitals (SCH) provide healthcare services based on Shariah or Islamic standards. Muslims prefer that all their movements and daily activities adhere to Islamic principles, as anything provided in line with Shariah is considered as *ibadah*. In addition to fulfilling patients' physical needs through medical treatment, SCH also addresses their religious and spiritual needs. The increased awareness among Muslims around the world about Islam as a way of life has greatly influenced the concept of hospitality services in the health care and tourism sectors in Malaysia. For this reason, the existence of Shariah-compliant hospitals in Malaysia is very relevant considering the demand of Muslim consumers (Ilyani Che Jamaludin *et al.,* 2023).

The integration of Islamic principles in healthcare services has several benefits for healthcare. In this regard, this approach provides a more inclusive healthcare environment by recognizing and respecting the cultural and religious values of both Muslim and non-Muslim patients. However, it remains unclear how much the Islamic principles has been integrated in healthcare services. In this review, we will identify the primary studies that provide evidence for the issues related to Islamic principles in healthcare services.

Materials and Methods

A literature search was carried out using relevance databases including IIUM Research Suppositories (IREP), Science Direct, Research Gate, SCOPUS, ProQuest, Emerald, PubMed and BMJ. Search terms included combinations of the following: Clinical, Shariah compliant, Muslim, Religion, Medical, Muslim friendly, Cultural competence, and Spiritual care with the use of Boolean operators “AND” and “OR”. The time frame of the published paper must be within ten years, 2014-2024. All selected papers must be written in English, Malay, or Indonesian, as these are the languages most comprehensible to the research team. Most importantly, the article needs to focus on the research topic which is Islamic principles in clinical practices. Any article that is not related to research topic is excluded from this review.

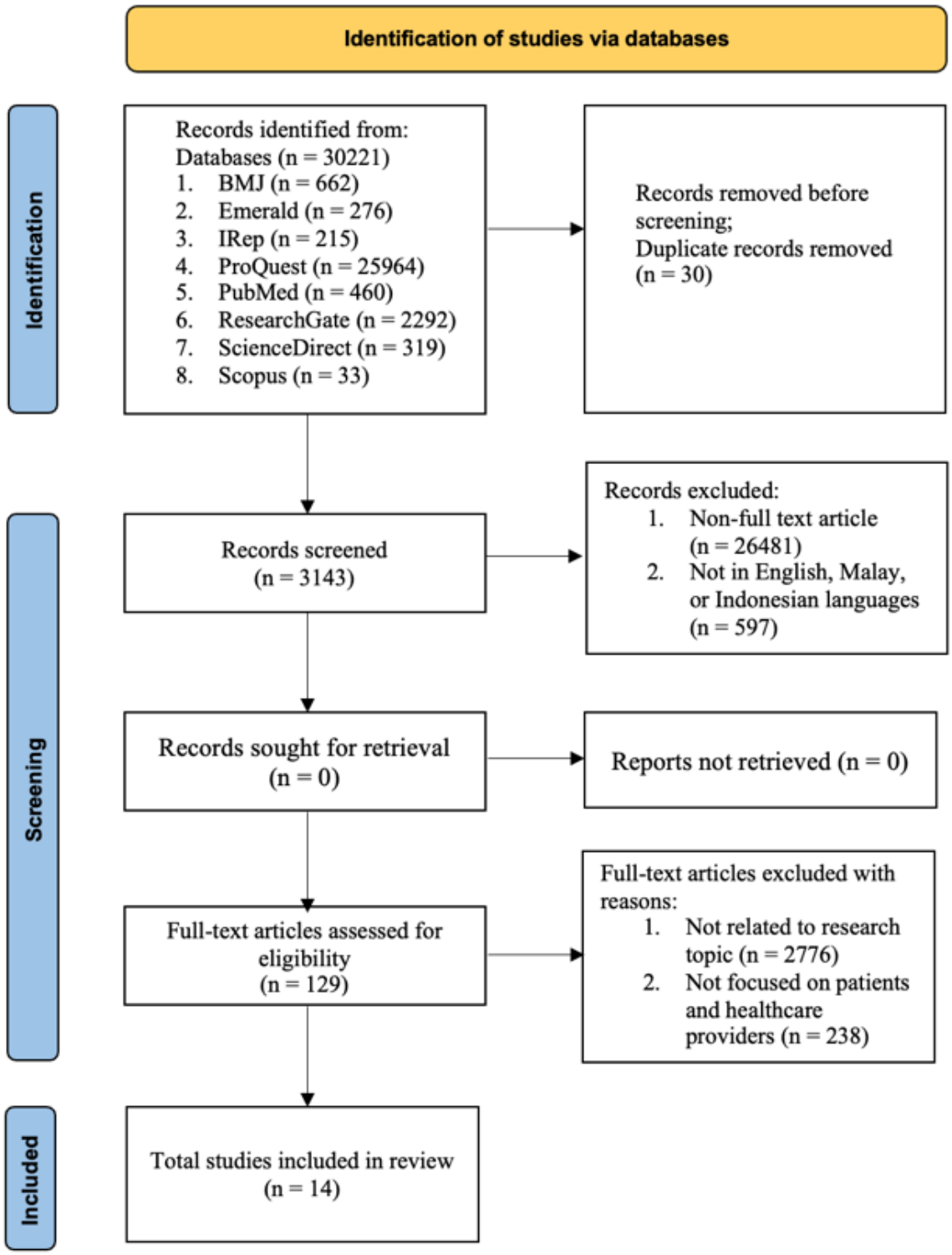

Figure 1. PRISMA flow diagram.

Figure 1 shows the PRISMA flow diagram. The database yielded 30,221 articles related to the research based on 8 databases used. 662 articles retrieved from BMJ database. 276 articles retrieved from Emerald database. 215 articles retrieved from IIUM Repository (IRep) database. 25964 articles retrieved from ProQuest database. 460 articles retrieved from PubMed database. 2292 articles retrieved from ResearchGate database. 319 articles retrieved from ScienceDirect database, and 33 articles

retrieved from BMJ database. Before screening, duplicate records were removed are 30 articles. After the removal of duplication, records were screened. A total of 26,481 non-full text articles and 597 articles not in English, Malay and Indonesian languages were removed. After the screening, 3143 articles with English, Malay and Indonesian languages were accepted before undergoing another screening process. There is no record sought for retrieval. Full text articles excluded with reasons of not related to research topic (n = 2776) and not focused on patients and healthcare providers (n = 238). A total of 129 full text articles were assessed for eligibility and finally only 14 studies were included, consisting of 10 quantitative studies, 3 qualitative studies, 1 review paper.

A total of 14 articles were analysed in this review. It was found that studies related to Islamic principles were conducted in both Muslim and non-Muslim countries. However, this review noticed that Muslim countries conducted more studies than non-Muslim countries due to majority of Muslim populations.

It has been spotted that the Healthcare Professionals (HCPs) involved in this review were: five studies on HCPs, five studies on patients, two studies on HCPs and patients and other participants included in this review were citizens and tourists which consists of two studies. In this review, 3 studies are qualitative, 10 are quantitative studies and one review study is included.

Result and Discussion

The review has found that integrating Islamic principles into healthcare services is complex and influenced by various factors includes understanding religious beliefs, adherence to Islamic teachings, and how cultural norms interact in healthcare. The three main components related to Islamic healthcare services: are (a) global healthcare services management, (b) patients' satisfaction on service delivery, and (c) behaviour of healthcare professionals.

1. Global healthcare services management

There were five papers that discussed the management of healthcare services worldwide in Muslim and non-Muslim countries.

A. Muslim countries

Rahman *et al.* (2018) conducted a study focusing on the role of Islamic medical care practices among Muslim doctors in Malaysian Muslim-friendly private hospitals. Their analysis highlighted that the effective integration of Islamic medical care depends on hospital management, healthcare professionals' (HCPs) understanding, and proper implementation strategies. Additionally, doctors must adhere to medical etiquette for Muslim patients, which involves mutual understanding and sharing of knowledge in accordance with Islamic principles. For instance, Muslim patients may receive blood from non-Muslims to save their lives, and nurses must cleanse patients' body parts contaminated with body fluids and blood to enable them to perform prayers. Furthermore, Muslim doctors in Muslim-friendly hospitals should actively facilitate and maintain Muslim patients' religious practices, such as fulfilling their obligation to pray during illness. Another key aspect of Islamic medical practice includes the prescription of halal medications to Muslim patients. In addition, ensuring a Muslim female patient's comfort and adherence to cultural preferences by allowing the presence of her spouse, chaperone, or family member during examinations is crucial.

Building on the discussion of Islamic medical care within hospital settings, Naserirad *et al.* (2023) extended the focus to the expectations and attitudes of international Muslim medical tourists regarding halal-friendly healthcare services. Their study, covering 17 hospitals across four Iranian cities (Tehran, Mashhad, Shiraz, and Tabriz), surveyed 365 Muslim medical tourists. The findings revealed that these patients hold high expectations for halal-friendly healthcare services, underscoring the

growing significance of this sector in the global healthcare landscape. As a prominent destination for Muslim medical tourists, Iran has substantial potential to provide halal-friendly healthcare services, attracting patients from regions such as the Persian Gulf and the Middle East. This aligns with the need for culturally and religiously inclusive healthcare, as emphasized in the study by Rahman *et al.* (2018), which stressed the importance of integrating Islamic medical practices within healthcare institutions.

Expanding on the influence of Islamic healthcare services on patient experiences, Rashid *et al.* (2022) examined the impact of service quality on patient loyalty within Malaysia's Muslim-friendly healthcare sector. Their study found that many young respondents perceived a lack of Islamic knowledge among doctors and nurses regarding medical practices. The study emphasized the importance of addressing both physical infrastructure—such as prayer rooms and Shariah-compliant amenities—and the provision of Islamic medical practices. Additionally, fostering empathy among medical staff and ensuring their familiarity with Islamic principles and procedures were identified as essential factors in respecting patients' religious beliefs and privacy. The study also pointed out that the quality of medical care in Malaysia's Muslim-friendly hospitals remains inadequate due to unmet patient expectations and challenges arising from the diverse religious backgrounds of HCPs. Key elements such as gender-specific healthcare services, halal food options, and prayer facilities must be prioritized to align with Muslim patient preferences. Ultimately, ensuring that healthcare services meet patient expectations is crucial for fostering customer loyalty and improving health outcomes, reinforcing the importance of culturally sensitive healthcare services as highlighted by both Rahman *et al.* (2018) and Naserirad *et al.* (2023).

B. Non-Muslim countries

King *et al.* (2023) focuses on the Islamic perspective on various healthcare aspects such as childbirth, end-of-life issues, pilgrimage, and fasting during Ramadan. It highlights the growing Muslim population in non-Muslim countries and insufficient Muslim clinicians to care for them. Studies have shown that non-Muslim clinicians have limited knowledge and understanding of Islamic practices affecting health may lead to disparities in quality of healthcare delivery. Differences between clinician and patient religion backgrounds can have an influence on rapport and communication, as well as patient adherence to treatment plans. With the increasing Muslim population in the United States, non-Muslim doctors must become more familiar with Islamic practices to provide high-quality care. Basic understanding of Islamic beliefs may help minimise diagnostic errors, support medical decisions, and improve relationships between doctors and patients. The shortage of Muslim physicians increases the likelihood of a non-Muslim clinician treating a Muslim patient. Providing cross-cultural medical care has both advantages and disadvantages, and a non-Muslim clinician's awareness of Muslim practices has a direct influence on the delivery of high-quality patient care to this community. This requires both knowledge of the disease process and an understanding of the patient as an individual, especially how they think, feel, and communicate with their family and community.

Similarly, Hassan (2022) carried out a study to increase healthcare providers' understanding and comprehension of Muslim women's needs, with the goal of improving interactions and promoting Muslim women's confidence in expressing their demands during maternity care in the United Kingdom (UK). The study revealed problems that Muslim women have while expressing their religious requirements during childbirth and interacting with maternity services through interviews and focus groups with HCPs. Despite their role as a resource for Muslim women during childbirth, many Muslim women lacked confidence in communicating their religious needs to HCPs, who frequently demonstrated insensitivity due to a lack of understanding of Islamic beliefs and practices. The findings have practical

implications since minority ethnic women, especially Muslims, frequently get poor maternity care because of judgmental attitudes and higher risks of maternal mortality. Cultural and religious differences that come into conflict with medical practices make it difficult for ethnic minority women to connect with maternity care. Thus, increasing awareness and supporting HCPs in understanding cultural diversity becomes essential for providing excellent maternity care. This study supports a woman-centered approach that recognises and addresses Muslim women's particular needs as described by them, while also providing evidence-based suggestions for professional practice. Understanding Muslim women's religious practices during pregnancy is crucial for delivering woman-centered care and improving relationships in maternity services. Empowering HCPs with the knowledge and skills to respond to patients' religious and cultural needs is essential not only in the United Kingdom but also in other Western countries. Improving care for Muslim women requires educating HCPs and modifying healthcare systems to meet their needs.

2. Patients' satisfaction on service delivery

There were 5 studies that discussed differently regarding the customer and patient preferences, perceptions, expectations, satisfactions, and loyalty of Islamic and Muslim friendly hospitals. A study by Windasari *et al.* (2024) and Ratnawati *et al.* (2020) was carried out in Indonesia while another three papers were conducted in Malaysia.

A study by Windasari *et al.* (2024) indicates that international certification takes preference over Sharia certification. The brand characteristic was identified as the most important attribute. The second and third most important attributes were service quality and Sharia service, while add-on services and infrastructure were the least important. This finding suggests that brand portioning has a major impact on customers' buying decisions and behaviour. Therefore, including an Islamic brand in the hospital's name may increase demand among Muslim clients.

Conversely, Rahman *et al.* (2023) conducted a study among 309 out of 500 Muslim patients who received healthcare services for no less than one day from four selected Islamic-friendly hospitals in Selangor and Kuala Lumpur. The results indicated that most of the respondents visited the hospital 3–4 times for illness and medical check-ups, at 57.9% and 27.8%, respectively, whereas most respondents reported good healthcare service (44.3%) within the hospital. It demonstrates that halal healthcare qualities, as well as the hospital's intrinsic and extrinsic value, all have an important impact on satisfaction. Satisfaction with halal healthcare services significantly affects word-of-mouth.

