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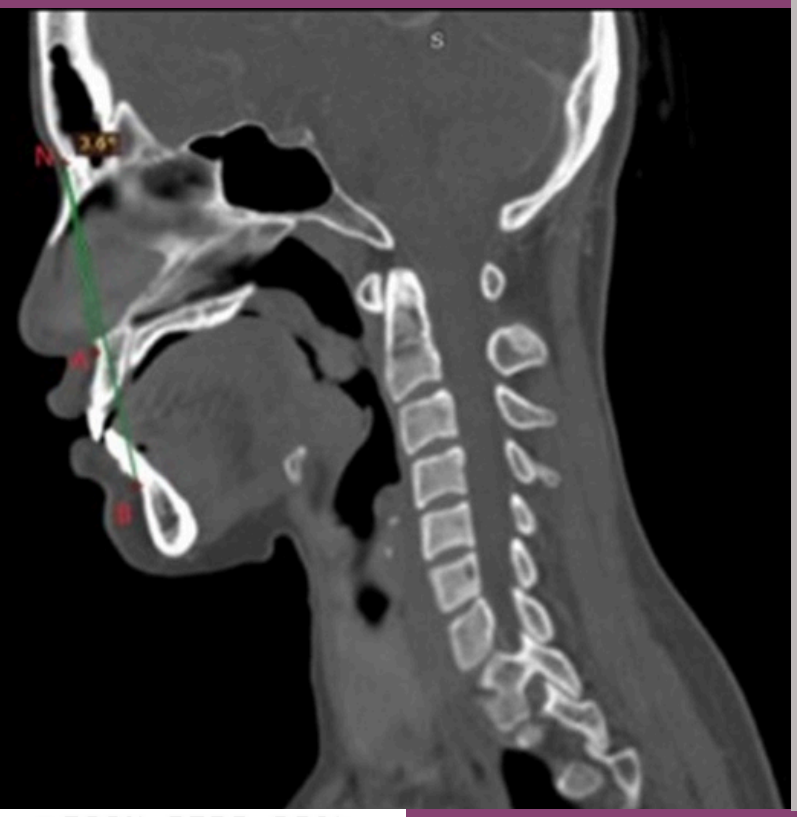

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IIUM Journal of Orofacial and Health Sciences (IJOHS) is a peer reviewed biannual international journal dedicated to publishing high quality of scientific research in the field of orofacial sciences, health sciences and interdisciplinary fields, including 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.

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EDITORIAL Open Access

Overview on bioceramics used in endodontics

Musliana Mustaffa*

Department of Restorative Dentistry, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia.

***Corresponding author:**
Address:
Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Telephone: +609 5705500

Email address:
muslianamustaffa@iium.edu.my , drmusliana@gmail.com

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Bioceramics have been classified as bioinert, bioactive, and biodegradable materials due to their inertness to surrounding tissues. The first generation of bioceramic namely mineral trioxide aggregate (MTA) was introduced in the field of endodontics in the 1990s. Due to its difficult handling, long setting time, low cohesive strength, heavy metal leaching and tooth discolouration, newer generation of bioceramics have been formulated to address these limitations while maintaining its original biocompatibility and excellent sealing ability properties (Chang *et al.*, 2018).

Clinicians need to consider various aspects when selecting bioceramics in endodontic applications such as physicochemical properties, cytotoxicity, and/or mineralisation potential. The incorporation of radiopacifier in bioceramics facilitate evaluation through radiographs although some materials have similar radiodensity as of dentine compromising the evaluation. Apart from that, a shortened setting time of approximately 20 minutes, more resistant to washout, and premixed syringe delivery allow the clinicians to perform the endodontic procedures more effectively. It is important to note that the components in bioceramics when hydrated in the oral environment form calcium hydroxide, which is rapidly dissociates into Ca^{2+} and OH^- ions, increasing the pH of the medium for antimicrobial properties (Villa *et al.*, 2020).

In general, newer generation of bioceramics are biocompatible, comparable to MTA, has mineralisation potential, and are designed for various endodontic procedures. These include vital pulp therapy, as an intracanal medicament, apexification, perforation repair, regenerative endodontics, periapical surgery and retrograde filling during tooth reimplantation. Promising results have been observed through various studies although the data on permanent teeth remain scarce.

In the event of limited access to bioceramics, the use of conventional materials has shown promising results as well, provided that clinicians adhere to standard treatment protocols. Despite a clear shift towards bioceramics use in clinical practice, selection of the appropriate bioceramic is still subject to individual case, availability of the bioceramics, clinician's preference, as well as clinician's skills and experience at handling the materials. The future of endodontics should focus on continuous development of bioceramics for various clinical applications, supported by robust scientific evidence to allow clinicians to provide better endodontic treatment for the community.

References

Chang, J.W.W., Praisarnti, C., Neelakantan, P. (2017). Increasing use of bioceramics in endodontics: A narrative review. Oral Health Group, 2017. Retrieved 22 July 2024, from https://www.oralhealthgroup.com/features/incr

easing-use-of-bioceramics-in-endodontics-a-narrative-review/

Villa, N., Santos, V.V.D., Costa, U.M.D., Mendes, A.T., Duarte, P.H.M., Rosa, R.A.D. et al. (2020). A new calcium silicate-based root canal dressing: Physical and chemical properties, cytotoxicity and dentinal tubule penetration. *Brazilian Dental Journal*, 31, 598-604.

ORIGINAL ARTICLE Open Access

Association of temporomandibular joint space and condylar head position with different skeletal patterns among the Malaysian population

Rafiq Khalid[1,4]*, Izzati Nabilah Ismail[1,4], Cheong Joo Ming[2], Azrul Safuan Mohd Ali[2], Wan Irfan W Mustapha[3,4]

[1]*Department of Oral Maxillofacial Surgery & Oral Diagnosis, Kulliyyah of Dentistry, IIUM, 25200 Kuantan, Pahang, Malaysia.*
[2]*Department of Orthodontics, Kulliyyah of Dentistry, IIUM, 25200 Kuantan, Pahang, Malaysia.*
[3]*Department of Radiology, Kulliyyah of Medicine, IIUM, 25200 Kuantan, Pahang, Malaysia.*
[4]*Sultan Ahmad Shah Medical Centre @ IIUM, 25200 Kuantan, Pahang, Malaysia.*

Abstract

During growth and development of the head and neck, some degree of interaction and interdependence between skeletal pattern with temporomandibular joint (TMJ) space and condylar head position occurs. Results from previous studies are varied; some reporting significant difference of TMJ space or condylar head position among the skeletal patterns, whilst others have shown that no such association is present. Considering that previous studies have been conducted in populations outside of Malaysia and the importance of determining the correlation between skeletal and TMJ morphology, this retrospective study was done to evaluate the TMJ space and condylar head position in different skeletal patterns among the Malaysian population using computed tomography (CT) images. A total of 90 CT images of the head and neck were included. Skeletal pattern (class I, II, III) was determined from each CT image based on the ANB angles obtained from reconstruction of these images. The TMJ space measurement and condylar head position were determined from sagittal images based on established landmarks from the reconstructed CT images. Statistical analysis was used to compare the TMJ space and condylar head position across the three skeletal classes and assess its significance. The results of this study demonstrated that there was no significant association between TMJ space or condylar head position in the different skeletal patterns among the Malaysian population. It is recommended that a prospective study with large sample size and standardized measurement techniques be implemented in the future to determine the precise association between TMJ morphology and different skeletal patterns.

Keywords: *condylar head position, skeletal pattern, temporomandibular joint space*

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***Corresponding author**
Address: Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia

Telephone: +6095705466

Email address:
drrafiq@iium.edu.my

Introduction

Skeletal patterns are commonly classified according to anteroposterior disproportions as either skeletal class I, II, or III. The determination of skeletal pattern of a patient is essential for orthodontic treatment planning and subsequent management. As referenced to Littlewood *et al.* (2019), a class I skeletal pattern indicates that the upper and lower jaws are growing or have grown at the same rate horizontally (upper jaw lies 2–4 mm in front of the lower). A class II skeletal pattern presents with a prominent maxilla (lower jaw would be greater than 4

mm behind the upper jaw), while a class III skeletal pattern presents with a prominent mandible (lower jaw is less than 2 mm behind the upper).

The temporomandibular joint (TMJ) is a complex joint formed between the condylar head of the mandible and the glenoid fossa of the temporal bone. The other main components of the joint include the articular disc, joint capsule, and associated muscles and ligaments.

During the growth and development of the structures of the head and neck region, some degree of interaction and interdependence between skeletal pattern and TMJ space and condylar head position takes place. Therefore, the determination of association between the TMJ space and condylar head position with the various skeletal patterns has been a topic of interest and intense study over the years.

The findings of these various studies however have proven to be mixed, with some studies showing a significant association between the various skeletal patterns with either TMJ space or condylar head position. However, on the other hand, numerous studies have also shown no significant association between these variables as well.

The morphology of the TMJ is important for treatment outcome in order to ensure long term stability in prosthodontic, orthodontic and orthognathic patients (Noh *et al*., 2020). As stated by Liu *et al.* (2003), the condyle morphology plays an important role in the long-term stability of orthognathic therapies due to its correlation with masseter muscle development. Additionally, as concluded by Ikeda *et al.* (2009), the data provided by determining optimal TMJ space and condyle head position would serve as a point of reference for determining optimal condylar position in assessing joint status and for 3D reconstruction for orthodontic, prosthodontic or other modalities. Furthermore, as described by Chae *et al.* (2020), a concentric condylar position is considered a normal relationship between the condyle and fossa and is seen in asymptomatic individuals, whereas a non-concentric condyle fossa relationship is observed in individuals with abnormal TMJ function. The observation of an adequate TMJ space would also avoid excessive compression of the disc in order to prevent temporomandibular joint dysfunction in patients undergoing surgical procedures related to the TMJ and its associated structures (Chae *et al.*, 2020).

Therefore, considering the points described above, the determination of association between the TMJ space and condylar head position with the various skeletal patterns would prove beneficial in providing clinicians with much needed information in patient treatment planning. Additionally, to the authors knowledge, no such study has been carried out in the Malaysian population prior to this.

Taking these factors into consideration, this study was carried out to evaluate the association of TMJ space and condylar head position in different skeletal patterns among the Malaysian population using computed tomography (CT) images.

Materials and Methods

Study design

This retrospective study was performed on the available CT scans of the head and neck region obtained from the records of the radiographic department of Sultan Ahmad Shah Medical Centre (SASMEC) IIUM, Kuantan, Pahang. Prior to data collection, ethical approval was obtained from the International Islamic University Malaysia Research Ethics Committee (ID No: IREC 2021-088).

Sample size

The required sample size was calculated using G*Power software version 3.1.9.7. An α error of 0.05 was set to achieve a test power of 80%. The calculation indicated that a total of 90 CT scan images were required; 30 for each skeletal pattern (class I, II, III). Purposive sampling was used in this study.

Image selection

A total of 90 CT scans of the head and neck (30 per class I, II and III) in Digital Imaging and Communications Medicine (DICOM) format, were included in this study.

The exclusion criteria for this study were CT images of patients below 20 years of age, patients with history of orthognathic or TMJ surgery, or patients having pathologies such as arthritis involving the TMJ, or tumours involving the facial or TMJ region.

CT reconstruction and measurements

For determination of skeletal pattern, multiplanar reconstructions of the lateral view derived from the axial CT image was first done, followed by determination of landmarks and measurements (Figure 1). The CT scan machine utilized in this study was model CT Somatom Definition AS (Siemens, Germany). The same CT scan machine was used for all patients in this study.

The skeletal pattern I, II and III was determined based on the following landmarks as referenced to Profitt *et al.* (2019):

- Point A: The deepest point in the concavity of the anterior maxilla between the anterior nasal spine and alveolar crest.
- Point B: The deepest point in the concavity of the anterior mandible between the alveolar crest and Pogonion.
- Point N: The junction between the frontal and nasal bones at the frontonasal suture.

The skeletal patterns were determined based on the following ANB angle values (□):

- Class I: 1° to 5°
- Class II: > 5°
- Class III: < 1

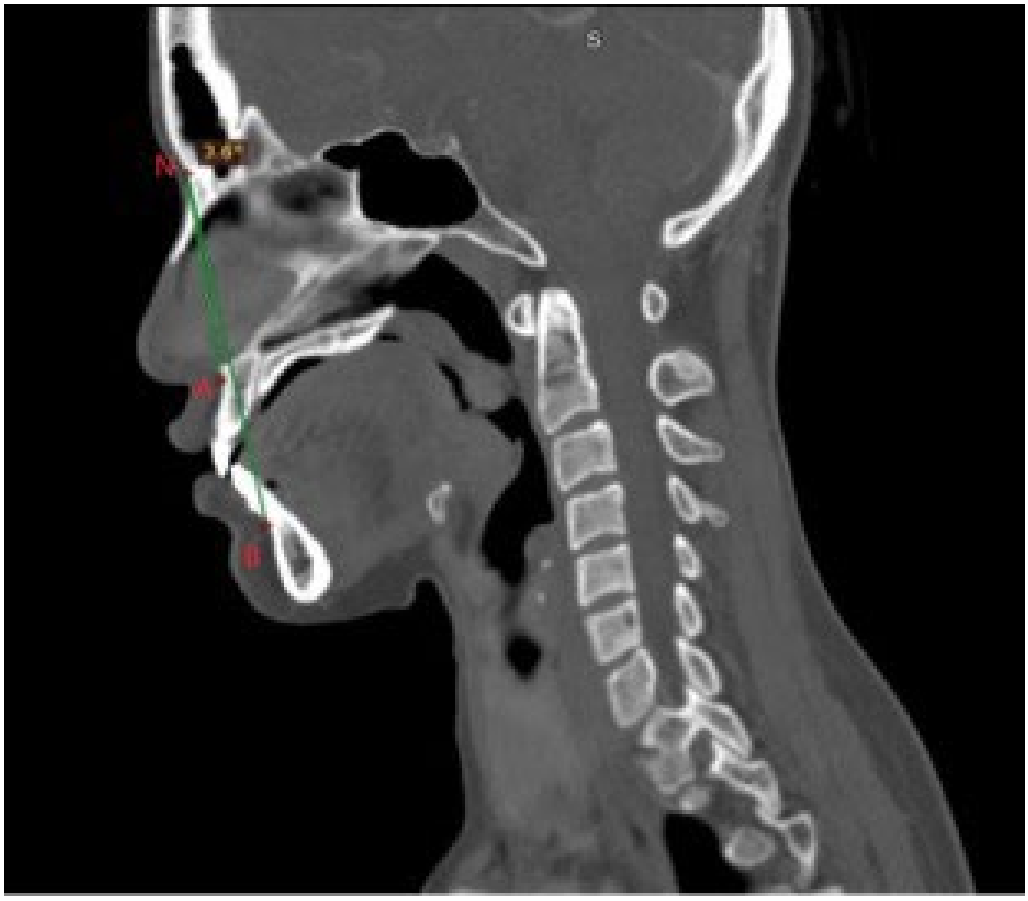

Figure 1. CT image showing ANB angle used for skeletal classification into Class I, II and II.