Ratnawati *et al.* (2020) examined public satisfaction on *Badan Penyelenggara Jaminan Sosial Kesehatan* (BPJS) health in Indonesia based on services in Islamic hospitals, where the service quality was analysed from a Shariah perspective. According to the findings, small hospitals rely on essential aspects including reliability, empathy, responsiveness, insurance systems, and sincerity to improve patient satisfaction. Large hospitals, on the other hand, prioritise compliance, reliability, tangibility, empathy, responsiveness, and insurance system efficiency as ways to improve patient satisfaction. Interestingly, compliance, insurance systems, sincerity, and satisfaction have an impact on loyalty in small hospitals, but empathy, insurance systems, sincerity, and satisfaction are the primary drivers in large hospitals. Furthermore, the study found that assurance has no impact on Muslim patients' satisfaction and loyalty in BPJS health across both small and large Islamic hospitals, whereas reliability and responsiveness influence satisfaction in BPJS health patients, but not directly on their loyalty. These findings highlight crucial variables that HCPs should consider when improving the patient experience and fostering long-term loyalty in a variety of healthcare settings.

Meanwhile, Khalilur Rahman & Zailani (2016) conducted a study to investigate the factors that influence to Muslim tourists' intention to revisit Islamic-friendly hospitals. The findings indicate that healthcare professionals' behaviour, Shariah compliance practices, healthcare ethics, and safety/security have an influence on attitudes and satisfaction. Attitudes have a significant association with satisfaction, but healthcare ethics does not. The findings also demonstrated that attitudes and satisfaction have a major influence on the intention for revisiting to Islamic-friendly hospitals. Malaysia should offer and promote Islamic-friendly medical tourism services to attract more Muslim patients from various Muslim and non-Muslim countries. Another important factor for Muslim patients in terms of satisfaction and behavioural intention when choosing Islamic medical tourism destinations is the reasonable cost of travel and health check-ups.

Rashid *et al.* (2022) decided to focus on the service quality factors towards patient loyalty in Malaysia's Muslim-friendly private healthcare sector at Kumpulan Perubatan Johor (KPJ). The variables of patient satisfaction and their influence on medical loyalty intention were explored in this investigation. Based on the results, the largest age group was the younger group, aged 18 to 25 years old, where 145 respondents were in this group, contributing to 58% of the overall respondents. The data indicated that respondents aged 18 to 25 had the greatest influence on seeking Islamic medical care for patient loyalty in a Muslim-friendly hospital. Patients' loyalty to Islamic medical treatment in Muslim-friendly hospitals has a positive association with tangible, empathy, and responsiveness components, whereas assurance and reliability have no significant association. Majority of the respondents are young, and they are unaware of doctors' and nurses' Islamic understanding of medical practices.
Satisfied patients are more likely to share positive experiences, which improves the reputation and credibility of healthcare organisations. In an era when patient-centered care is an essential component of effective healthcare, prioritising customer satisfaction is important for achieving not only positive health outcomes but also building a healthcare system that is responsive, compassionate, and constantly evolving to meet the diverse needs of its community. Effective communication, including cultural and religious concerns are essential and regular community participation ensures that the hospital remains aware of the specific needs and preferences of the local Muslim community. A Muslim-friendly hospital aims to provide not just high-quality medical care, but also an environment in which patients feel culturally and religiously accepted, hence increasing overall satisfaction and good healthcare experiences.

3. Behaviour of healthcare professionals:

There were six studies that discussed a few issues which are attitude and practice, and spiritual care among HCPs.

A. Attitude and practice of healthcare professionals

Amin & Abdelmageed (2020) carried out a study in Egypt and United States of America (USA) to assist clinicians in communicating with Muslim patients considering fasting during Ramadan by proposing a communication tool, RAMCOM which stands for RAMadan COMmunication. In total, 21 clinicians were interviewed. However, some clinicians in this study indicated that they were unlikely to use the tool with low socioeconomic patients. Patients with low socioeconomic status frequently receive less helpful socioemotional utterances from their doctor, as well as more directive and less participative, information-giving, instructions, and socioemotional and partnership-building utterances. Although the suggested tool enhances communication and treatment quality, it is critical to identify and fulfil the specific communication needs and preferences of patients from varied socioeconomic backgrounds. Clinicians may promote a more inclusive and equitable healthcare environment by taking a patient-centered approach that considers individual preferences for participation in healthcare

choices. This guarantees that all patients, regardless of their socioeconomic status, receive communication styles that are appropriate for their preferences, resulting in a more patient-engaged and satisfying healthcare experience.

Like the study by Rehman & Diah (2020) which focuses on the doctor-patient relationship in two Muslim countries; Pakistan and Malaysia, specifically to explore the ethical practices in the health profession. The findings highlighted a moderate relationship between doctors and patients. In Pakistan, most doctors emphasized the importance of provider attitudes toward patients, particularly in maternity healthcare, which is highly sensitive and critical. Despite learning professional ethics based on Islamic principles and integrity during their medical training, the power of doctors over patients has been reported. Surprisingly, most women who visited the menopausal clinic in Malaysia accepted the doctor's dominance since doctors talk to them about their concerns and women prefer to trust their expertise. Some of the key issues found during physician-patient relationships include a lack of communication between patients and physicians, negative provider behaviour, and language barriers. In contrast, several respondents reported that all HCPs treated them well. They had heard that physicians and nurses mistreated patients and acted inappropriately, but nothing happened to them.

A study by Rahman *et al.* (2018) regarding the role of Islamic medical care practice of Muslim doctors in Malaysian Muslim-friendly private hospitals found that the perceived roles of Islamic medical care practices by Muslim doctors are important for the medical well-being of Muslim patients. The findings reveal that the Muslim doctor's practice of medical etiquettes, the cleansing process of body and blood fluids, treating infectious diseases, advising patients with regards to mental health and end-of-life care to Muslim patients are also important facts and factors to be widely attended to without discriminatory attitudes. The attitudes of HCPs play an important role in the recovery and well-being of patients. Positive attitudes promote trust, communication, and collaboration between patients and HCPs, which improves overall treatment quality and promotes faster recovery. Integrating Islamic medical practices allows HCPs to better accommodate Muslim patients' religious and cultural requirements, fostering a feeling of inclusiveness, respect, and understanding within healthcare settings.

Similarly, understanding of Islamic medical practice (IMP) and the associated factors among HCPs including doctors and nurses in a Shariah-compliant hospital was also discovered by Mohd Arifin *et al.* (2022). The study found that most of the participants 80.3% (n=122) had high knowledge on IMP, while 19.7% (n=30) had a moderate understanding. Meanwhile, 47.4% participants (n = 72) had an excellent level of knowledge of *rukhsah solah*, 50% (n=76) had a good level of knowledge and 2.6% (n=4) had poor level of understanding of *rukhsah solat*. Furthermore, the participants' IMP understanding level was associated with their years of working experience, position, and gender ($p < 0.05$). In addition, the *rukhsah solat* was associated with the departments ($p < 0.05$). The study findings suggested more training on *rukhsah solat* is essential among HCPs, especially those working in a Shariah-compliant hospital to support the IMP implementation. Enhanced *rukhsah solat* competency among HCPs is important in enabling them to effectively cater to the religious and cultural requirements of patients within a Shariah-compliant hospital setting. This targeted training initiative serves to not only enhance the overall effectiveness of IMP but also fosters a more inclusive and culturally sensitive approach to healthcare delivery within Shariah-compliant hospitals. Considering the importance of HCPs in patient care, by addressing their understanding and practice of *rukhsah solat* can facilitate a more seamless integration of Islamic Medical Practice into the broader healthcare framework.

B. Perspectives on spiritual care among healthcare professionals

Taylor *et al.* (2023) stated that nurses are increasingly educated and expected to give spiritual care to their patients. Although nurses report positive attitudes toward spiritual care, they typically self-report providing it infrequently. The evidence for the reported frequency of spiritual care is limited by significant variance in measurement. For this secondary analysis, data acquired from practicing nurses using the Nurse Spiritual Care Therapeutics Scale (NSCTS) from 16 studies carried out in Indonesia, Iran, Malaysia, the Philippines, Portugal, Taiwan, Turkey, and the United States were compiled (n = 4062).

The findings show that spiritual care varies across and within countries. Spiritual care implementation was slightly more common in Islamic cultures than in predominantly Christian cultures. In Indonesia, nurses from a national survey provided spiritual care significantly more frequently than nurses from one public hospital. In the Philippines, one of every three hospital nurse samples reported significantly more frequent spiritual care. Surprisingly, the sample taken from a Christian faith-based healthcare system reported the least amount of spiritual care. While palliative care (and mostly advanced practice) nurses gave much more spiritual care than the others, mental health nurses also offered more frequent spiritual care than the remaining samples, which were mostly hospital-based. When the frequencies for each item were compared between samples from mostly Muslim and predominantly Christian cultures, the pattern remained similar, demonstrating that nurses in Muslim cultures provide more significant spiritual care. Surprisingly, 79% of Portuguese palliative care nurses said they never/rarely remained there to demonstrate caring. ANOVA supported these findings, revealing no significant difference between Muslim and Christian populations across all 17 items. However, comparing NSCTS scores, it revealed that Muslim nurses provide more frequent spiritual care than Christian nurses. Another factor linked to spiritual care frequency was the major religion of the country (or region), with Muslim nurses delivering spiritual care somewhat more frequently than Christian nurses. Islam was the primary religion in four of these countries (Indonesia, Iran, Malaysia, and Turkey), yet the frequency of spiritual care differed amongst them. Similarly, the frequency of spiritual care varies throughout the primarily Christian countries of Portugal, the Philippines, and the United States.

Like Adib-Hajbaghery *et al.* (2017) study on evaluating Iranian nurses perceived professional competence in spiritual care, the relationship between perceived competence and nurses' personal characteristics, and barriers to provide spiritual care. The findings showed that among 239 nurses, 23% had poor, 51% had moderate, and 26% had favourable competence in spiritual care. No significant differences were found between the mean competence scores of spiritual cares in terms of gender, marital status, employment status, and level of qualification. Significant differences were found between nurses' overall score of competence in spiritual care and receiving training on spiritual care, nurses' position, and the ward they worked in. This study showed that more than half of the nurses had a positive attitude toward spirituality and spiritual care as a professional responsibility. Most of the nurses who participated in this study had a moderate or unfavourable competence in providing spiritual care. Many nurses who participated in this study remarked that they have not received any training about spiritual care.

Spiritual care provided by HCPs is an important aspect of overall patient care. Healthcare professionals that give spiritual care display a willingness to understand and support their patients' ideas and values, regardless of their beliefs. By adding spiritual care into their interactions, HCPs help patients' emotional and psychological well-being while also generating a sense of support and understanding. In a Muslim country, the provision of spiritual care by HCPs is especially important since Islam plays such an important role in the lives of

many patients including prayer times into everyday schedules and establishing an environment that promotes Islamic values. This culturally sensitive approach not only improves the overall patient experience, but it also represents healthcare professionals' dedication to recognising and honouring the essential spiritual components that are fundamental to the lives of people in Muslim-majority societies.

Conclusion

From the exploration of literature, the integration of Islamic principles into clinical practices emerges as a multifaceted endeavor influenced by various factors. This includes the understanding of religious precepts, adherence to Islamic teachings, and the interplay of cultural norms within healthcare settings. The perspectives of patients, HCPs, and family members significantly shape the approach towards integrating Islamic principles within hospitals in Muslim or non-Muslim countries. This review highlights the importance of understanding the current healthcare management within hospitals worldwide. Furthermore, this study aims to contribute to the knowledge surrounding the integration of Islamic principles and shedding light on the importance of patient-centered approaches and supportive environments within healthcare settings. However, there is still a gap and disparities in integrating Islamic principles into healthcare services. Further research on exploring integration of Islamic principles in healthcare services worldwide is recommended.

Acknowledgement

Ministry of Higher Education Malaysia for providing the Fundamental Research Grant Scheme (FRGS/1/2021/SS02/UIAM/01/1) for the study.

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REVIEW Open Access

The current status of intentional replantation: a narrative review

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Abstract

Intentional replantation which has been practiced since the 1940s has evolved from its initial position as a final course of treatment to a viable alternative for managing failed root canal treatment. This review provides an overview of the current status of intentional replantation, clinical considerations prior to intentional replantation procedure, treatment outcomes and to explore future direction in this field. A literature search was conducted via Google Scholar using the search terms 'tooth reimplantation' and 'intentional replantation', and PubMed using the search terms 'tooth reimplantation AND endodontics', and 'intentional replantation' AND endodontics' for English language publications from January 2000 to December 2024. Additional relevant articles were identified through manual review of reference list from selected publications. Findings from this review indicate that favourable treatment outcomes can be achieved depending on several critical factors such as the access and understanding of current intentional replantation protocols, meticulous preoperative assessments, careful case selection criteria, adherence to established extra-oral manipulation time limitations during the procedure, and implementation of atraumatic tooth extraction techniques to prevent root damage.

Keywords: *endodontics, extra oral root-end surgery, intentional replantation, tooth reimplantation*

Received:
14 January 2025
Revised:
23 July 2025
Accepted:
23 July 2025
Published Online:
31 July 2025
How to cite this article:
Mustaffa, M., Mohamed Khazin, S., Ramlan, N. A., & Abd Ghani, H. (2025). The current status of intentional replantation: a narrative review. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 236–243. https://doi.org/10.31436/ijohs.v6i2.379
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.379
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Introduction

Intentional replantation, also known as tooth reimplantation has been documented in dental practice since the 1940s. Intentional replantation has been regarded as a final course of treatment when other treatment options such as nonsurgical root canal retreatment or endodontic surgery are not feasible. However, current dental practice has repositioned intentional replantation as an alternative to failed root canal treatment rather than as a last resort intervention (Marouane *et al.,* 2017). This procedure is a viable option in various clinical cases, as it is associated with fewer complications and superior cost-effectiveness at preserving the natural tooth compared to other treatment modalities (Asgary *et al.,* 2014; Javed *et al.,* 2020; Plotino *et al.,* 2022; Lin *et al.,* 2024) provided appropriate case selection criteria are met.