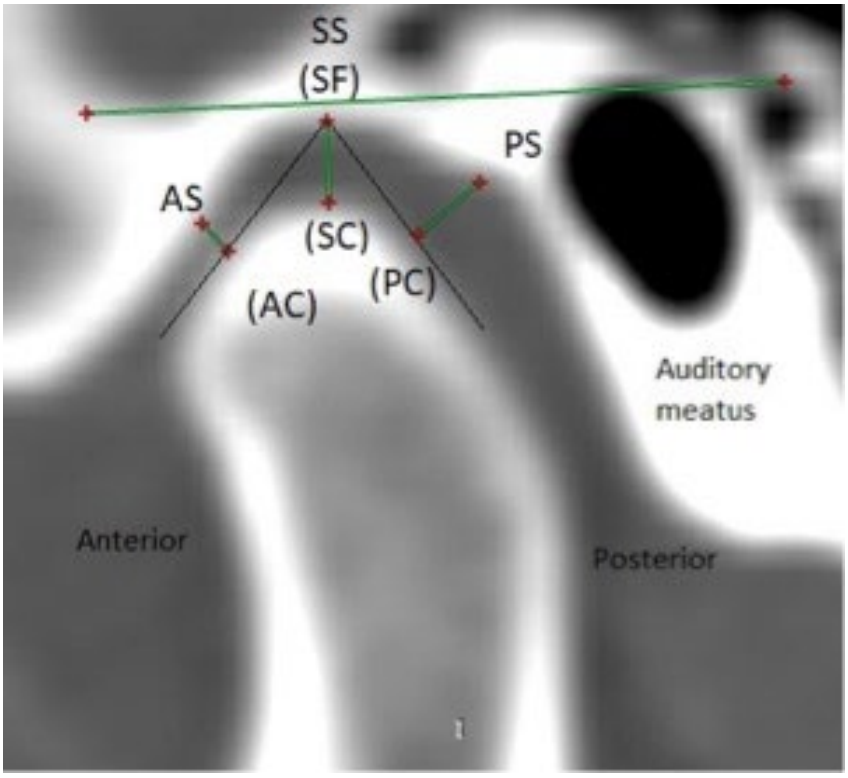

Figure 2. CT image showing landmarks and linear measurements of the TMJ space.

For the purpose of TMJ space measurement, a true central sagittal image with 2 mm thickness and interval distance was chosen from the CT. Following this; anterior, superior and posterior joint spaces were measured on the sagittal image (Figure 2). Initially, a horizontal line from the auditory meatus was drawn (true horizontal line) and the intersection of this line with the glenoid fossa was considered as the superior reference point (SF). Sequentially, this point is then connected to the most prominent points on the anterior (AC) and posterior (PC) aspects of the condyle. Finally, the perpendicular distance from AC and PC tangent points to the glenoid fossa was

measured as the anterior joint space (AS) and posterior joint space (PS). The distance between SF point and superior prominent point of the condylar head (SC) was considered as the superior joint space (SS). This method of measurement was adapted from Ikeda and Kawamura's study (Ikeda & Kawamura, 2009). All radiographic measurements were carried out utilizing RadiAnt DICOM Viewer software version 2022.1.

For the purpose of condylar position measurement, the sagittal plane was assessed with the method first established and used by Pullinger and Hollender; which is measured on the most centered sagittal slice of TMJ. The values of the anterior (AS) and posterior (PS) joint spaces were measured and calculated based on the following formula:

- (PS − AS) / (PS + AS) × 100

An attained value within ± 12% indicates a concentric position of the condyle. A value smaller than – 12 is considered a posterior condyle position, while a value greater than + 12 is considered an anterior condyle position (Pullinger & Hollender, 1986).

Statistical Analysis

Statistical analysis was performed using SPSS version 27.0. Descriptive statistics were performed and reported for mean and standard deviation for all variables in each class. An Anova test was performed to determine significance between skeletal pattern with TMJ space measurements. A chi squared test was performed to determine

significance between skeletal pattern with gender and condylar position. Statistical significance was established at $p < 0.05$.

Result

In this study, a total of 90 CT scans were retrieved which were equally divided into 3 separate skeletal patterns (I, II, III). The CT scans were taken from patients within the age range of 20-80 years old (mean:54.84, SD±15.975) with the demographic data as seen in Table 1.
From the results obtained, there were no statistical differences between the skeletal patterns for the various right or left TMJ space measurements (AS, SS, PS) as demonstrated in Table 2.

Similarly, there were also no statistical differences between the skeletal patterns for either the right or left condylar position (anterior, concentric, posterior) as shown in Table 3

Discussion

The morphology of the TMJ varies between individuals, involving an interplay of multiple factors during growth and development of the individual. Over the years, numerous studies have been conducted to ascertain the association between position of the TMJ and skeletal patterns, the overall result of these individual studies have been varied, with mixed results at best.

A number of these studies have shown some degree of association between TMJ space or condylar position and skeletal pattern, such as Song *et al.* (2020); which noted that the superior joint space in class III was the smallest when compared to class I and II, and that the condyle position in class III patients were more anteriorly placed compared with that in class I patients. Similarly, according to Alhammadi *et al.* (2016), class III had the most superiorly positioned condyle with the smallest superior joint space and class II had the most inferiorly positioned condyle with the largest anterior joint space. In a study by Milan *et al.* (2021), the condyle was seen to be concentrically positioned in class I while class III had the most superiorly positioned condyle. However, in a study by Paknahad *et al.* (2016), the condyles were observed to be positioned anteriorly in class II patients, in comparison with class I and III patients and according to Krisjane *et al.* (2009), the condyles were found to be more anteriorly positioned in class II and III patients. Therefore, even among these studies that do manage to find a significant association, there appears to be a variety of mixed findings.

The results obtained from this study however, show no significant association between either TMJ space or condylar position and skeletal patten. These findings are in agreement with Chae *et al.* (2020), whom observed almost no statistical differences in condyle-fossa relationships according to skeletal patterns. These findings are also in accordance with findings by Feres *et al.* (2020), which demonstrate no significant difference between class II and class I patients in relation to the condyle sagittal position. Similarly, in a study by Ma *et al.* (2018), it was shown that although there was some difference in condylar morphology, there was no significant difference in condylar position between the skeletal classes I, II, III. A recent study by Diwakar *et al.* (2023), further demonstrates a lack of significant association between TMJ space with skeletal pattern, with only the anterior joint space showing some significance, while all other measurements were not significant across all 3 skeletal classes.

A systematic review and meta-analysis conducted by Martins *et al.* (2015) with regards to sagittal joint spaces measurements of the TMJ, demonstrated that of the 17 studies examined, it was suggested that the posterior joint space was larger than the anterior joint space.

Table 1. Demographic data for patients.

		Frequency	Percent
Gender	Female	50	55.6
	Male	40	44.4
Skeletal Pattern	I	30	33.3
	II	30	33.3
	III	30	33.3

Table 2. Association between skeletal pattern with TMJ space measurements (N=90).

Factors	Skeletal Pattern	Mean	Std. Deviation	Minimum	Maximum	IQR	F	p
Right AS	I	1.59	0.52	0.90	3.10	0.77	0.37	0.691
	II	1.50	0.49	0.72	2.90	0.74		
	III	1.49	0.42	0.94	2.70	0.52		
Right SS	I	3.15	1.48	1.35	7.00	1.88	2.59	0.081
	II	2.55	0.86	1.42	4.39	1.30		
	III	2.64	0.80	1.30	4.40	1.28		
Right PS	I	1.95	1.33	0.70	6.01	0.77	1.90	0.156
	II	1.83	0.90	1.00	4.72	1.00		
	III	1.48	0.50	0.77	2.70	0.65		
Right condylar position (%)	I	4.78	25.11	-47.62	55.50	32.46	1.10	0.337
	II	7.14	22.36	-31.82	57.45	40.23		
	III	-1.17	19.19	-40.74	35.00	32.12		
Left AS	I	1.54	0.41	0.90	2.80	0.52	0.74	0.480
	II	1.38	0.56	0.70	3.50	0.48		
	III	1.45	0.49	0.90	3.20	0.62		
Left SS	I	3.02	1.46	1.10	7.80	1.53	1.40	0.253
	II	2.71	0.77	1.07	4.29	0.89		
	III	2.58	0.80	1.10	4.40	0.92		
Left PS	I	2.03	1.48	0.50	7.80	0.85	2.75	0.070
	II	1.82	0.90	0.90	4.69	0.97		
	III	1.41	0.42	0.60	2.30	0.73		
Left condylar position (%)	I	5.58	31.18	-62.96	71.43	38.19	1.67	0.194
	II	10.94	26.70	-42.86	58.97	41.89		
	III	-1.25	18.08	-42.86	26.56	25.83		

AS: Anterior joint space, SS: Superior joint space, PS: Posterior joint space

Table 3. Association between skeletal pattern with gender and condylar position (N=90).

Factors	Category	Total	Skeletal Pattern				
			I	II	III		
			n (%)	n (%)	n (%)	χ^2	p
Gender	Female	50	19 (38)	16 (32)	15 (30)	1.18	0.554
	Male	40	11 (27.5)	14 (35)	15 (37.5)		
Right condylar position	anterior	31	10 (32.3)	12 (38.7)	9 (29)	0.85	0.931
	concentric	35	12 (34.3)	10 (28.6)	13 (37.1)		
	posterior	24	8 (33.3)	8 (33.3)	8 (33.3)		
Left condylar position	anterior	35	10 (28.6)	16 (45.7)	9 (25.7)	5.82	0.231
	concentric	32	13 (40.6)	6 (18.8)	13 (40.6)		
	posterior	23	7 (30.4)	8 (34.8)	8 (34.8)		

These findings are echoed here in this study, with the posterior joint space being generally larger than the anterior joint space as well. Additional findings of the study by Martins *et al.* (2015) included the mean anterior joint space measurement was 1.86 mm, the superior joint space was 2.36 mm and the posterior joint space was 2.22 mm.

It is important to note that Martins *et al.* (2015) mentioned that the meta-analysis showed high levels of heterogeneity among the selected studies, with factors such as sample size, sample selection and methods of measurements contributing to this high heterogeneity level. This finding would probably explain the inconsistency and mixed findings of the various studies mentioned in this paper when it came to determine the association between skeletal pattern and TMJ morphology. Furthermore, other contributary factors such as ethnicity, especially in a multiethnic population as in Malaysia may play a role in the growth and development of the TMJ, further resulting in the mixed findings. Therefore, taking into consideration the current available literature and the contributory findings of this study here as well, a much larger study would need to be carried out, with standardized sample selection criteria, as well as standardized measurement techniques to yield significant findings.

Conclusion

The results of this study demonstrate that there is no significant association between TMJ space or condylar head position in the different skeletal patterns (I, II, II) among the Malaysian population. It is recommended that a prospective study with large sample size and with standardized sample selection criteria and measurement techniques be implemented in the future to determine the precise association between TMJ space and condylar head position in these different skeletal patterns. The gathering of such detailed and accurate information on TMJ anatomy would provide an in depth understanding in craniofacial morphology and development.

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References

Alhammadi, M. S., Fayed, M. S., & Labib, A. (2016). Three-dimensional assessment of temporomandibular joints in skeletal Class I, Class II, and Class III malocclusions: Cone beam computed tomography analysis. *Journal of the*

World Federation of Orthodontists, 5(3), 80–86. https://doi.org/10.1016/j.ejwf.2016.07.001

Chae, J.-M., Park, J. H., Tai, K., Mizutani, K., Uzuka, S., Miyashita, W., & Seo, H. Y. (2020). Evaluation of condyle-fossa relationships in adolescents with various skeletal patterns using cone-beam computed tomography. *The Angle Orthodontist*, 90(2), 224–232. https://doi.org/10.2319/052919-369.1

Diwakar, R., Bucci, R., Kaushik, A., Bansal, A., Bucci, P., Kochhar, A. S., & Spagnuolo, G. (2023). Three-dimensional assessment of temporomandibular joint morphology and facial asymmetry in individuals with different vertical skeletal growth patterns. *International Journal of Environmental Research and Public Health*, 20(2). https://doi.org/10.3390/ijerph20021437

Feres, M. F. N., Eissa, O., Roscoe, M. G., & El-Bialy, T. (2020). Comparison of the condyle sagittal position of Class I and Class II division 2 in orthodontic patients. *Journal of Contemporary Dental Practice*, 21(9), 977–981. https://doi.org/10.5005/jp-journals-10024-2867

Ikeda, K., & Kawamura, A. (2009). Assessment of optimal condylar position with limited cone-beam computed tomography. *American Journal of Orthodontics and Dentofacial Orthopedics*, 135(4), 495–501. https://doi.org/10.1016/j.ajodo.2007.05.021

Krisjane, Z., Urtane, I., Krumina, G., & Zepa, K. (2009). Three-dimensional evaluation of TMJ parameters in Class II and Class III patients. *Stomatologija*.11(1), 32–36.

Littlewood, S. J., & Mitchell, L. (2019). *An Introduction to Orthodontics*, 5th ed. Oxford University Press.

Liu, Z. J., King, G. J., & Herring, S. W. (2003). Alterations of morphology and microdensity in the condyle after mandibular osteodistraction in the rat. *Journal of Oral and Maxillofacial Surgery*, 61(8), 918–927. https://doi.org/10.1016/S0278-2391(03)00294-5

Ma, Q., Bimal, P., Mei, L., Olliver, S., Farella, M., & Li, H. (2018). Temporomandibular condylar morphology in diverse maxillary–mandibular skeletal patterns: A 3-dimensional cone-beam computed tomography study. *Journal of the American Dental Association*, 149(7), 589–598. https://doi.org/10.1016/j.adaj.2018.02.016

Martins, E., Silva, J. C., Pires, C. A., Ponces, M. J., & Lopes, J. D. (2015). Sagittal joint spaces of the temporomandibular joint: Systematic review and meta-analysis. *Revista Portuguesa de Estomatologia, Medicina Dentaria e Cirurgia Maxilofacial*, 56(2), 80–88. https://doi.org/10.1016/j.rpemd.2015.04.002

Noh, K. J., Baik, H., Han, S., Jang, W., & Choi, Y. J. (2020). Mandibular condyle and glenoid fossa morphology according to vertical and sagittal skeletal patterns: A cone beam computed tomography study. *The Korean Journal of Orthodontics*, 1–22.

Paknahad, M., Shahidi, S., & Abbaszade, H. (2016). Correlation between condylar position and different sagittal skeletal facial types. *Journal of Orofacial Orthopedics*, 77(5), 350–356. https://doi.org/10.1007/s00056-016-0039-z

Proffit, W. R., Fields, H., Larson, B., & Sarver, D. M. (2019). *Contemporary Orthodontics* (6e: South). Elsevier.

Pullinger, A., & Hollender, L. (1986). Variation in condyle-fossa relationships according to different methods of evaluation in tomograms. *Oral Surgery, Oral Medicine, Oral Pathology*, 62(6), 719–727. https://doi.org/10.1016/0030-4220(86)90270-7

Rivero-Millán, P., Barrera-Mora, J. M., Espinar-Escalona, E., Pino, C. A. G. Del, Martín-Salvador, D., & Llamas-Carreras, J. M. (2021). Comparison of condylar position in normal occlusion, Class II Division 1, Class II Division 2 and Class III malocclusions using CBCT imaging. *Journal of Clinical and Experimental Dentistry*, 13(12), 1216–1226. https://doi.org/10.4317/jced.58970

Song, J., Cheng, M., Qian, Y., & Chu, F. (2020). Cone-beam CT evaluation of temporomandibular joint in permanent dentition according to Angle's classification. *Oral Radiology*, 36(3), 261–266. https://doi.org/10.1007/s11282-019-00403-3

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A randomised controlled trial comparing online versus face-to-face smoking cessation course for Malaysian dental officer

Khairul Fikri Sebri[1,2], Nor Faezah Bohari Md. Bohari[1], Nawwal Alwani Mohd Radzi[1]*

[1]*Centre of Population Oral Health and Clinical Prevention, Faculty of Dentistry, Universiti Teknologi MARA (UiTM), Sg Buloh Campus, 47000, Sungai Buloh, Selangor, Malaysia.*
[2]*Oral Health Programme, Ministry of Health, Level 5, Block E10, Complex E, Federal Government, Administrative Centre, 62590, Putrajaya, Malaysia.*