Intentional replantation is the planned extraction of a tooth, followed by extra-oral

root-end surgery or other necessary repairs, and subsequent replacement of the tooth into the original tooth socket. This procedure offers clinicians the distinct advantage of comprehensive tooth surface examination under the magnification, allowing detailed assessment of anatomical variations, portals of exit, fracture lines, and otherwise inaccessible areas. This facilitates repair or root-end surgery without damaging the supporting tooth structures, thus promoting the reestablishment of healthy periradicular tissues (Plotino *et al.*, 2020; Plotino *et al.*, 2022).

Figure 1. Flow diagram of tooth replantation procedure.

The indications and techniques for intentional replantation protocols are clearly outlined in the literature to facilitate clinicians providing this treatment to patients (Kratchman, 2018; Plotino *et al.,* 2021; Plotino *et al.,* 2022; Pisano *et al.,* 2023) (Figure 1). Despite established clinical protocols, variations in the techniques with regards to the prescription of preoperative antibiotics, number of clinicians involved in the procedure, tooth extraction method and tooth handling post extraction, socket manipulation/curettage, root resection method, root-end preparation method, root-end filling material, extra-oral manipulation time, and tooth splinting have been

documented (Becker, 2018). It has been suggested that the prophylactic antibiotics should only be prescribed under certain medical conditions, including complex congenital heart defects, prosthetic cardiac valves, history of infective endocarditis, ongoing intravenous bisphosphonate therapy, and recent joint surgery (within first 3 months) (Segura-Egea *et al.,* 2018). Despite a viable alternative to retain the natural tooth, clinicians should have a thorough understanding with regards to the indications, clinical procedures and possible complications because the affected tooth is usually compromised and is susceptible to fracture during the tooth extraction process, which can affect its long-term success (Lin *et al.,* 2024).

The majority of complications following intentional replantation are persistent periapical inflammation, external root resorption, ankylosis, periodontal pocket formation and potential tooth loss manifest within the first year, although delayed complications remain possible (Cho *et al.,* 2016). Despite these complications, improved healing outcomes were observed in cases where replanted is completed within 15 minutes (Cho *et al.,* 2016). The primary complication following intentional replantation is ankylosis, which is frequently associated with excessive splinting. When sufficient tooth stability is achieved following intentional replantation, postoperative fixation on the replanted tooth may be accomplished using a crossed suture suspended above the occlusal surface with optional resin composite reinforcement at the tooth surface (Plotino *et al.*, 2020). However, in cases of inadequate tooth stability, a flexible splint with a steel wire not exceeding 0.3-0.4mm is applied for 2 weeks to allow physiologic tooth mobility and minimise the risk of ankylosis (Plotino *et al.*, 2020).

The article aims to provide an overview of the current status of intentional replantation, clinical considerations prior to intentional replantation procedure, treatment outcomes and to explore future direction in this field.

Materials and Method

A literature search was carried out using Google Scholar with the search terms 'tooth reimplantation' and 'intentional replantation'. Another database was PubMed with the search terms 'tooth reimplantation AND endodontics', and 'intentional replantation' AND endodontics'. The search included English language publications from January 2000 to December 2024. Two independent assessors reviewed the scientific contents of the identified articles. Additional relevant studies were selected through manual review of the reference lists of selected articles. Disagreement between two assessors was resolved through consensus discussion. This review included 23 articles related to intentional replantation and it is worth noting that original research articles on this topic were limited, with the majority of articles predominantly comprising review articles, case reports/series and other study designs including systematic reviews (Table 1).

Discussion

Intentional replantation demonstrates a viable alternative across various clinical cases (Table 2), contingent upon careful case selection criteria (Figure 2). Based on reported data, the survival of intentionally replanted teeth, defined as tooth retention across varying follow-up periods was 88% (95% CI, 81%-94%) (Torabinejad *et al.,* 2015). Additional study revealed 90% survival rates at less than 6 months follow-up with slight decline observed in cases followed up beyond 36 months (Wang *et al.,* 2020). In another study, the mean survival rate of 85.9% for approximately 12 months observation period was observed (Javed *et al.,* 2020). A recent study reported a survival rate of approximately 89% and 86% for single rooted and multi rooted teeth respectively (Pisano *et al.,* 2023).

Table 1. Articles on intentional replantation.

Type of study	Number of article (s)	Area of studies
Systematic review	5	• Tooth survival after intentional replantation (Torabinejad *et al.,* 2015; Pisano *et al.,* 2023) • Clinical outcomes involving the survival and success of intentionally replanted teeth (Wang *et al.,* 2020) • Clinical outcomes (Javed *et al.,* 2020) • Effectiveness of intentional replantation (Plotino *et al.,* 2023)
Prospective study	2	• Tooth retention and healing after intentional replantation and outcome predictors (Cho *et al.,* 2016) • Clinical outcomes and bone changes determined using cone beam computed tomography (Park *et al.,* 2023)
Retrospective study	1	• Clinical outcomes of intentionally replanted teeth in terms of tooth survival and periradicular healing and investigation of their prognostic factors (Choi *et al.,* 2014)
Case report/series	4	• Indication and case selection (Asgary *et al.,* 2014) • Viable treatment option when a dental implant, nonsurgical retreatment or surgical treatment is not possible (Cotter & Panzarino, 2006) • Clinical procedure and outcomes (Alves *et al.,* 2020) • Clinical outcomes and bone changes before and after intentional replantation (Santos *et al.,* 2022)
Position statement	1	• Evidence on clinical guidance to undergraduate and postgraduate students, dental practitioners, clinical teachers and researchers (Plotino *et al.,* 2021)
Review article	10	• Case selection (Unver *et al.,* 2011) • Clinical procedures, indications, outcomes (Marouane *et al.*, 2017) • Indication (Kratchman, 2018) • Clinical procedures including variations in the techniques (Becker, 2018) • Concepts and techniques (Kratchman, 2019; Plotino *et al.,* 2020) • Rationale and indications, treatment protocols, treatment outcomes (Plotino *et al.,* 2022)

	• Clinical procedures and outcomes (Sangiovanni *et al.,* 2021; Kumar *et al.,* 2024) • Case selection, preoperative assessment, clinical procedures, post-operative management and follow-up, treatment outcomes, prognosis and complications (Lin *et al.,* 2024)

Meanwhile, the success, characterised by absence of clinical symptoms, improvement in the periodontal probing depth and radiographic evidence of bone regeneration was 70% to 90% (Wang *et al.,* 2020). In another study, the success rate was 77.23% for approximately 12 months observation period was also reported (Javed *et al.,* 2020). Although tooth survival is the most commonly reported outcome in existing literature, success and failure rates of intentional replantation have also been reported.

Table 2. Considerations for choosing intentional replantation over intra-oral surgery.

	Considerations	Relevance
Tooth-related	Lingually inclined mandibular second molar (Kratchman, 2019)	Thick buccal cortical bone removal is required to access the roots ridge causing excessive bone removal due to the external oblique ridge
	Mandibular teeth in proximity with the inferior dental canal or mental nerve (Kratchman, 2019)	Risk of paraesthesia from potential nerve injury
	Roots of maxillary molar in proximity with maxillary sinus floor (Kratchman, 2019; Plotino *et al.,* 2022)	Risk of perforating maxillary sinus floor, risking post-operative sinus infection
	Palatally positioned maxillary molars (Kratchman, 2019)	Buccal access will require unnecessary bone removal. Palatal access will risk injury to greater palatine artery
	Difficult access to sites requiring repair (perforations/ resorption/ palatogingival groove/ vertical root fracture) (Plotino *et al.,* 2022)	Unnecessary bone removal will jeopardize periodontal support
	Periodontally compromised tooth (Park *et al.,* 2022)	Apical bone removal will reduce periodontal support to access the root
General	Patients who cannot tolerate surgical procedures (Kratchman, 2019)	Tooth replantation procedures are performed extra-orally
	Patients with tremor (Kratchman, 2019)	Risk of iatrogenic injury during surgical procedures due to patient movement, especially during incision, bone removal, and root-end cavity preparation. Intra-orally surgery might be difficult due to loss of focus from “moving” surgical site

Figure 2. Periapical radiograph of endodontically treated molars. A and B: straight roots with interseptal bone, good candidate for intentional replantation without splinting. C: Fused root, easy removal, but requires splinting after intentional replantation.

In cases presenting with complicated root structure and high risk of fracture during tooth extraction, teeth with repeated nonsurgical root canal treatments, large root canal with minimal root dentine thickness, and insufficient coronal tooth structure for forceps engagement, preoperative orthodontic extrusion (Figure 3A, 3B) for 2-3 weeks prior to intention increase tooth mobility and volume of periodontal ligament to facilitate atraumatic tooth extraction, thus minimising the risk of complications such as root resorption and ankylosis (Choi *et al.,* 2014), ultimately improving tooth survival (Torabinejad *et al.,* 2015). Alternatively, the use of orthodontic separators (Figure 3C) at the inter-proximal regions approximately 10-14 days prior to tooth extraction may also facilitate the tooth extraction process (Kratchman, 2019).

Figure 3. A and B: Clinical photographs of maxillary second premolar with minimal coronal tooth structure undergoing orthodontic extrusion (Photos courtesy of Lt. Colonel Dr. Muhammad Khiratti Bin Mat Zainal). C: Orthodontic separators placed interproximally prior to tooth removal.

Systematic reviews have documented the success and survival rates, along with prognostic indicators that support the effectiveness of intentional replantation procedure (Torabinejad *et al.,* 2015; Wang *et al.,* 2020; Pisano *et al.,* 2023). Critical prognostic indicator includes preoperative orthodontic extrusion, which can reduce the risk of root resorption and increase tooth survival (Torabinejad *et al.,* 2015).

Additional significant indicators identified in literature include minimised extra-oral manipulation time, reductions in periodontal pocket depth, type of tooth, type of root-end filling material, prevention of atraumatic tooth root damage during extraction (Wang *et al.,* 2020), and careful case selection criteria (Pisano *et al.,* 2023).

Treatment outcomes are considered as favourable in the absence of clinical signs and symptoms, radiographic evidence of resolution and return of the tooth to normal function (Asgary *et al.,* 2014). Although existing data demonstrates the predictability of the procedure, several consideration warrant consideration such as

the predominance of case reports and/or case series (Pisano *et al.,* 2023), retrospective studies (Wang *et al.,* 2020), combined retrospective and other study designs (Torabinejad *et al.,* 2015) and lack of comparative data between intentional replantation and other treatment modalities (Plotino *et al.,* 2023), underscoring the need for more rigorous prospective clinical studies.

In general, the outcomes of intentional replantation is dependent on multiples critical factors such as implementation of atraumatic tooth extraction, adherence to less than 15 minutes extra-oral manipulation time, copious irrigation with sterile saline solution or Hank's balanced salt solution to prevent drying out of the root surface, meticulous instrumentation steps, and patient compliance post procedure (Cotter & Panzarino, 2006). The success of intentional replantation carries various opportunities for technical mishaps and is highly dependent on the clinicians (Sangiovanni *et al.,* 2022). While there is a lack of evaluation regarding the skillset and experience of clinicians in literature, available evidence suggests that careful case selection and adequate procedural training may positively impact treatment outcomes (Asgary *et al.,* 2014). Future research into the impact of this variable on treatment outcomes represents an important direction for future research.

The integration of intentional replantation into dental school curricula is a crucial step towards preparing future clinicians for this treatment modality. Additionally, the development of comprehensive educational initiatives encompassing both theoretical knowledge and clinical competencies are fundamental for dental educators, practicing clinicians, graduates and students. This ongoing lifelong educational process is essential to ensure continuous update on intentional replantation and optimal patient care to offering this procedure as a treatment option.

Conclusion

Favourable treatment outcomes of intentional replantation can be achieved through access to updated knowledge, comprehensive preoperative assessments, careful case selection criteria, adherence to extra-oral manipulation time, and implementation of atraumatic tooth extraction to prevent root damage. Although higher levels of evidence for the procedure such as randomised clinical trials are lacking, current evidence suggests promising results, subject to the clinicians following standardised protocol aligned with evidence-based recommendations.

Acknowledgement

The authors would like to thank Lt. Colonel Dr. Muhammad Khiratti Bin Mat Zainal, Asst. Prof. Dr. Azrul Safuan Bin Ali, and Asst. Prof. Dr. Cheong Joo Ming for contributing valuable clinical photographs.

Conflict of Interest

None

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OPINION ARTICLE Open Access

The digital workflow in dentistry: adoption and challenges

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Abstract

The incorporation of digital technologies has brought about a revolution in the profession of dentistry, resulting in greater diagnostic accuracy, enhanced patient outcomes and streamlined operations. Intraoral scanners, cone beam computed tomography (CBCT), computer-aided design/computer-aided manufacturing (CAD/CAM) systems, and 3D printing have profoundly influenced the field of prosthodontics, implantology and orthodontics. These developments provide enhanced precision in planning, manufacture and customization of dental prostheses and surgical guides. Nonetheless, the implementation of digital workflows entails problems such as elevated expenses, steep learning curves and the need for ongoing equipment maintenance. This study examines the advantages and obstacles of digital dentistry, emphasizes technological improvements, and considers future directions, including the potential for AI integration. A balanced approach, addressing the technological and clinical challenges, is crucial for maximizing the benefits of digital tools in modern dental practice.
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Keywords: *3D printing in dentistry, CAD/CAM, digital dentistry, digital workflow challenges, intraoral scanning, teledentistry*

Received:
1 July 2024
Revised:
8 May 2025
Accepted:
9 May 2025
Published Online:
31 July 2025
How to cite this article:
Chu, S. B., & Ooi, H. S. (2025). The digital workflow in dentistry: adoption and challenges. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 244–251. https://doi.org/10.31436/ijohs.v6i2.336
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.336
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Introduction

In recent years, the dental industry has undergone a transformative shift with the widespread adoption of digital technologies. Technological advancements such as intraoral scanners, cone beam computed tomography (CBCT), and computer-aided design and manufacturing (CAD/CAM) systems have completely revolutionized dental practices (Reddy *et al.*, 2023; Wennerberg & Albrektsson, 2011) . These digital tools facilitate accurate diagnoses and treatment planning, improves patient communication, and streamlines the laboratory procedures for designing and fabricating prostheses. This article explores the profound impact of digital dentistry on enhancing patient experiences and treatment outcomes.

Digital data acquisition: intraoral and extraoral scanning

Digital workflow in dentistry begins with accurate digital data acquisition, with intraoral scanners playing a crucial role. Intraoral scanners provide numerous advantages by substituting the conventional analog impressions with accurate digital scans. They capture highly detailed 3-dimensional representations of oral tissues non-invasively, significantly enhancing patient comfort (Ahlholm *et al.*, 2018; Ahmed *et al.*, 2024; Andriessen *et al.*, 2014; Giachetti *et al.*, 2020; Nayar & Mahadevan,

2015; Seelbach *et al.*, 2013). These scans can be used to create digital models that can be easily edited, stored and shared (Kan *et al.*, 1999). Thus, improving information exchange between dental professionals, with patients, and with dental technicians, facilitating collaborative treatment planning and prosthetic design.

Practitioners without intraoral scanners who wish to access to digital workflow can alternatively adopt a "hybrid" approach by taking the conventional analog silicone impressions before scanning the impressions extraorally. Alternatively, they can first pour the silicone impressions into physical stone models followed by digital scanning with an extraoral or desktop scanner. This results in the acquisition of digital files that are similar to those obtained from intraoral scanners. This method highlights the versatility and adaptability of digital technologies in daily practice.

Integration of CBCT and advanced imaging in digital workflow

In addition to intraoral or extraoral scanning, CBCT is an essential tool for obtaining vital information that are helpful for treatment planning. By producing detailed 3-dimensional radiographic images of oral and maxillofacial structures, CBCT enables precise evaluation of bone volume, bone quality, and anatomical landmarks essential for implant planning (Kim *et al.*, 2005). The integration of intraoral scans with CBCT and other digital scans, such as facial scans, enhances case assessment and visualization, resulting in a more reliable treatment planning and optimized outcomes.

Precision in implantology: virtual planning and surgical guides

CBCT imaging has become indispensable in implantology, with virtually no implant procedure proceeding without prior CBCT assessment. Virtual implant planning software, integrated with CBCT, allows for precise planning of the implant fixture angulation and positioning within the residual bone (Andriessen *et al.*, 2014; Jemt and Lie, 1995; Reddy *et al.*, 2023). When the proposed plan is combined with surgical guide fabrication, fully guided implant placement workflow can be applied. This ensures an accurate 3-dimensional surgical placement of the implant fixtures thus minimizing surgical errors and complications. Moreover, with these digital tools, the position of implant can be planned accordingly to be prosthetically driven placement that will ease the final implant-supported prostheses fabrication. This approach exemplifies how digital dentistry enhances precision and predictability in complex dental procedures.

Digital Smile Design (DSD) and aesthetic dentistry

The integration of digital technologies in aesthetic dentistry has brought about a revolutionary change with the implementation of Digital Smile Design (DSD), which allows for the visualization and planning of smile makeovers. The use of facial scans, extraoral and intraoral photographs as well as intraoral scans in DSD allows for accurate individualized assessment of facial aesthetics, tooth proportions and gingival contours that suitable for patients. This method enables collaborative treatment planning among dental professionals and dental technicians, improving patient satisfaction by ensuring predictable results and personalized smile designs.

Teledentistry and remote consultations

Since the Covid-19 pandemic outbreak in 2019, the emergence of telecommunication technologies has facilitated the rise of teledentistry, enabling remote consultations, diagnosis, and treatment planning (Chu *et al.*, 2024). Dental professionals can utilize secure digital platforms to remotely evaluate patient conditions, offer virtual consultations, and

engage in global collaboration with other specialists worldwide. Teledentistry enhances access to dental services, especially in remote areas, and ensures the ongoing provision of care to underserved populations.

A recent study on Malaysian dental professionals found that many were aware of the benefits of teledentistry, particularly its role in increasing accessibility and reducing patient chair time. However, barriers such as limited infrastructure, insufficient training, and concerns about diagnostic accuracy still hinder its widespread adoption (Chu *et al.*, 2024).

Digital orthodontics: aligners and virtual treatment planning

Since the introduction of clear aligner system and virtual orthodontic simulation and treatment planning software, the practice of orthodontics has been revolutionized by digital orthodontics. 3D models are generated by using intraoral scans and CBCT data to accurately simulate virtual tooth movements to facilitate precise treatment planning. CAD software enables the creation of personalized aligners, streamlining and ensuring the effectiveness of orthodontic treatments (Rajasekaran & Chaudhari, 2022). This digital workflow enhances patient comfort, compliance and treatment efficacy when compared to the conventional braces (Harikrishnan & Subramanian, 2023; Rajasekaran & Chaudhari, 2022; Vaid, 2018).

Digital endodontics: microscopic imaging and treatment planning

Digital endodontics combines the use of microscopic imaging, CBCT, and digital treatment planning to improve the accuracy and precision in root canal therapy. Advanced imaging systems with high resolution offer precise visibility of the intricate root canal structure, which greatly aids the accurate diagnosis and treatment planning. Utilizing digital software facilitates the process of measuring, sealing and evaluating the quality of the obturated canal post-endodontic, thus guaranteeing a higher success treatment rate (Mikrogeorgis & Delantoni, 2024). This contributes to better long-term outcomes, lowers retreatment rates, and enhances patient satisfaction through minimally invasive techniques.

Education and training in digital dentistry

Integrating digital technologies into dental education improves learning experiences and equips future dentists with modern clinical skills. Virtual reality simulations, augmented reality applications, and digital learning platforms offer interactive instruction in diagnostics, treatment planning, and procedures (Jahangiri *et al.*, 2020).

For example, the use of virtual simulation systems such as DentSim has been widely adopted in dental education globally to enhance psychomotor skills and clinical preparedness. These systems provide real-time feedback and objective assessment, helping students improve their operative techniques and decision-making abilities (Jahangiri *et al.*, 2020). Moreover, digital case-based learning modules and online CAD training allow dental students to master digital workflows, even remotely.

Continuing professional development through hands-on workshops and webinars further helps practicing dentists to stay updated with emerging technologies (Gross *et al.*, 2019).

Ethical and legal considerations

With the advancement of digital dentistry, there are emerging ethical and legal concerns related to patient privacy, data security, and informed consent. Compliance with regulatory requirements and rules guarantees the responsible utilization of digital technologies in dental practice (Rokhshad *et al.*, 2023). Providing education on ethical principles, patient rights, and data

protection protections fosters ethical behavior and builds trust between dental practitioners and patients in the era of digital technology.

Digital fabrication: CAD/CAM and 3D printing technologies

Within the laboratory environments, Digital workflows optimize prosthesis production by simplifying design and manufacturing, ensuring precision, and reducing waste. Computer-aided design (CAD) software allows for virtual design of prostheses with high accuracy and customization (Sulaiman, 2020).

These digital designs can be fabricated through:

- **Subtractive manufacturing (milling)**: Uses milling machines to carve restorations from ceramic, composite, titanium, or zirconia blocks. Suitable for permanent restorations, implant abutments, and frameworks (Turkyilmaz & Wilkins, 2021).
- **Additive manufacturing (3D printing)**: Builds objects layer by layer using biocompatible resins, ceramics, or metals. Applicable in producing crowns, bridges, dentures, surgical guides, and clear aligners (Alharbi *et al.*, 2017; Rajasekaran & Chaudhari, 2022).

Both methods offer exceptional precision and faster turnaround times, enabling same-day restorations and improved patient satisfaction. They support a wide range of biocompatible materials and ensure restorations meet clinical and aesthetic demands (Galante *et al.*, 2019; Bae *et al.*, 2017).

Additive manufacturing (3D printing)

3D printing, often called additive manufacturing, has greatly transformed the production of dental prostheses and appliances. 3D printers use biocompatible materials like resin, ceramic, or metal powders to manufacture layers of material according to digital design generated by CAD software. This technology has multiple applications in the field of dentistry. It allows the production of personalized dental prostheses, such as crowns, bridges, and dentures (Alharbi *et al.*, 2017; Barazanchi *et al.*, 2017; Galante *et al.*, 2019; Revilla-León *et al.*, 2020; Tian *et al.*, 2021). By utilizing digital technology, designs may be customized to match the unique anatomy of each patient, guaranteeing an accurate fit and optimal comfort. Furthermore, 3D printing is also used in implant dentistry to provide accurate surgical guides that are based on virtual implant design. This enhances the precision of implant placement during surgery, minimizing procedural mistakes and improving the treatment outcomes. In addition, orthodontic appliances including as clear aligners and retainers are now being made more commonly using 3D printing technology (Rajasekaran & Chaudhari, 2022). Intraoral scans are utilized to create digital models, which are then employed to construct aligners. These aligners gradually reposition teeth, providing a more pleasant and visually pleasing alternative to conventional braces.

Subtractive manufacturing (milling)

Subtractive manufacturing in dentistry refers to the accurate subtraction of material from blocks or blanks with the use of computer-controlled milling machines (Turkyilmaz & Wilkins, 2021). This technique is predominantly utilized for permanent fixed restorations, implant abutments as well as removable prosthesis frameworks. Permanent restorations like crowns and bridges from ceramic or composite material can be milled easily from blocks. The technique guarantees exceptional precision and consistency of restorations, satisfying rigorous clinical standards for both fit and aesthetics. Besides, frameworks for fixed partial dentures (bridges) and implant-supported prostheses can be manufactured to uphold the functional and aesthetic elements of dental restorations. Moreover, implant abutments, which attaches the crown

superstructure to the implant fixture, can be customized and designed accordingly and subsequently fabricated by milling titanium or zirconia blocks. This CAD/CAM technique guarantees the best possible fit and alignment with the implant platform, hence improving the stability and durability of the restoration (Aeran *et al.*, 2014; Braian *et al.*, 2018; Jeong *et al.*, 2018; Reddy *et al.*, 2023).

Advantages of CAM technologies in dentistry

Both additive and subtractive manufacturing techniques provide exceptional precision, ensuring that dental prostheses fit flawlessly and perform optimally (Aeran *et al.*, 2014; Alharbi *et al.*, 2017; Galante *et al.*, 2019; Jeong *et al.*, 2018). Digital workflows enable the customization of dental solutions to meet the specific demands of each patient, enhancing patient comfort and satisfaction through personalized care. These technologies also enhance productivity by reducing the production time required for dental prostheses. Thus enables the possibility of same-day restorations and reduces the need for patients to make multiple trips for appointments. Additionally, with the diverse and continuous advancement of dental materials, CAM systems have the capability to handle a broad spectrum of biocompatible materials, providing the flexibility to select materials that meet specific aesthetic and durability criteria (Bae *et al.*, 2017; Sulaiman, 2020; Turkyilmaz & Wilkins, 2021).

Future directions and challenges

In the future, progressive development in CAD/CAM technology will continue to stimulate innovation in dental practice. Potential advancements may prioritize the improvement of material choices, the streamlining of manufacturing techniques, and the incorporation of artificial intelligence for automated design and production. Nevertheless, the use of CAD/CAM technologies still requires careful consideration of factors such as the upfront expenses, the need for regular equipment upkeep, and the continuous training requirements for dental practitioners. To expand the adoption of digital manufacturing in dentistry, it will be necessary to address these issues by focusing on continuing education, technological assistance, and research collaboration.

Challenges and considerations

Although digital dentistry offers significant advantages, it also poses certain challenges and conflicts. Embracing digital technologies in dentistry necessitates a substantial commitment to acquiring knowledge and undergoing training. Dental professionals need to acquire expertise in utilizing new hardware and software, which can be intricate and time-consuming (Jahangiri *et al.*, 2020). Thorough training programs are necessary to ensure that professionals can efficiently utilize these technologies to attain the best possible outcomes. The learning curve might provide a challenge, especially for experienced professionals who are used to conventional approaches.

Furthermore, the cost implication is another significant factor to consider when implementing digital dentistry. The initial capital outlay for digital equipment, such as intraoral scanners, CBCT machines, and CAD/CAM systems, can be significant. Additionally, there are recurring expenses associated with software upgrades, upkeep, and consumable materials. Providing training to employees for the usage of new technology involves costs in terms of both time and money. These financial considerations can discourage certain dental clinics, especially smaller ones, from adopting digital dentistry

In terms of equipment maintenance and upkeep, regular checkup and calibration are necessary for digital dental equipment to ensure accuracy and longevity. This can be both expensive and time-consuming. Practice operations and patient care might be disrupted by downtime caused by

equipment failure or repair. Providing training for workers to handle simple problems and perform regular maintenance can help reduce these interruptions, but it also increases their level of responsibility.
Although digital dentistry provides improved accuracy, there may be disparities in reported results when compared to traditional procedures (Mehl *et al.*, 2021). Digital impressions and restorations may vary in accuracy due to factors such as equipment calibration, software algorithms, and operator competency. Establishing standardized methods and conducting ongoing research are essential to guarantee that digital workflows continually yield dependable and precise outcomes.

As the utilization of digital technology grows, it becomes crucial to ensure the privacy and security of patient data (Gross *et al.*, 2019). It is imperative to securely keep digital dental data, which encompass photographs and scans, in order to safeguard against unwanted access and breaches. Dental practices are required to adhere to regulatory standards, to protect patient information. Besides, complying with ethical principles and regulatory guidelines regarding the usage, storage, and exchange of digital data is crucial for upholding patient trust and professional integrity. Therefore, enforcing resilient cybersecurity protocols and providing comprehensive data protection training to employees are essential approaches for resolving these concerns.

Incorporating digital technologies into current dental workflows might pose difficult for some practitioners as the digital workflow is swiftly progressing, with ongoing breakthroughs in technology. Practices must modify and adapt their procedures to accommodate the introduction of new technology and software while keeping abreast with the most recent advancements. Implementing this integration may necessitate substantial modifications in practice administration, encompassing scheduling, record-keeping, and communication with patients and laboratories. Achieving a smooth integration without causing any disruptions to everyday operations requires meticulous planning and cooperation.

Although digital dentistry offers numerous advantages, including enhanced patient comfort and reduced treatment durations, some individuals may exhibit reluctance or doubt about new technological advancements (Radwan *et al.*, 2023). Efficient dissemination of information and instruction regarding the benefits of digital instruments can mitigate apprehensions and foster confidence. Validating the precision and effectiveness of digital operations can be further bolstered by showcasing case studies or testimonials from patients, hence increasing acceptance.