Abstract

Oral health professionals play a vital role in tobacco cessation efforts, but there is a notable gap in their training and skills in this area. Online Smoking Cessation Course was developed by UiTM to benefit the oral health professionals however it has not been evaluated yet. Thus, the aim of this study is to evaluate the effectiveness of online smoking cessation module in comparison with the face-to-face method, in term of the level knowledge. This randomized controlled trial involved 185 new dental officers from four states in Peninsular Malaysia, divided into online and face-to-face (F2F) delivery groups. They were assessed using validated questionnaire, both pre- and post-intervention. The results showed that both the control (F2F) and intervention (online) groups demonstrated significant improvements in knowledge post-training. The control group's average score increased from 6.05 to 7.99, while the intervention group saw an increase from 6.22 to 8.20, with both groups showing statistically significant improvements ($p < 0.001$). This indicates the effectiveness of the smoking cessation course in enhancing knowledge. The study concluded that the online module is suitable for new dental officers, equipping them with knowledge and skills for smoking cessation counselling as it found that online delivery is as effective as F2F training. This suggests that online training could provide a more cost-effective and accessible method for future smoking cessation training, reaching a broader audience.

Keywords: *active learning, dental officer, online learning, smoking cessation*

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***Corresponding author**
Address:
Centre of Population Oral Health and Clinical Prevention, Faculty of Dentistry, Universiti Teknologi MARA (UiTM), Sg Buloh Campus, 47000, Sungai Buloh, Selangor, Malaysia.

Telephone: +603 61266621
Email address:
nawwal@uitm.edu.my

Introduction

Smoking remains a critical public health issue worldwide, with its impact being significantly felt both globally and in specific countries like Malaysia. According to the World Health Organization (WHO), more than 8 million people die each year from tobacco use, with over 7 million of these deaths resulting from direct tobacco use (Ritchie & Roser, 2013). Additionally, tobacco is responsible for the deaths of around 1.3 million non-smokers who are exposed to second-hand smoke (World Health Organization, 2023).

Focusing on Malaysia, more than 27,200 deaths annually are attributed to smoking (Focus Malaysia, 2021), This number is particularly alarming considering the relatively small population of Malaysia compared to larger countries. The situation is exacerbated by the high prevalence of smoking in the country, the prevalence of tobacco use among adults remains high, with

about 21.9% of adults smoking as of 2020. The smoking rates are notably higher among men (42.1%) compared to women (0.5%) (Global State of Tobacco Harm Reduction, 2021). These reports indicate that Malaysia is likely to miss the global target for reducing tobacco use prevalence by 30% by 2025 (Focus Malaysia, 2021).

Globally, the burden of smoking-related deaths is expected to rise, with projections suggesting that tobacco-attributable mortality could reach 8.4 million by 2020 (Tam & Lee, 2014). This trend is particularly concerning in developing countries, which account for about 70% of these mortalities due to higher smoking prevalence (Lim *et al.*, 2018). These statistics highlight the urgent need for effective tobacco control and public health strategies to combat the smoking epidemic both globally and in countries like Malaysia.

Internationally, the importance of training in smoking cessation for healthcare students is widely recognized. Programs like "Rx for Change: Clinician-Assisted Tobacco Cessation" offer comprehensive tobacco cessation training to health professionals of all disciplines, focusing on evidence-based knowledge and skills to assist patients in quitting tobacco use (Centers for Disease Control and Prevention, 2021). Additionally, the University of Wisconsin-Center for Tobacco Research and Intervention provides healthcare provider training videos, including training on motivational interviewing to help patients quit smoking (Centers for Disease Control and Prevention, 2021). Furthermore, the University of Arizona offers continuing education and certification programs in nicotine dependence treatment, emphasizing the need for specialized training in this area (Centers for Disease Control and Prevention, 2021).

In Malaysia, the training of healthcare professionals in smoking cessation techniques has been significantly improved by several initiatives. Currently, there are two types of training: face-to-face, which is Smoking Cessation Organizing, Planning and Execution (SCOPE), and mixed, which is Certified Smoking Cessation Service Provider" (CSCSP). The CSCSP program, launched in 2004 by the Malaysian Academy of Pharmacy (MAP) and the Malaysian Pharmacists Society (MPS), targets community pharmacists. This program includes a one-month self-study online, a one-day workshop, and a one-day clinic attachment, aiming to equip healthcare professionals with skills for evidence-based smoking cessation interventions (Commonwealth Pharmacists Association, 2022). Another key initiative is the SCOPE program, developed by the Nicotine Addiction research group at the University of Malaya and accredited by the Ministry of Health. This program involves six thought modules, two skills, and one role-play session and has trained nearly 2500 healthcare providers since its inception in 2015 (Asia Research News, 2017). These efforts are instrumental in supporting Malaysia's commitment to the WHO Framework Convention on Tobacco Control and its goal for a tobacco-free nation by 2040 (Commonwealth Pharmacists Association, 2022).

Online training offers flexibility and accessibility, allowing healthcare professionals to learn at their own pace and convenience. This method often includes interactive modules, webinars, and virtual simulations, providing a comprehensive understanding of smoking cessation strategies. Research indicates that online training can be as effective as face-to-face training in improving knowledge and skills related to smoking cessation. For instance, a study by Saulle *et al.* (2013) found that online modules significantly enhanced the ability of dental professionals to provide smoking cessation counseling, with participants reporting increased confidence and competency in their skills.

On the other hand, face-to-face training provides a more interactive and personal learning experience. This method often involves workshops, seminars, and role-playing scenarios that allow for immediate feedback and hands-on practice. Face-to-face training fosters a collaborative learning environment, which can enhance motivation

and engagement. A study by Carson *et al.* (2012) highlighted that face-to-face training sessions resulted in higher satisfaction and perceived effectiveness among participants compared to online training. Direct interaction with trainers and peers in face-to-face settings can also facilitate the development of practical skills and the application of theoretical knowledge in real-life scenarios.

Oral health professionals play a vital role in tobacco cessation efforts, but there is a notable gap in their training and skills in this area. The FDI World Dental Federation emphasizes that oral health practitioners should ideally deliver the 5A's of tobacco cessation in which the health personnel need to ask about tobacco use, advise to quit, assess quitting motives, assist in quitting, and arrange follow-up contacts to quit smoking. At a minimum, they should deliver the 3A's approach, which includes asking about tobacco use, giving advice to quit, and acting by referring to tobacco cessation clinics or services. This approach aligns with the WHO Framework Convention on Tobacco Control Article 14 guidelines, which recommend that oral health practitioners deliver brief tobacco interventions as part of their routine services in primary care (FDI World Dental Federation, 2021).

In Malaysia, the oral health team also are in a unique position to influence young adults and adolescents as many of them were in frequent contact with the dental team during the annual school dental check-up programme as well as the school-based smoking cessation programme, namely, Kesihatan Oral Tanpa Asap Rokok (KOTAK) programme. In addition, the immediate effects of smoking on the mouth, such as staining of teeth and halitosis, may be a concern for many people and, therefore, practical motivating factors to quit. Furthermore, smoking cessation advice provided by general practitioners has been shown to be effective in systematic reviews of many randomized controlled trials (Omaña-Cepeda *et al.*, 2016).

To further empower the dental team and increase competency in smoking cessation, in December 2013 at the Malaysian Dental Deans' Council meeting, smoking cessation became part of the Minimum Competency Exit requirement for Malaysian undergraduate dental curricula, embedded in the Preventive Dentistry module (Tobacco Control, 2014). For the first time, this commits all dental schools in Malaysia to have a minimum level of tobacco control training. However, such training is only available for undergraduate dental students in Malaysia, and according to the latest available annual report from MDC, in 2022, 314 new registrants were from foreign institutions, which constituted 41.98% of total registrants of that year (Malaysian Dental council, 2022). All newly graduated dentists must serve a compulsory year with the MOH and were required to provide quit-smoking advice to schoolchildren for the KOTAK programme.

Thus, there is a need for smoking cessation training that is accessible to all new registrants from foreign institutions to ensure that they have the basic knowledge of smoking cessation to fill their job requirements in the Ministry of Health.

As a prominent dental institution, Universiti Teknologi MARA (UiTM) has been offering smoking cessation training to postgraduate students since the year 2020. In keeping pace with technological advancement while utilising the new norms post-pandemic period, the researchers have extended the efforts by introducing the online version of the smoking cessation module in 2022, designed to benefit oral healthcare professionals. Thus, the aim of this study is to evaluate the effectiveness of the online smoking cessation module in comparison with the face-to-face method, in terms of the level of knowledge.

Materials and Methods

This study employed a Randomized Control Trial (RCT) method using a 2 (F2F delivery as control group and, online delivery as intervention group) × 2 (pre-test, post-test) mixed design to compare outcomes of different smoking cessation training delivery modes. This study received approval from the Research Ethics

Committee (REC), Research Management Centre, UiTM, (ref: REC/06/2021 (MR/426)), and the National Medical Research Register (NMRR) (ref: NMRR ID-23-00921-V0Q (IIR)).

A total of 185 new dental officers were recruited from four states representing 4 regions in Peninsular Malaysia. Participant inclusion criteria were: (1) new dental officers who serve within one to three years in government; and (2) have not joined any training on smoking cessation in Malaysia namely CSCSP or SCOPE. The name list of the new dental officers was obtained from the specified states (Kedah, Perak, Terengganu, Negeri Sembilan). They were randomly divided into two groups, each containing an equal number of participants, using simple randomization techniques via a computerized random list generator. The first 24 individuals were selected for the intervention group, while the subsequent 24 were chosen for the control group. Finally, the selected participants were contacted and invited to join this study by the State's Oral Health Division (Bahagian Kesihatan Pergigian, Jabatan Kesihatan Negeri).

The participants in the online group were allocated a specific place and time identical to the face-to-face (F2F) group, spanning two days from 8 am to 4 pm. This component of the program was conducted in the computer lab. Meanwhile, the online or intervention group completed the module accessible through the UiTM Massive Open Online Course Platform (MOOC). In contrast, the F2F control group received their training in a seminar room. This training was provided by a Dental Public Health Specialist or a dental officer possessing at least a master's degree in dental public health and skilled in conducting smoking cessation counselling. The educational modules provided to both the control and intervention groups are composed of the same materials. These materials include slide presentations designed to visually convey key information, explanatory videos that offer detailed discussions of the topics, and a variety of reading materials to supplement learning. This uniformity ensures that any differences observed between the groups can be attributed to the intervention itself rather than variations in the educational content. The timing and duration of the program for the online group were also made similar to those of the control group. Participant blinding in this study was not possible. Participants accessing the online course were only able to access the content of the module from 8 am to 4 pm on both days of the programme.

All participants completed a questionnaire from a previous study on "Training Malaysian Pharmacy Undergraduates with Knowledge and Skills on Smoking Cessation." This questionnaire had been previously validated (Saraswathi Simansalam *et al.*, 2015). Surveys were administered at two-time points: immediately before training (pre-test) and immediately after training (post-test). It was conducted by distributing the questionnaire in person to ensure a 100% response rate. A pilot study was conducted prior to the main research phase, involving postgraduate students from Universiti Teknologi MARA (UiTM).

The questionnaires used were not translated as the participants of this study were all fluent in English. Participants were asked fourteen multiple-choice questions pertaining to the module's content to assess their knowledge level. Each participant had to select the best answer for each question. One mark was awarded for each correct answer, while no marks were given for incorrect answers. Importantly, there was no deduction of marks for wrong answers. The total points accumulated by each participant were summed up and then divided by the total number of questions, which was 14, to assess knowledge. This result was subsequently converted into a percentage to determine each participant's score. Those scoring more than 50% were considered to have good knowledge, while those scoring 50% or less were deemed to have less satisfactory knowledge.

Data was analysed using the software package SPSS (v.27) Paired t-tests were used to analyse knowledge scores before and after the intervention, and chi-square tests

determined the change in the proportion of students scoring above 50%.

Results

The preintervention and postintervention survey instruments were completed by 185 participants, yielding a 96.4% overall response rate, of which 93 were in the control group and 92 were in the intervention group. The mean age and its standard deviation for participants were 26.5(1.47). The majority of the participants were female, 78.4% (n=145) while male was 21.6% (n=40).

In Table 1, there was significant improvement in preintervention to postintervention mean knowledge scores among all participants, with slightly higher improvement among the intervention group, who received the training via online method.

Table 1. Changes in knowledge levels between physical (control) and online (intervention) groups by mean scores (n= 185).

Variable	Pre-course Score (Mean ± SD)	Post-course Score (Mean ± SD)	Mean of score diff. (95% CI)	t statistic (df)	p-value
Knowledge	6.14 ± 1.71	8.09 ±1.64	1.957 (1.66, 2.25)	12.98 (184)	<0.001
Physical (n=93)	6.05 ± 1.66	7.99 ± 1.61	1.94 (1.55, 2.32)	9.92 (92)	<0.001
Online (n=92)	6.22 ± 1.77	8.20 ± 1.68	1.98 (1.52, 2.44)	8.55 (91)	<0.001

Note: Paired t-test; SD = Standard Deviation; 95% CI = 95% Confidence Interval; df = Degrees of Freedom.

Table 2. Association between physical (control) and online (intervention) group with pre course knowledge score.

Variables	n	**Knowledge Score** Poor n (%)	Good n (%)	**X^2 statistic (df)**	**P-value[a]**
Mode of Delivery				0.13 (1)	0.718
Physical	93	54 (58.1%)	39 (41.9%)		
Online	92	51 (55.4%)	41 (44.6%)		

Note: [a]Chi-square test for independence; *df* = Degrees of Freedom.

Table 3. Association between physical (control) and online (intervention) group with post course knowledge score.

Variables	**n**	**Knowledge Score** **Poor n (%)**	**Good n (%)**	**X^2 statistic (df)**	**P-value[a]**
Mode of Delivery				0.14 (1)	0.705
Physical	93	15 (16.1%)	78 (83.9%)		
Online	92	13 (14.1%)	41 (85.9%)		

Note: [a]Chi-square test for independence; *df* = Degrees of Freedom.

The results from two separate Chi-square tests for independence which tabulated in the table 2 and 3 indicate that there are no significant differences in the prevalence (proportion) of pre and post-course knowledge scores between control and

intervention groups. Even though, the number of participants who scored above 50% for the knowledge component improved from 80 at preintervention to 119 at postintervention. The first test revealed that the pre-course knowledge scores were not significantly different, with $\chi2(1) = 0.13$ and a p-value of 0.718. Similarly, the second test showed that the post-course knowledge scores were also not significantly different, as evidenced by $\chi2(1) = 0.14$ and a p-value of 0.705. Consequently, these findings suggest that there is no significant association between the mode of delivery and the knowledge scores both before and after the course.

Discussion

Various studies have compared the effectiveness of online and face-to-face methods in smoking cessation education and counselling, with mixed results. A study conducted at a German medical school compared e-learning with role-playing in medical education for smoking cessation counselling. It found that while practical skills scores were slightly higher in the face-to-face group for certain aspects, both approaches were equally effective in increasing theoretical knowledge, suggesting that both methods could be combined for effective teaching (Lauerer *et al*., 2021).