Lastly, utilizing digital technologies, specifically those related to manufacturing processes such as 3D printing and milling, might result in environmental consequences. The manufacturing and disposal of electronic devices, along with the utilization of consumables and resources, add to the ecological impact of this practice. Adopting sustainable methods, such as recycling materials and minimizing waste, can assist in alleviating these environmental problems.

Conclusion

The advent of digital dentistry has introduced a new era characterized by accuracy, effectiveness, and patient-focused healthcare. From the use of intraoral scanning to the process of virtual planning and CAD/CAM fabrication, these technologies have not only enhanced the results of dental treatments but also broadened the potential for personalized dental solutions tailored to individual patients. To fully leverage the promise of digital dentistry in improving dental practice worldwide, it is crucial to tackle problems by focusing on education, research, and technological improvement as developments progress and acceptance increases.

Despite the transformative benefits of digital dentistry, there are challenges and

considerations that highlight the importance of a balanced approach to adoption. By addressing the steep learning curve, managing costs, ensuring data security, and staying current with technological advancements, dental professionals can fully leverage digital tools to enhance patient care and treatment outcomes. Continuous education, standardized protocols, and ethical practices will be key to maximizing the potential of digital dentistry in the ever-evolving landscape of dental care.

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CASE REPORT Open Access

Prosthetic rehabilitation of a severely resorbed ridge using a maxillary complete denture opposing a mandibular implant-supported overdenture: a case report

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Abstract

A 64-year-old patient was referred to the prosthodontics clinic with a history of two failed mandibular dentures and significant functional impairment. The patient had been completely edentulous since the age of 40 due to advanced chronic periodontal disease. She experienced progressive loss of retention and stability of the mandibular prostheses, resulting in discomfort, pain, and difficulty with speech and mastication. The intraoral examination revealed severe alveolar bone resorption of both arches, shallow palatal vault, and reduced maxillary and mandibular arch height and width. The existing dentures, partially lined with soft lining material, exhibited poor retention and stability. The maxillary denture lacked posterior seal, and the mandibular denture, despite adequate extension, was considered intolerable. A treatment plan consisting of a combination of maxillary conventional complete denture and mandibular implant-supported overdenture was executed. This approach was found to be a clinically effective, cost-efficient, and predictable solution in addressing the patient's concern for improved oral function.

Keywords: *complete edentulism, implant-supported prosthesis, mandibular overdenture, ridge resorption*

Received:
16 January 2025
Revised:
5 May 2025
Accepted:
2 July 2025
Published Online:
31 July 2025
How to cite this article:
Ahmad, N., Wan Nik, W. N. N., Mohd. Nor, H., & Chu, S. B. (2025). The prosthetic rehabilitation of a severely resorbed ridge using a maxillary complete denture opposing a mandibular implant-supported overdenture: a case report. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 252–261. https://doi.org/10.31436/ijohs.v6i2.381
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.381

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Introduction

Conventional complete dentures have been the standard treatment for edentulism for decades. However, prolonged use of conventional complete dentures can lead to reduced denture retention and stability due to progressive alveolar bone resorption. This condition compromises the intimate fit of the denture base with the residual alveolar ridge, resulting in reduced masticatory efficiency and increased patient discomfort. Furthermore, the underlying oral mucosa will be exposed to undue stress, resulting in mucosal irritation and ulceration, which will further diminish the patient's quality of life. (Soboleva and Rogovska, 2022).

The implant-supported overdenture has proven to be an effective treatment option for edentulous patients, particularly for those with severely resorbed mandibular ridges, in which the conventional dentures' retention and stability are compromised. Studies have shown that implant-supported

overdentures provide superior outcomes compared with conventional dentures in terms of masticatory function, patient satisfaction, and preservation of residual ridge (Kutkut *et al.,* 2018). The implants serve as an attachment to the prosthesis, which significantly reduces the prosthesis's mobility, thus improving the masticatory efficiency, patient comfort and satisfaction. Additionally, implants have been shown to preserve residual alveolar bone by decreasing the rate of bone resorption, an advantage not offered by conventional dentures (Kutkut *et al.,* 2018).

The provision of a combination of maxillary conventional denture and mandibular implant-supported overdenture for edentulous patients provides a cost-effective and minimally invasive solution. This treatment strategy was recommended by the McGill Consensus in 2002 and the York Consensus in 2009. It advocated the use of a two-implant retained mandibular overdenture, opposing a complete maxillary denture as the standard of care. This recommendation is based on substantial evidence indicating improvements in denture retention and stability, as well as significantly better patient satisfaction and quality of life compared to conventional dentures (ELsyad *et al.*, 2013; Thomason *et al.*, 2012). Patients using a fixed implant-supported prosthesis in the mandible, while retaining a maxillary complete denture, experience considerable improvements in oral function and quality of life (Carlsson, 2014).

Moreover, the McGill Consensus emphasises the cost-effectiveness of this treatment approach. Overdentures supported by implants are not only easier to clean but also provide a more satisfactory solution for patients who struggle with the retention and stability of conventional dentures (Kortam & Abdeen, 2021). The consensus suggested that while the patient preference should be considered, the clinical benefits of implant-supported overdentures make them a compelling choice for many edentulous individuals (Thomason *et al.,* 2012). Thus, the treatment objectives, by providing a conventional maxillary denture and a mandibular implant-supported overdenture, are to offer a cost-effective, minimally invasive treatment that enhances denture retention, stability, oral function, and overall patient quality of life.

Case report

A 64-year-old Caucasian lady was referred to the prosthodontics clinic with a history of failed two pairs of complete dentures. She reported significant difficulty in speaking and chewing due to the looseness of the mandibular denture. Her primary concern was finding a predictable and reasonable treatment option to restore the oral function and improve her quality of life.

The patient had been fully edentulous since the age of 40, following the loss of her teeth due to advanced chronic periodontal disease. Since then, she has had three sets of complete dentures. However, the two most recent sets of dentures, particularly the mandibular dentures, were deemed intolerable due to poor retention and stability. Over time, the looseness of the mandibular denture had worsened, causing discomfort and pain during speech and mastication.

The patient's medical and social history revealed that she had no medical illness and had quit smoking 15 years ago after being a habitual smoker. The extraoral examination revealed no abnormalities or significant findings, while the intraoral examination demonstrated severe residual ridge resorption in the maxillary and mandibular arches without prominent muscle attachments. The maxillary arch exhibited a shallow palatal vault and reduced arch height and width (Figure 1).

The current maxillary complete denture exhibited poor retention and stability caused by the insufficient posterior extension, which led to the absence of a proper posterior seal. The fitting surface of this denture was partially lined with soft lining material (Figure 1). Despite having adequate extension, the mandibular complete denture demonstrated poor retention and stability.

Similar to the maxillary denture, the fitting surface was also lined with a soft lining material.

A thorough discussion with the patient concluded that a maxillary conventional complete denture combined with a mandibular implant-supported overdenture would be the most appropriate solution to fulfil the patient's functional and aesthetic requirements. This treatment plan was selected based on its predictability, clinical efficacy, and cost-effectiveness, aligning with the patient's preference for a reliable and reasonably priced solution.

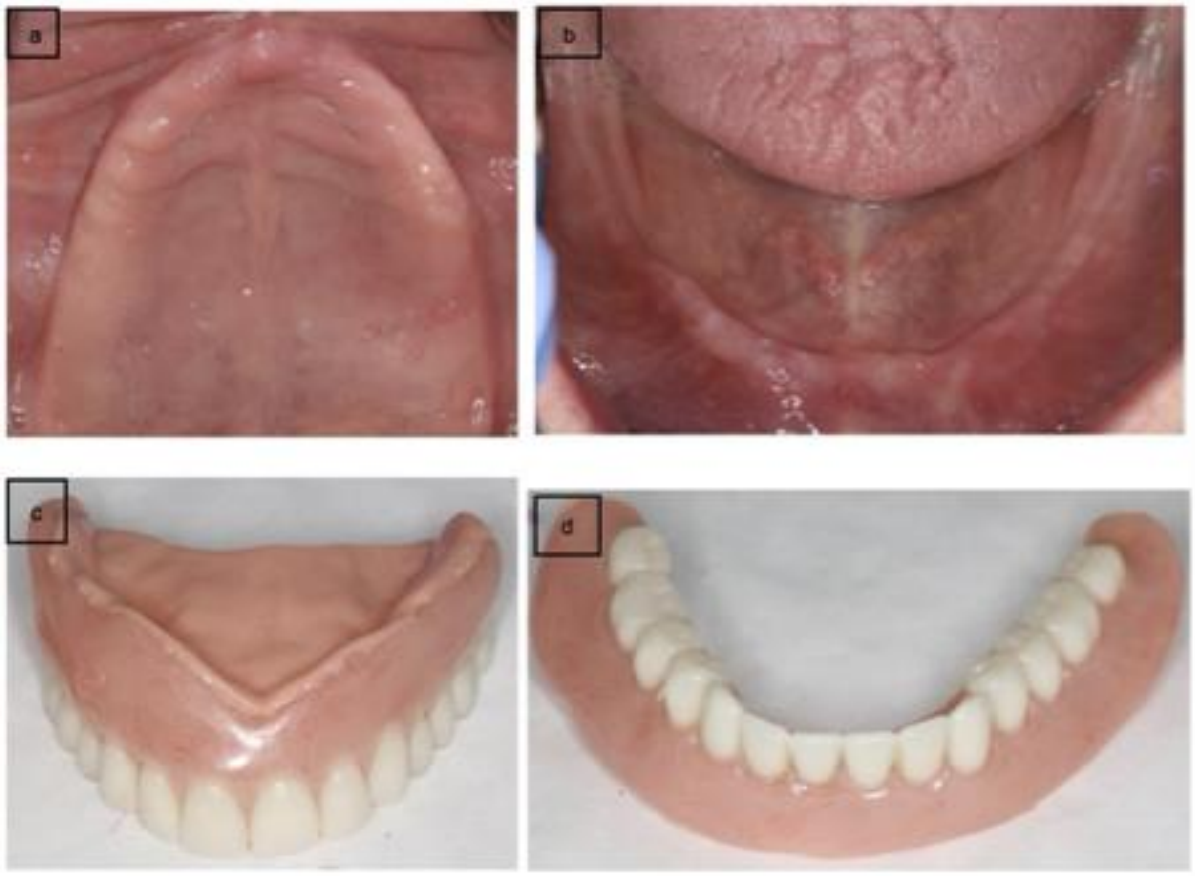

Figure 1. (a) maxillary edentulous ridge, (b) mandibular edentulous ridge (c) current maxillary conventional denture, (d) current mandibular conventional denture.

Treatment procedures

Stage 1 surgery

The case was planned for a delayed loading protocol, where the surgical sites are allowed to heal for a period of typically 3-6 months after implant placement before attaching the definitive restoration. This protocol was chosen to enhance implant stability and promote optimal osseointegration. Moreover, this step also allows the soft tissue around the implant to heal and mature, reducing inflammation and the risk of peri-implant diseases.

A conventional two-stage surgical protocol was carried out for implant placement. Based on the clinical and radiographic evaluations (Figure 2), two 4.0 x 6 mm Astra Tech™ implants (Astra Tech, Dentsply) were selected to be positioned in the interforaminal region. A clear acrylic surgical stent which had been fabricated by copying the existing mandibular denture was used to guide the surgical drills during osteotomy and fixture carrier drill with implant fixture into the accurate position in the bone (Figure 3). Both implants recorded a final placement torque of more than 20 Ncm, as recommended by the manufacturer.

Subsequently, two cover screws were placed in the respective fixtures before the soft tissue flaps were approximated with non-resorbable nylon sutures. Post-operative instructions were given. The sutures were removed after one-week post-surgery and the surgical sites were left to heal for the next three months.

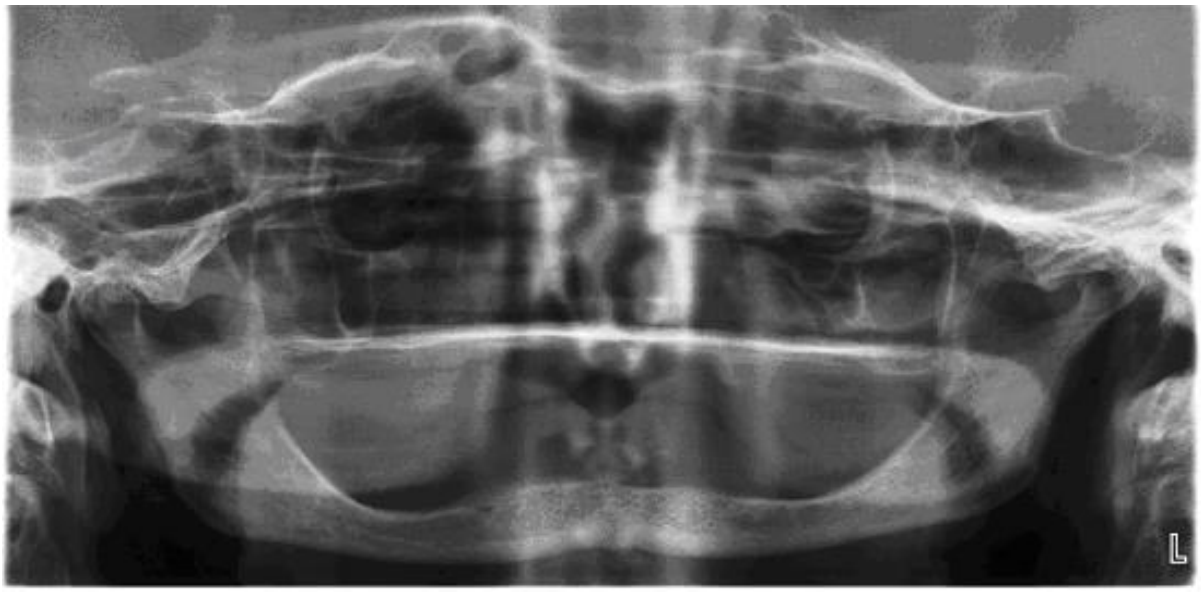

Figure 2. Orthopantomogram (OPG) indicates severely reduced mandibular bone height and enlarged maxillary sinuses.