Our findings indicated that dental officers' knowledge pertaining to smoking cessation improved following the smoking cessation online training intervention. This is consistent with the recent studies which have demonstrated the effectiveness of online training programs in enhancing the knowledge and skills of healthcare professionals in smoking cessation interventions. This is consistent with the findings of Brown and Janke, who reported significant improvement for knowledge scores, (from preintervention of 36.3% to 84.5% at postintervention) following a web-based training (Brown & Janke, 2013). Martínez *et al.* (2019) conducted a study involving 127 clinicians and found significant improvements in the implementation of the assist and arrange follow-up components of smoking cessation interventions post-training (Cristina Martínez *et al.*, 2019). Similarly, a study by McDermott, West, Brose, and McEwen (2012) highlighted that online training led to a notable increase in knowledge among practitioners, with correct responses rising from 64.4% to 77.7% (McDermott *et al*., 2012). Furthermore, research by Company, Guillen, Martínez, and Fernández (2018) emphasized the effectiveness of an online tobacco cessation training program in increasing smoking cessation knowledge, attitudes, self-confidence, and performance interventions among health professionals in low- and middle-income Latin American and Caribbean countries (Martínez *et al*., 2018). Pardavila-Belio *et al.* (2018) also underscored the benefits of an online health sciences training program for brief smoking intervention in four European countries, focusing on enhancing health professionals' knowledge and skills (Pardavila-Belio *et al.*, 2023). Finally, a study by Etter (2005) compared two Internet-based, computer-tailored smoking cessation programs, shedding light on the efficacy of different online training methodologies (Etter, 2005). These studies collectively affirm the positive impact of online training programs on the preparedness and effectiveness of healthcare providers in smoking cessation interventions.

The positive impact of online smoking cessation training on participants' knowledge levels can be attributed to several factors. One major factor is the flexibility and self-paced nature of online learning, which allows participants to access training materials at their convenience and spend additional time on challenging topics (Hrastinski, 2008). This flexibility is complemented by the ability to review content multiple times, reinforcing understanding and retention (Clark & Mayer, 2016). Interactive elements such as quizzes and simulations, along with immediate feedback, enhance engagement and help learners correct mistakes quickly, leading to better learning outcomes (Shute, 2008; Sitzmann, 2011). These aspects of

online learning make it more effective in increasing knowledge compared to traditional physical training.

Additionally, online training provides continuous access to a wide range of resources, fostering a deeper understanding of smoking cessation (Means *et al.*, 2010). The availability of diverse materials, such as articles and videos, allows for comprehensive learning. Personalized learning paths further enhance effectiveness by catering to individual needs and learning styles (Dabbagh & Kitsantas, 2012). The cost-effectiveness of online training also plays a significant role, as it enables broader access and the efficient use of resources, thus reaching a wider audience (Zhang *et al.*, 2004). Overall, these factors contribute to the success of online smoking cessation training in improving participants' knowledge and supporting their efforts to help patients quit smoking.

Conclusion

The Smoking Cessation Course for Healthcare Professional that was available on MOOC UiTM platform, an online module developed for healthcare professionals, was found suitable in equipping new dental officers with knowledge on smoking cessation topics. It also found that online delivery is as effective as F2F training. This suggests that online training could provide a more cost-effective and accessible method for future smoking cessation training, reaching a broader audience.

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References

Asia Research News. (2017). Developing smoking cessation practitioners through SCOPE. Retrieved from https://www.asiaresearchnews.com/content/developing-smoking-cessation-practitioners-through-scope

Brown, M., & Janke, K. (2013). Impact of an internet-based smoking cessation educational module on pharmacists' knowledge and practice. *American Journal of Pharmaceutical Education.*

Carson, K. V., Verbiest, M. E., Crone, M. R., Brinn, M. P., Esterman, A. J., Assendelft, W. J., & Smith, B. J. (2012). Training health professionals in smoking cessation. *Cochrane Database of Systematic Reviews*, 2012(5), Cd000214.

Centers for Disease Control and Prevention. (2021). Clinical education and training. Retrieved from https://www.cdc.gov/tobacco/patient-care/education-training/index.html

Commonwealth Pharmacists Association. (2022). Training community pharmacists in Malaysia as smoking cessation service providers. Retrieved from https://commonwealthpharmacy.org/training-community-pharmacists-in-malaysia-as-smoking-cessation-service-providers/

Dabbagh, N., & Kitsantas, A. (2012). Personal learning environments, social media, and self-regulated learning: A natural formula for connecting formal and informal learning. *The Internet and Higher Education*, 15(1), 3-8.

Etter, J.-F. (2005). Comparing the efficacy of two internet-based, computer-tailored smoking cessation programs: a randomized trial. *Journal of Medical Internet Research*, 7(1), e2.

FDI World Dental Federation. (2021). The role of oral health practitioners in tobacco cessation. Retrieved from https://www.fdiworlddental.org/the-role-of-oral-health-practitioners-in-tobacco-cessation

Focus Malaysia. (2021). Rethink tobacco harm reduction strategies to curb smoking. Retrieved from https://focusmalaysia.my/rethink-tobacco-harm-reduction-strategies-to-curb-smoking/

Global State of Tobacco Harm Reduction. (2021). Tobacco smoking in Malaysia. Retrieved from https://gsthr.org

Hrastinski, S. (2008). Asynchronous and synchronous e-learning. *Educause Quarterly*, 4.

Lauerer, E., Tiedemann, E., Polak, T., & Simmenroth, A. (2021). Can smoking cessation be taught online? A prospective study comparing e-learning and role-playing in medical education. *International Journal of Medical Education*, 12, 12-21.

Lim, K. H., Teh, C. H., Pan, S., Ling, M. Y., Yusoff, M. F. M., Ghazali, S. M., *et al.* (2018). Prevalence and factors associated with smoking among adults in Malaysia: Findings from the National Health and Morbidity Survey (NHMS) 2015. *Tobacco Induced Diseases*, 16, 01.

Malaysian Dental council. (2022). MDC Annual Statistic 2022. Retrieved from https://hq.moh.gov.my/ohd/mdc/

Martínez, C., Castellano, Y., Andrés, A., Fu, M., Feliu, A., Antón, L., *et al.* (2019). Impact of an online training program in smoking cessation interventions in hospitals. *Journal of Nursing Scholarship*, 51(4), 449-458.

Martínez, C., Castellano, Y., Company, A., Guillen, O., Margalef, M., Alicia Arrien, M., *et al.* (2018). Impact of an online training program in hospital workers' smoking cessation interventions in Bolivia, Guatemala and Paraguay. *Gaceta Sanitaria*, 32(3), 236-243.

McDermott, M. S., West, R., Brose, L. S., & McEwen, A. (2012). Self-reported practices, attitudes and levels of training of practitioners in the English NHS Stop Smoking Services. *Addictive Behaviors*, 37(4), 498-506.

Means, B., Toyama, Y., Murphy, R., Bakia, M., Jones, K., & Planning, E. (2010). Evaluation of evidence-based practices in online learning: a meta-analysis and review of online learning studies.

Omaña-Cepeda, C., Jané-Salas, E., Estrugo-Devesa, A., Chimenos-Küstner, E., & López-López, J. (2016). Effectiveness of dentist's intervention in smoking cessation: A review. *Journal of Clinical and Experimental Dentistry*, 8(1), e78-83.

Pardavila-Belio, M. I., Moreno-Arroyo, C., Romero-Clará, O., Tricas-Sauras, S., Barroso, T., Duaso, M., *et al.* (2023). Adaptation, implementation, and evaluation of an online health sciences training program for brief smoking intervention: A pre-post study in four European countries. *Nurse Education Today*, 130, 105924.

Ritchie, H., & Roser, M. (2013, 2023). Smoking. Retrieved from https://ourworldindata.org/smoking

Saraswathi Simansalam, Joan M. Brewster, & Mohamed, M. H. N. (2015). Training Malaysian pharmacy undergraduates with knowledge and skills on smoking cessation. *American Journal of Pharmaceutical Education*, 79(5).71.

Saulle, R., Bontempi, C., Baldo, V., Boccia, G., Bonaccorsi, G., Brusaferro, S., *et al.* (2013). GHPSS multicenter Italian survey: Smoking prevalence, knowledge and attitudes, and tobacco cessation training among third-year medical students. *Tumori*, 99, 17-22.