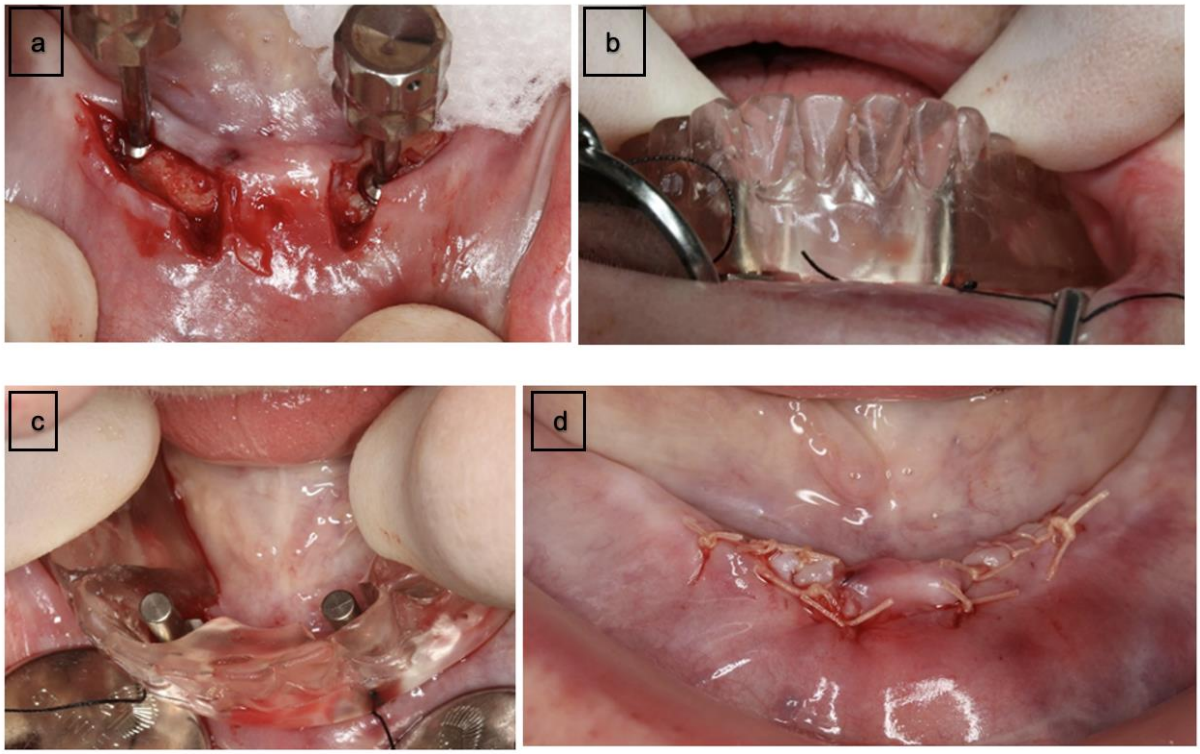

Figure 3. Stage 1 surgery. (a) Two incisions were made for two implants, (b) surgical stent was used to aid during the implant placement, (c) Placement of the guide pin to assess the parallelism of the implants, and (d) Incisions were sutured using non-resorbable nylon suture.

Stage 2 surgery

After the healing period, a second-stage procedure was performed to expose the submerged implant fixtures. This stage aimed to ensure the implants had successfully osseointegrated and prepared the surrounding soft tissues for the final prosthetic phase.

A slit incision was made over the implant sites to expose the cover screws, carefully preserving the surrounding soft tissue. The cover screws were then removed using a manual driver, and the implant fixtures were thoroughly inspected for signs of osseointegration, such as absence of mobility and stability within the bone.

Next, two 4.0 x 4.0 mm healing abutments (DESS® Dental) were selected based on the soft tissue height and contour of the gingival margins (Figure 4). It is hand-tightened to the implant fixture. The healing abutments guided the formation of soft tissue contours, creating an ideal emergence profile for future prosthetic restorations.

The patient was instructed on maintaining oral hygiene around the healing abutments, including the use of soft-bristle toothbrushes and antiseptic mouth rinses, to minimise the risk of peri-implant mucositis during the healing phase.

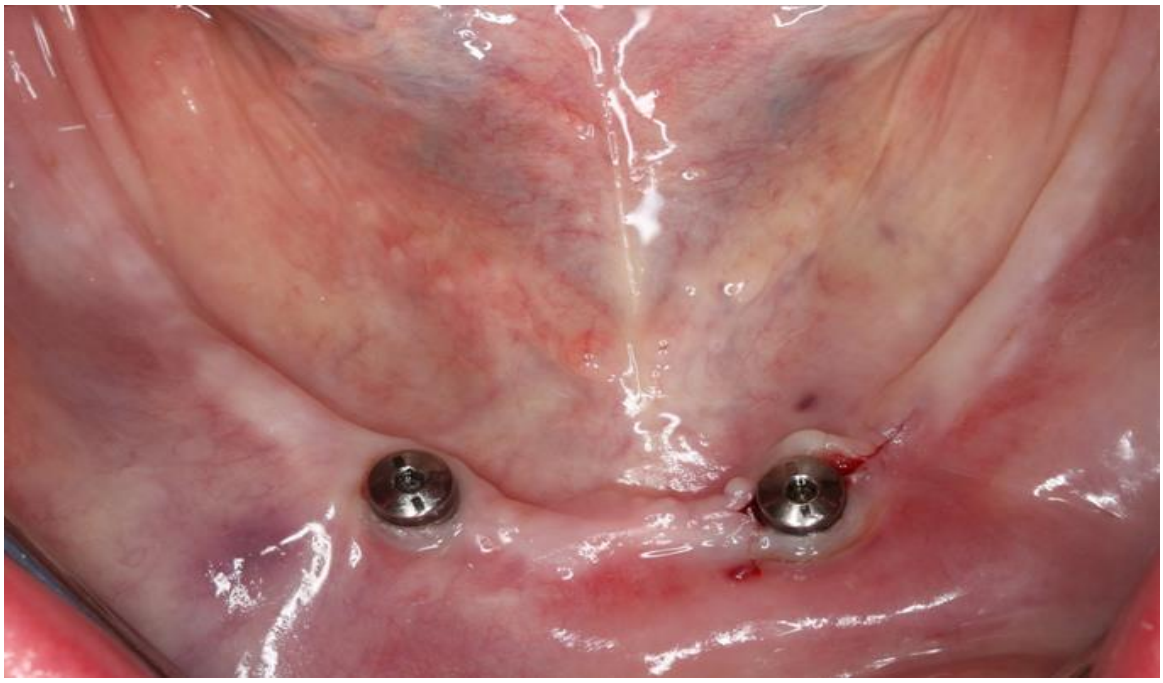

Figure 4. 4.0 x 4.0 mm healing abutments (DESS® Dental) placement.

Restorative phase

Two weeks post-stage two surgery, the healing abutments were removed and replaced with the locator abutments (Zest Dental Solutions, United States), which were torqued to 25 Ncm as per the manufacturer's recommendation (Figure 5). The appropriate height of the locator abutments was determined by measuring the gingival cuff heights. A secondary impression of the maxillary arch was taken using zinc oxide eugenol impression material. For the mandibular arch, an abutment-level impression was made with polyether impression material using a closed-tray technique. These impressions provided accurate details of the implant positions and the surrounding tissues.

The registration of the maxillo-mandibular relationship (MMR) record was made using heat-cured acrylic bases with wax occlusal rims. The locator housings and black processing inserts for the implants were incorporated into the mandibular base. The

wax rims were adjusted to allow appropriate labial support, buccal corridor, occlusal plane, freeway space, midline position, smile line and inter-canine width. The retruded jaw relation was recorded using addition silicone occlusal registration material (VPS Hydro Bite®) and the master casts were then mounted on a semi-adjustable articulator with a facebow transfer.

A wax try-in was performed to verify aesthetics, occlusal plane, phonetics, and functional support. Once satisfactory, the dentures were processed using heat-cured polymethyl methacrylate (PMMA). At the denture insertion stage (Figure 6), the dentures were evaluated for retention, extension, and stability, and any overextended flanges were adjusted. The occlusion was refined for accurate intercuspal and excursive movements. Finally, the mandibular denture's black processing inserts were replaced with blue Locator™ inserts, providing 5 lbs of retention force to ensure optimal functionality and comfort for the patient. The patient was also provided with denture hygiene education, which included instruction on proper denture cleaning technique, the importance of daily care and the need to remove them at night to prevent irritation and infection.

Figure 5. Locator abutments (Zest Dental Solutions, United States) placement.

Review and maintenance phase

The patient was reviewed one week after the insertion of the maxillary denture and mandibular implant-supported overdenture. She reported excellent tolerance to the dentures and expressed satisfaction with the improved retention and stability. The patient was particularly pleased with the ability to wear the dentures comfortably during eating and with the overall aesthetic appearance.

During the appointment, the soft tissues were carefully examined for any signs of trauma or irritation or pressure points. The occlusion was also evaluated to identify and address any potential interferences or uneven contacts. No significant concerns were observed. The oral hygiene practices and denture maintenance were reinforced, emphasising the importance of meticulous cleaning of both the prosthesis and peri-implant structures.

The patient was advised to attend regular follow-up visits every 3 to 6 months for the first year, followed by annual check-ups. These appointments are to monitor the condition of the implants, soft tissues, and prostheses. These routine visits are essential for maintaining the long-term functionality, stability, and comfort of the dentures, as well as promptly addressing any emerging issues. This ongoing care will help ensure optimal oral health and sustained patient satisfaction over time.

Figure 6. The new maxillary conventional denture opposing mandibular implant-supported overdenture. (a) Frontal view, (b) patient appearance with the denture, (c) Right side (d) Left side.

Discussion

Conventional complete dentures are a popular treatment option in managing complete edentulism. It is often associated with several limitations that impact their functionality, comfort, and long-term efficacy. Their retention and stability primarily rely on a combination of physical and physiological factors, including the denture base adaptation, border seal and interaction with the surrounding oral tissue. However, progressive resorption of the alveolar ridge over time compromises the fit and function of the dentures. This can lead to discomfort, diminished masticatory efficiency, and impaired speech. Many patients report dissatisfaction due to instability, decreased confidence during mastication or speech, and an overall reduction in oral functionality (Ortensi *et al.*, 2020).

Implant-supported overdentures provide a superior alternative to conventional complete dentures by addressing some of the limitations associated with them (Doundoulakis *et al.,* 2003). It provides significantly more stability and retention than conventional dentures, which improves chewing efficiency, speech, and patient confidence(Burns, 2004). Moreover, the functional load transmitted through the implants helps to preserve the underlying alveolar bone and reduce the rate of bone resorption typically associated with conventional dentures.

The use of two implants to support an overdenture is a widely accepted approach for managing severely resorbed mandibles, particularly endorsed by the McGill Consensus Statement (2002) and the York Consensus (2009) (Feine *et al.,* 2002; Thomason *et al.,* 2009). This method effectively enhances denture retention and stability, addressing the common challenges associated with conventional dentures in cases of advanced ridge resorption (Thomason *et al.,* 2009). By anchoring an overdenture to two implants, the stability of the prosthesis is significantly improved, minimising movement during function and enhancing patient comfort (Kumar *et al.*,2018)

One of the primary advantages of this approach is the preservation of alveolar bone(Burns, 2004). Unlike conventional dentures, which can accelerate ridge resorption due to uneven pressure distribution, implants provide functional stimulation to the surrounding bone, helping to maintain its structure over time. This benefit is particularly pronounced in the anterior mandible, where bone density is generally higher. Furthermore, the use of only two implants is a cost-effective alternative to an extensive full-arch implant solution, making it accessible to a wider range of patients (Imre *et al.,* 2011). It is also a minimally invasive procedure, reducing the need for complex surgeries such as bone grafting or ridge augmentation. This is especially beneficial for elderly patients or those with systemic health conditions.

From a prosthetic perspective, the use of attachment systems such as locators, ball attachments, or bar systems enhances the retention and function of the overdenture. Locator attachments are highly popular due to their low profile and ease of use, which is why we opt for locator attachments. In addition, the locator system also allows the prosthesis to be easily removed for cleaning, promoting better oral hygiene and long-term implant health (Lee & Lee, 2019).

Implant placement is typically performed in the interforaminal region of the mandible, where bone quality and quantity are generally sufficient, and vital structures, such as the inferior alveolar nerve, can be avoided (Bassi *et al.,* 2013). In cases where bone is severely compromised, as in this case, short or narrow implants may be considered.

Short implants (especially those ≤6 mm in length) are increasingly used in implant dentistry, particularly in cases with limited vertical bone height. These implants eliminate the need for invasive procedures, such as sinus lifts or vertical ridge augmentations, thereby reducing surgical morbidity, treatment time, and cost (Kanazawa *et al.,* 2016). Previous studies have also shown a comparable success rate for short implants to standard implants in many scenarios, particularly when placed in dense bone or using modern implant designs, such as wide-diameter and tapered implants (Froum *et al.*, 2020).

Delay loading protocols are adopted because they are frequently associated with lower failure rates, especially when patient risk factors are present (H.Cai *et al.*). In addition, several studies indicate that delayed loading results in less marginal bone loss around the implant compared to immediate loading (Bahaaeldeen Mohamed *et al.*, Yasmeen O. Hassan *et al.*). Thus, this protocol provides a more predictable outcome and a reliable approach.

Ultimately, the combination of a maxillary complete denture with a mandibular implant-supported overdenture is a viable and cost-effective treatment option for edentulous patients (Thomason *et al.,* 2009). Compared to full-arch implant-supported prostheses, this approach is less invasive and more accessible for patients with medical, anatomical, or financial constraints(Grageda & Rieck, 2013). It effectively enhances oral functionality, including improved chewing efficiency and speech, while significantly increasing patient satisfaction and quality of life. This option offers significant clinical benefits that justify the investment.

Conclusion

The combination of a maxillary complete denture and a mandibular implant-supported overdenture successfully met the treatment objectives by enhancing prosthesis retention, stability, and oral function. The patient reported high satisfaction, particularly in terms of comfort during mastication and improved aesthetics. This minimally invasive and cost-effective approach not only improved quality of life but also contributed to alveolar bone preservation, aligning with the McGill Consensus (2002) recommendations for standard edentulous care.

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CASE REPORT Open Access

Root canal treatment of a maxillary left first molar with 2 palatal canals - a case report

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Abstract

Comprehensive knowledge of normal dental anatomy and awareness of potential anatomical variations are crucial to successful endodontic treatment. Anatomical variations such as additional canals in the palatal root of the maxillary molar are poorly reported, attributed to their low prevalence in general populations. This case report highlights the utilization of cone beam computed tomography (CBCT) as a diagnostic tool for locating additional canal in the palatal root of maxillary left first molar. The application of CBCT imaging technology in endodontics enables precise diagnosis through enhanced visualization of anatomical variations, thereby enhancing treatment planning and management of cases presenting with complex canal morphology. The present case documents the successful management of a maxillary left first molar exhibiting abnormal morphology of four canals: two located in the palatal root, one in the mesiobuccal root, and one in the distobuccal root. The canals were biomechanically prepared with crown-down technique and obturated using cold lateral compaction technique with gutta-percha points and AH-Plus root canal sealer. Post-treatment evaluation at six months demonstrated clinical success, with the tooth remaining asymptomatic and maintaining its normal function.

Keywords: *aberrant root canal, CBCT aided, endodontic management, maxillary molar*

Received:
13 March 2025
Revised:
6 July 2025
Accepted:
6 July 2025
Published Online:
31 July 2025
How to cite this article:
Sivan, H. D., Azih, N. F., & Mustaffa, M. (2025). Root canal treatment of a maxillary left first molar with 2 palatal canals - a case report. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 262–267. https://doi.org/10.31436/ijohs.v6i2.312
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.312
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Introduction

The success of root canal treatment heavily relies on knowledge of the anatomy of the roots and canals of the tooth in question (Cleghorn *et al.,* 2006). However, anatomical variations can occur, resulting in complicated root canal treatment. Incomplete endodontic treatment is more likely to occur in teeth with such anatomical complexities, resulting in endodontic failure (Song *et al.,* 2011). Literature indicates a generally low reported prevalence (<2%) of anatomical variations in the palatal root canal of maxillary molars (Wasti *et al.,* 2001; Neelakantan *et al.,* 2010). However, specific populations reveal higher frequencies of additional palatal root canals. Prevalence rates include 33.3% in maxillary first molars among Pakistani subjects (Wasti *et al.,* 2001), 9.7% in maxillary first molars in an Indian population (Neelakantan *et al.,* 2010), 6% in maxillary second molars in a Chinese population (Weng *et al.,* 2009), and 14% in maxillary second molars of an Indian population (Singh & Pawar, 2015). These higher prevalence rates in certain ethnic populations suggest an increased risk of missed root canals identification during root canal treatment, particularly in dental practitioners possessing limited knowledge of these anatomical variations in these ethnic groups.

Accurate root canal morphology identification and characterization prior to

initiating root canal treatment is of utmost importance as inability to detect these anatomical complexities or variations can result in incomplete chemomechanical debridement, microbial colonization, and subsequent treatment failure. The interpretation of these morphological variations through preoperative radiographic images remains challenging. This highlights the importance of the usage of more advanced imaging (Holderrieth & Gernhardt, 2009).

Treatment outcomes can be significantly improved through the integration of cone beam computed tomography (CBCT) coupled with treatment under magnification, as well as advanced clinical skills and experience of the dental practitioner. The application of CBCT in assessment of anatomical variations in the palatal root has been reported in previous case reports with favorable treatment outcomes (Asghari *et al.,* 2015; Sung *et al.,* 2021; Al-Qudah *et al.,* 2023).

This case report presents the clinical application of CBCT as a useful imaging technique for the management of a maxillary left first molar presenting with abnormal canal configuration of two canals in the palatal root.

Case report

A 63-year-old Indian man was referred to the Restorative Unit of Klinik Pergigian Pakar Jalan Gambut, Kuantan, Pahang for the management of a maxillary left first molar with necrotic pulp, symptomatic apical periodontitis and calcified mesiobuccal canals. The patient reported intermittent throbbing pain for the past five years, occasionally affecting sleep and meals. Pulp extirpation of tooth 26 was carried out by the primary care unit for pain management and MB root canals could not be localized. Patient had no known medical illness. Extra oral examination revealed no significant findings. Intra oral examination revealed a supragingival intact Class II composite restoration, no soft tissue swelling or sinus tract, no tooth mobility, probing depth within normal limits, and tenderness to palpation and percussion. Periapical radiograph of tooth 26 revealed an ill-defined periapical lesion measuring approximately 4 mm in diameter in relation to the palatal root. A limited field-of-view CBCT was taken as an additional diagnostic aid to establish the diagnosis as well as identification and localization of calcified MB root canals. The scanning parameters were 90 kV, 5 mA, with a spatial resolution of 80 microns (Castellini X Radius Trio Plus, Cefla, Italy). Comprehensive observation of the root anatomy, the dimensions of the periapical lesions, and their relations with surrounding tissue was performed across all planes. An ill-defined radiolucent lesion was noted in the periapical region of the palatal root measuring approximately 5 mm in diameter in the coronal plane, but the number of canals could not be determined (Figure 1). However, the axial plane confirmed the presence of three root canals: two palatal root canals, and one DB root canal. The MB root appeared oval shaped with narrowing in the mid region indicative of 2 root canals. Both canals appeared completely calcified with no periapical radiolucency (Figure 2).

Based on the findings, the diagnosis was established as previously initiated RCT of tooth 26 with necrotic pulp and symptomatic periapical periodontitis.

The diagnostic findings were explained to the patient during the initial visit, and root canal treatment was proposed for the management of tooth 26. Patient understood and consented to the procedure. Local anaesthesia (adrenaline 1:100 000 with 2% lidocaine, Septanest Special, Septodont, Paris, France) was administered to the buccal and palatal side of tooth 26. A rubber dam was placed. Procedure was done under 5.0x dental loupes. Examination of the pulp chamber confirmed the presence of two root canal orifices on the palatal aspect after the access cavity was modified from conventional triangular to square shape with endodontic access bur no. A0164 (Dentsply Maillefer, Baillaigues, Switzerland) (Figure 3).

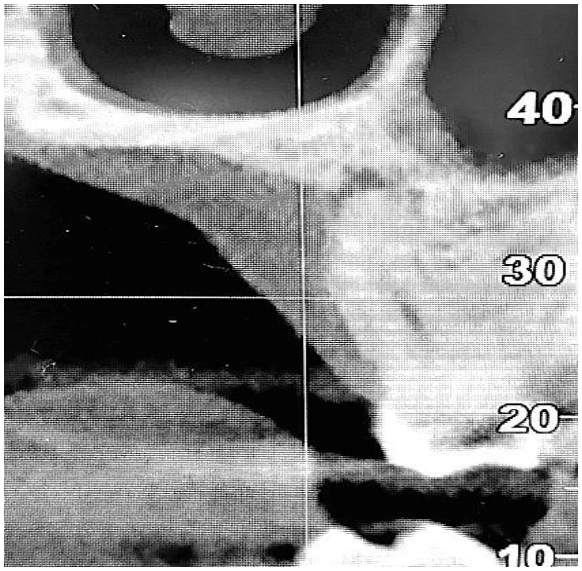

Figure 1. Palatal root with periapical lesion observed in the coronal plane.

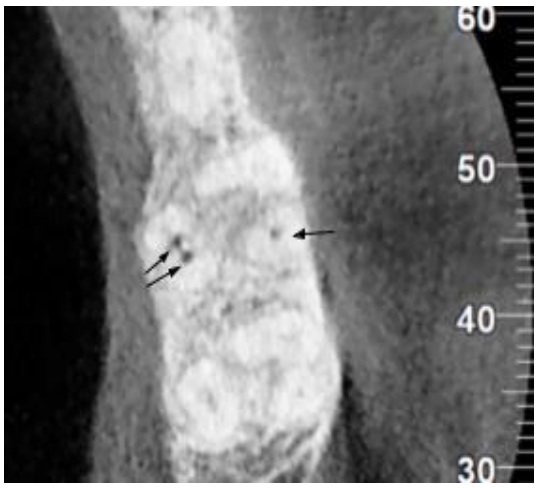

Figure 2. Two palatal root canals, oval shaped MB root with calcified MB2 root canal, and one DB canal were observed.

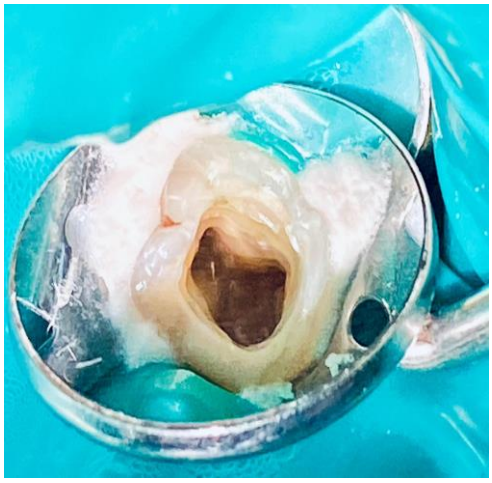

Figure 3. Square shaped access cavity.

Exploration with a DG-16 explorer revealed MB and DB root canals. Troughing of the pulp chamber floor about 2 mm palatal to the MB1 root canal and about 1mm mesial to the line drawn from MB1 to the palatal canal was done. No catch was detected. Ultrasonic tips were used to remove pulp calcifications and troughing was repeated yet no catch was detected. 1% methylene blue, a non-toxic dye was brushed over the chamber floor and then washed with water. No stain indicative of root canal orifice was seen. No further attempts were made to locate the MB2 root canal.

The working length of all the root canals was determined using an electronic apex locator (Dentaport ZX, Morita MFG Corp, Japan) and confirmed with a working length radiograph. The root canals were initially instrumented with an ISO 10 K-file and 15 K-file (Dentsply Maillefer, Switzerland). A glide path was prepared under copious irrigation with 3% sodium hypochlorite (CanalPro, Coltene, USA) (25 mL per canal). The MB1 root canal was instrumented with ProTaper Gold rotary files until F1 (Dentsply Sirona, Switzerland). Meanwhile, the DB and two root canals in the palatal root were instrumented with ProTaper Gold rotary files until F2 (Dentsply Sirona, Switzerland). All the root canals were copiously irrigated with 3% sodium hypochlorite (CanalPro, Coltene, USA) (25 mL per canal), followed by a final rinse with 17% EDTA (CanalPro, Coltene, USA) for 30s before drying the canals with matched paper points (Dentsply Maillefer, Baillaigues, Switzerland). The root canals were obturated with gutta-percha (Dentsply, Maillefer, Switzerland) using the cold lateral compaction technique and AH Plus root canal sealer (Dentsply, De Trey, Germany). The access cavity was restored with Filtek P60 (3M ESPE, USA) composite resin, and the tooth was scheduled for full coverage ceramic crown restoration treatment. The tooth was reviewed at three months, and six months (Figure 4) following completion of root canal treatment, and was asymptomatic and functional. IOPA of tooth 26 shows a root canal treated tooth with obturated canals of adequate length and density (Farzaneh *et al.,* 2004). No evidence of periapical radiolucency is seen and the lamina dura is intact.

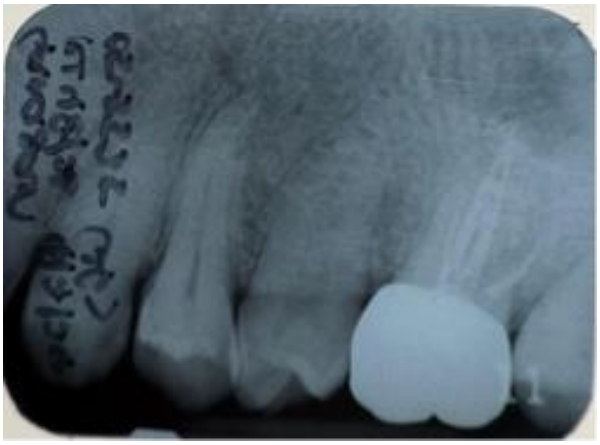

Figure 4. Periapical radiograph at 6-month follow-up.

Discussion

One of the primary objectives of chemomechanical debridement of the root canal system during root canal treatment is to reduce microorganisms to a subcritical level necessary for periapical healing (Ng *et al.,* 2008; Azim *et al.,* 2016). A thorough understanding of the root canal anatomy is necessary prior to root canal treatment to ensure successful treatment outcomes (Nosrat *et al.,* 2015; Azim *et al.,* 2015), where treatment failures frequently result from the inadequate detection of complex root canal

morphology and unidentified root canal systems (Nair, 2006).

Maxillary molars are commonly associated with carious lesions and represent the second most frequently endodontically treated teeth (Hull *et al.,* 2008; Fransson *et al.,* 2016). The typical morphology of this tooth consists of three roots: one or two root canals in the MB root, one root canal in the DB root, and one root canal in the palatal root (Wilcox *et al.,* 1989; Cleghorn *et al.,* 2006). This current case report portrays the successful non-surgical management of a maxillary left first molar with one MB root canal, one DB and two palatal root canals. The root canals were first visualized using CBCT, and were subsequently verified through visual inspection with the aid of dental loupes.

Management of anatomies such as these can be aided by an analysis of two or more diagnostic periapical radiographs taken at various horizontal angulations or sophisticated diagnostic radiographic techniques like CBCT. Conventional radiographs present inherent limitations at effective assessment of root canal configurations, CBCT serves as an invaluable diagnostic tool for detailed *in vivo* analysis and elucidation of the root canal morphology ofmaxillary molars (Vizzotto *et al.,* 2013; Nosrat *et al.,* 2015). Current guidelines, specifically the joint position statement by the AAE and AAOMR (2015) recommend a limited field-of-view CBCT imaging modality for cases presenting with the potential for additional root canals or complex root canal morphologies. For this current case, a limited field-of-view CBCT was taken as an additional diagnostic aid to establish the diagnosis as well as identification and localization of calcified MB canals. This CBCT suggested the possibility of the presence of an additional palatal root canal.

When managing cases where it is possible for two palatal root canals to exist, modification of the access cavity is indicated. For this current case, the palatal root canal orifice was not located in the center relative to the tooth shape but mesially. The access cavity was expanded in the distal direction using an endodontic access bur no. A0164 (Dentsply Maillefer, Baillaigues, Switzerland) resulting in a square shaped access cavity.

In this clinical case, the procedure was done under 5.0x loupes which helped in locating the additional canal. It offered excellent operating field illumination and magnification which allowed the visualization of the pulpal floor as well as the root canal orifice. (Low *et al.,* 2018).

Fins, isthmus areas, and other irregularities may add to the treatment's difficulties (Shalavi *et al., 2012*). Routine endodontic procedures like irrigation, cleaning, shaping and obturation primarily act on the main root canal, which harbors maximum microorganisms. It has been observed that part of the root canal space often remains untouched during cleaning and shaping, regardless of the technique and instruments employed (Lin *et al., 1991).* However, one of the aims of obturation is entombment of bacteria within the dentinal tubules and root canal ramifications. So in a well-obturated root canal, these remnant bacteria usually die or are prevented from gaining access to periradicular tissues, thereby preventing reinfection (Siqueira *et al., 2001)* Thus inability to locate and manage an isthmus rarely causes failure of orthograde endodontic treatment as seen in this case.

Locating the calcified MB2 root canal was a major challenge in this case. Despite the usage of CBCT for exact evaluation, modification of access cavity from triangular to rhomboid shape (Zhouk *et al.,* 2020), applying dental loupes (Camacho-Aparicio L.A *et al.*,2022) usage of DG 16 explorer and 1% methylene blue as dye, MB2 root canal was not detected. This could be due to the calcific nature of the canal as seen in the CBCT as well as limited experience of the clinician.

Conclusion

Comprehensive understanding of the normal root canal morphology and its anatomical variations, coupled with

thorough preoperative assessments incorporating CBCT imaging technology enhanced the management of tooth 26 with four root canals, underscoring the significance of advanced diagnostic imaging in identifying and effectively treating anatomical variations for successful endodontic treatment outcomes.

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CASE REPORT Open Access

A rare genetic disorder encountered in dentistry: a case of lipoid proteinosis

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Abstract

Lipoid proteinosis disease is a rare autosomal recessive genodermatosis first described by Urbach and Wiethe in 1929. This disease occurs as a result of homozygous or compound heterozygous mutations in the ECM1 gene located in the 1q21 chromosome region. Approximately 400 cases have been encountered in the literature to date. Although it is seen worldwide, a higher prevalence of has been observed in Europe and South Africa. Although this disease can be seen anywhere in the body, the upper respiratory tract and mouth are affected in the majority of patients. The first clinical sign in Lipoid Proteinosis patients is a weak and muffled cry caused by laryngeal infiltration that develops shortly after birth or during infancy. Skin and mucosal changes develop during the first few years of life and later. Intraoral symptoms include macroglossia due to infiltration of waxy yellowish-white plaques and nodules, fissured macrocheilia, and nodular thickened mucosa. The prognosis of Lipoid Proteinosis disease is good and there is no specific treatment. Dentists are in the earliest position to diagnose Lipoid Proteinosis and help provide appropriate treatment to improve the quality of life impaired by the disease.

Received:
21 April 2025
Revised:
12 May 2025
Accepted:
14 May 2025
Published Online:
31 July 2025
How to cite this article:
Yazmaci, B., Dogan, M. S., & Yavuz, I. (2025). A rare genetic disorder encountered in dentistry: a case of lipoid proteinosis. *IIUM Journal of Orofacial and Health Sciences*, *6*(2), 268–272. https://doi.org/10.31436/ijohs.v6i2.407
Article DOI:
https://doi.org/10.31436/ijohs.v6i2.407
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Keywords: *dentistry, genetic disorder, lipoid proteinosis*

Introduction

Lipoid proteinosis (LP) is a rare autosomal recessive disease that was first described by Urbach and Wiethe in 1929 (Khan *et al.*, 2023). It has been reported that LP develops as a result of mutation in the ECM1 gene located on chromosome 1q21 (Gonçalves *et al.*, 2010). The ECM1 gene is known to encode the structural element of the basement membrane and extracellular matrix (Ravi Prakash *et al.*, 2013). There are 3 types of glycoproteins in the ECM1 gene: ECM1a, ECM1b and ECM1c (Gonçalves *et al.*, 2010). The ECM1 gene is a glycoprotein that can contribute to scarring, skin adhesion, angiogenesis and wound healing. It has been reported that deficiency of the ECM1 gene leads to impaired protein-protein interactions, leading to the degradation of sphingolipids and glycolipids, as well as the accumulation of basement membrane collagen types and hyaline material (Shah & Shah, 2022). Histopathologically; The presence of irregular acanthosis, thickened dermis, epidermal hyperkeratosis, large periodic acid Schiff-positive and diastase-resistant extracellular amorphous hyaline tissue deposits has been reported (Mittal *et al.*, 2016).

This rare disease has approximately 400 cases reported in the medical literature to date (LeWitt *et al.*, 2023). Lipoid proteinosis is a disease that can be seen worldwide; however, it has been more frequently reported in Europe and South Africa. Although a significant number of cases in the

literature have been reported from Turkey, the true prevalence of the disease remains unclear (An *et al.*, 2021; Nanda *et al.*, 2001).

Lipoid proteinosis has been reported to present with hoarseness due to vocal cord infiltration, usually in early infancy. This is later followed by recurrent blood or pus-filled vesicles, bullae, macules, papules and skin-colored nodules; these are often described as being itchy. It has been reported that it can appear anywhere on the body (Kabre *et al.*, 2015). It has been reported that LP can cause calcification in the temporal lobes or hippocampus of the brain. This condition can manifest itself in some patients with epilepsy, memory problems, schizophrenia-like behaviors, mental retardation, emotional fluctuations and other mental problems (Shah & Shah, 2022). Oral manifestations of LP are usually described to occur before the development of cutaneous lesions. One of the most common findings is a "woody" or thickened tongue appearance due to hyaline deposition in both the lingual frenulum and the tongue tissue, along with restriction of tongue movement (Lee *et al.*, 2018). Gingival hypertrophy has also been reported to develop (Chan *et al.*, 2007). The salivary glands are also affected by this disease and it has been reported that the submandibular and parotid glands are usually involved, which can lead to poor oral hygiene by causing decreased saliva secretion or xerostomia. Ulcerations in the oral mucosa have also been detected (Kabre *et al.*, 2015).

There is no definitive and effective treatment for LP. It has been reported that the treatment generally aims to reduce morbidity and prevent complications. Although it is a progressive disease, the prognosis is good with a normal life expectancy (Deshpande *et al.*, 2015).

This case report discusses the clinical findings of a patient with Lipoid proteinosis. It is aimed to evaluate the general and oral findings of Lipoid proteinosis by emphasizing them.

Case report

A 13-year-old male patient applied to our Harran University Faculty of Dentistry Pedodontics clinic due to oral and dental problems. In the anamnesis, it was learned that the patient had Lipoid Proteinosis. It was also learned that the patient had affected relatives and that the patient's parents were in a consanguineous marriage. Intraoral examination revealed that the patient had missing teeth, anomalous shape in the upper canines, thickening and hardness of the tongue, and thickening of the lower lip. Clinical examination revealed the presence of numerous beaded papules (moniliform blepharosis) on the patient's eyelid margins (Figure 1-4). At the same time, the patient was observed to have hoarseness.

Discussion

Lipoid proteinosis (LP) disease has been reported to be a rare autosomal recessive genodermatosis (Alfahaad *et al.*, 2023). Amorphous hyaline deposits in the glycoprotein structure have been reported to affect various organs including the skin, oral mucosa, larynx, lymph nodes, small intestine, and brain. The etiopathogenesis of LP is still not fully elucidated, but it has been suggested that it may be associated with abnormalities in collagen synthesis and metabolism (An, 2025; Kabre *et al.*, 2015). It has been reported that mutations in the Extracellular Matrix Protein 1 (ECM1) gene located on chromosome 1q21 play a role in the etiology of the disease. At the same time, it has been shown that the ECM1 gene encodes an important component that ensures the structural integrity of the basement membrane and the extracellular matrix (Shah & Shah, 2022).

The first signs and symptoms of LP are reported to appear more frequently in the first year of life and include a hoarse and low-pitched cry due to the involvement of the vocal cords. Apart from vocal cord symptoms, skin lesions have also been reported to tend to appear later in childhood

(Lourenço *et al.*, 2020). The disease has been reported to commonly affect the oral mucosa. The mucosal membranes of the pharynx, tongue, and lips are usually reported to be infiltrated with firm, yellow-white papular lesions.

Figure 1. The patient's lateral teeth are missing, microdontia is seen in the canine teeth.

Figure 2. Hard and thick tongue view (A), and lip involvement view(B).

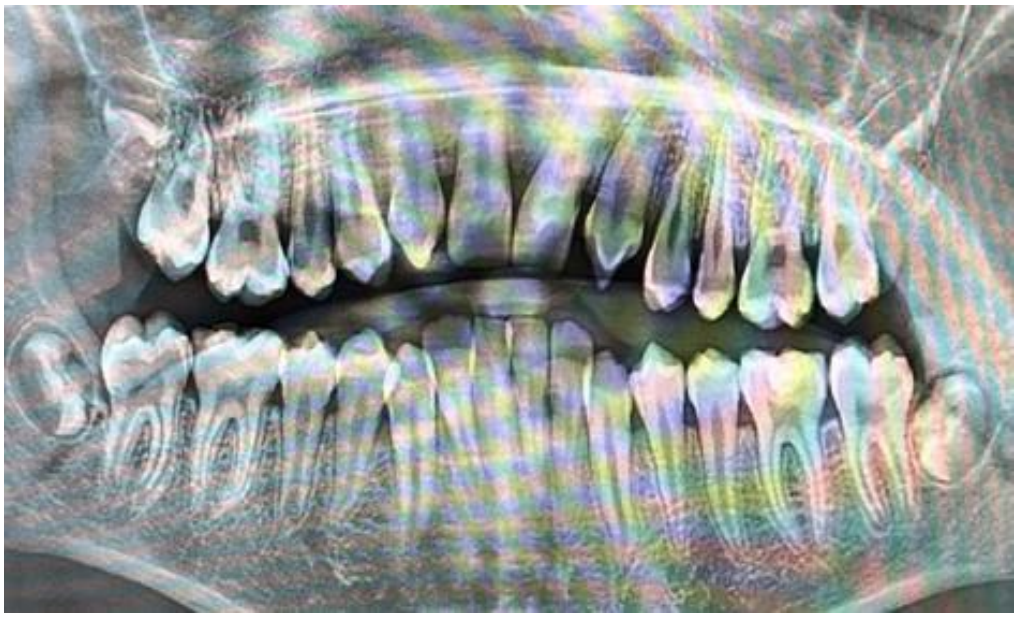

Figure 3. Panoramic image of the patient.

Figure 4. The view of bead-like papules at the eyelid margins (moniliform blepharosis).

Tongue enlargement and hardness on palpation have been reported. It has been reported that widespread infiltration of the larynx and pharynx can lead to dysphagia and respiratory distress (Dogru *et al.*, 2008). In the study conducted by Frenkel et al., the primary sites of oral involvement in patients with LP were reported as tongue (68%), palate (25%), lips (43%), floor of mouth (55.8%), buccal mucosa (40%) and gingiva (5.8%) (Frenkel *et al.*, 2017). In a case report conducted by Mainali et al., it was reported that during the intraoral examination of a 12-year-old female patient, the mouth opening was limited, the tongue was completely devoid of papillae, shiny, hard and had a woody consistency. And the patient's lingual frenulum was reported to be thick, short and hardened. The patient was reported to have both lateral incisors congenitally missing (Mainali *et al.*, 2011). In our case, the intraoral examination revealed that the patient's lateral teeth were congenitally missing, the tongue was hard and the lower lip was thickened.

It has been reported that the beaded papules extending along the eyelid margins, called moniliform blepharosis, are the most characteristic features of LP in LP patients (Lee *et al.*, 2018). In a study by Jahanimoghadam et al., moniliform blepharosis (multiple, beaded papules along the eyelash line) was reported in the eye findings of a 10-year-old boy (Jahanimoghadam & Hasheminejad, 2022). In our case, the patient's eye findings also revealed the presence of beaded papules on the eyelid margins.

Bilateral calcifications in the medial temporal lobes are a characteristic feature of LP and have been reported to occur in 52% of cases. When intracranial calcifications are prominent, epilepsy, mental dysfunction, and neuropsychiatric abnormalities have been reported (Jahanimoghadam & Hasheminejad, 2022).

It has been reported as a differential diagnosis of erythropoietic protoporphyria and systemic amyloidosis. Histopathologically, in erythropoietic protoporphyria, the accumulation of periodic acid-Schiff positive material was reported to be less dense around blood vessels and was not seen around sweat gland coils (Rao & Koppada, 2015).

It has been reported that there is no definitive treatment for this disease, and that treatment is symptomatic in most cases. Several drugs have been reported for the treatment of skin lesions, including dimethyl sulfoxide, its active metabolite acitretin, etretinate, D-penicillamine, and intralesional heparin. However, none of these drugs have consistently shown good results. It has been reported that dermabrasion can be recommended for patients whose skin lesions do not heal with routine oral medications. Carbon dioxide laser has also been reported as an option to consider for eyelid and aerogastrointestinal system

lesions. Removal of airway lesions using microlaryngoscopy has been described to improve airway and voice quality. It has been reported that anticonvulsants can be prescribed for patients with frequent seizures (Deshpande *et al.*, 2015; Jahanimoghadam & Hasheminejad, 2022). Dental treatment has been reported to be difficult due to limited mouth opening and mucosal irritation. Gingivectomy treatment has been reported to be an effective treatment option to reduce periodontal pocket formation and facilitate dental care (Lee *et al.*, 2018).

Conclusion

Lipoid proteinosis is a rare genetic disorder with systemic involvement, and it can significantly affect oral mucosa and dental structures. Therefore, it is essential for dental professionals to be aware of its clinical manifestations to ensure early diagnosis and appropriate referral. Given the multisystemic nature of the disease, a multidisciplinary approach involving close collaboration between dental and medical professionals is crucial for effective management. This case highlights the importance of awareness in recognizing and managing lipoid proteinosis within dental practice.

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