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, 78(1), 153-189.

Sitzmann, T. (2011). A meta-analytic examination of the instructional effectiveness of computer-based simulation games. *Personnel Psychology*, 64, 489-528.

Tam, C.-L., & Lee, M. (2014). Smoking and burden of ill health: A review of the malaysian context. *International Journal of Collaborative Research on Internal Medicine & Public Health*, 6(7).190.

Tobacco Control. (2014). Retrieved from https://tobaccocontrol.bmj.com/content/23/4/281

World Health Organization. (2023, 31 July 2023). Tobacco. Retrieved from https://www.who.int/news-room/fact-sheets/detail/tobacco

Zhang, D., Zhao, J., Zhou, L., & Jr, J. (2004). Can e-learning replace classroom learning?. *Communications of the ACM*, 47, 75-79.

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Evaluation of anatomic variations in the posterior superior alveolar artery – A Cone-beam Computed Tomography (CBCT) study

Izzati Nabilah Ismail[1], Nur Alyssa Abdul Rahman[2], Amir Harris Hasran[2]

[1]*Oral Maxillofacial Surgery and Oral Diagnosis, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan Pahang, Malaysia.*
[2]*Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan Pahang, Malaysia.*

Abstract

Anatomical variation of the course of posterior superior alveolar artery (PSAA) within maxillary bone are vital information for surgeons before any maxillary surgery. This study was designed to evaluate the variations of PSAA by determining the prevalence of intraosseous PSAA and assessing the anatomical reference points and diameter of the PSAA. Comparison between dentate and edentulous alveolus was also done. One hundred CBCT images were included in this study to enumerate the prevalence of intraosseous PSAA in maxilla. Anatomical reference points which include the horizontal position of the PSAA and the vertical distance from the PSAA to the maxillary sinus floor and alveolar crest were identified. The diameter and horizontal position of PSAA were also analysed. The results were tested using independent t-test and chi square test. The PSAA was seen in 73.5% of the cases and 70.1% were located intraosseously. There was no significant difference in the vertical distance between PSAA and alveolar crest, as well as between maxillary sinus floor and alveolar crest for dentate and edentulous patients. Meanwhile, there was a significantly greater vertical distance between the PSAA and the maxillary sinus floor in edentulous (9.24 ± 4.75 mm) than in dentate patients (6.78 ± 3.43 mm) with p-value of 0.002. Mean diameter of the canal was 1.09 ± 0.43 mm. In conclusion, this study provides useful information regarding the most prevalent location and diameter of the PSAA which indicates the importance of preoperative evaluation through CBCT to reduce the risk of intraoperative bleeding that may complicate the treatment.

Keywords: *cone beam computed tomography, maxillary sinus, maxillary artery, posterior superior alveolar artery*

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***Corresponding author**
Address:
Department of Oral Maxillofacial Surgery & Oral Diagnosis, Kulliyyah of Dentistry, IIUM Kuantan Campus, 25200 Kuantan, Pahang, Malaysia

Telephone: +609 5702942
Email address:
izzatiismail@iium.edu.my

Introduction

Posterior superior alveolar artery (PSAA) is one of the fifteen branches of the maxillary artery, which is the terminal division of the external carotid artery. Maxillary artery can pass superficially or deeply to the lateral pterygoid muscle and enters the pterygopalatine fossa where it divides into its terminal branches, one of them being the posterior superior alveolar artery (Gofur and Khalili, 2023). The PSAA is one of the main contributors to the maxillary structures whereby it divides into several branches in which some of them enter the alveolar canals to supply the molar and premolar teeth as well as the maxillary sinus lining. This is called the dental branch of the PSAA. This artery travels intraosseously and will create a horizontal anastomosis with the infraorbital artery (Yusof *et al.*, 2020). The other branches would travel towards the alveolar process to supply the posterior

buccal gingiva. The PSAA shares the same route as the posterior superior alveolar nerve as they innervate the same structure (Cheng and Hacking, 2023).

The course of the PSAA and their location within the maxillary structures can vary distinctly and can exist extraosseous or intraosseously (Pandharbale *et al.*, 2016). Therefore, it is vital to have the knowledge of the anatomical variations and landmarks of the PSAA especially when performing surgeries that involve the posterior maxilla area such as the Le Fort 1 osteotomy, the maxillary sinus augmentation and subsequent insertion of dental implants (Padovani *et al.*, 2020). The assessment of the anatomy of the maxillary sinus and surrounding vital structures including the PSAA can avoid any unnecessary surgical complications such as intraoperative haemorrhage due to the close proximity between the artery and the maxillary sinus. It was also reported that when a haemorrhage occurs during a sinus lifting procedure, the surgeon's access to the surgical field will be diminished and can potentially cause perforation to the sinus membrane (Panjnoush *et al.*, 2017)

Review of the current literature on the detection rate of the PSAA found that the artery is present in CBCT in more than half of the cases (Güncü *et al*., 2011; Jung *et al*., 2011; Panjnoush *et al.*, 2017). This shows that the prevalence of the artery is relatively high in CBCT images. However, the undetected canal of the artery in a CT scan does not neglect its existence as it may not be visible due to the small diameter and the lesser definition of images in CT scans compared to CBCT scans. Another study suggested that the diameter would decrease with age (Yusof *et al.*, 2020). Hence, the type of device used for the imaging also plays an important role for preoperative assessment in pre-prosthetic surgery of edentulous elder patients.

There was also a huge variability in the horizontal and vertical position of the artery reported in the literature (Güncü *et al.*, 2011; Jung et al., 2011; Panjnoush et al., 2017). The location of the artery is also influenced by the status of the dentition in the posterior maxilla where it reported a greater distance between the artery and sinus floor in edentulous ridges, but shortest at the first molar region and longest at the first premolar region (Panjnoush *et al.*, 2017; Yusof *et al.*, 2020). The importance of identifying the location of this artery is particularly significant in the lateral wall approach of the sinus lift procedure where the flap and the bony window created may be within the surgical field. This may limit the surgical access to avoid iatrogenic damage to the artery whereby it may lead to intraoperative haemorrhage and poor vascular supply which will hinder the healing of the bone graft in sinus lift (Ella *et al.,* 2008; Rysz *et al.*, 2014).

Therefore, the aim of this study was to determine the presence of the PSAA detectable in CBCT of posterior maxilla in dentate and edentulous patients, as well as to determine the horizontal and vertical locations of the PSAA and to calculate the mean diameter of the PSAA in dentate and edentulous patients.

Materials and Methods

A cross-sectional study performed on CBCT images of the posterior maxilla of patients presented to the Oral Radiology Unit in a dental institute from 2011 until 2016 was conducted upon ethical approval by the IIUM Research Ethical Committee (IREC 2021-159). The CBCT images were identified through assessment of the radiographic database available in the institute. The CBCT scans of adult patients aged above 18-years which had the posterior maxilla and maxillary sinus within the field of view regardless of the imaging indication were collected. Patients with a history of maxillary fracture, surgery or bony pathology were excluded from the study. Low quality CBCT images hindering the investigation of the posterior maxilla were also excluded from this study. In order to identify the prevalence of the posterior superior alveolar artery in dentate and edentulous patients, assuming a two-sided significance level of 95%, a power of 80% while expecting a 30% to 70% ratio

of prevalence, using the Fleiss formula, a total sample size of 58 CBCT images is required.

The CBCT images collected were obtained using Planmeca Promax 3D imaging device (Planmeca, Helsinki, Finland) at 90kV, with a voxel size of 0.2 mm and a field of view of 18 - 20 cm, being the scan time of 18 seconds. The CBCT 3D images were then analysed and measured using Planmeca Romexis version 2.2 software program (Planmeca, Helsinki, Finland). Two researchers underwent training for the Planmeca Romexis software and a pilot assessment in observing 10 CBCT images for the intra-observer reliability testing was done to ensure reproducibility of the identification of landmarks prior to data collection. The inter-rater reliability showed a strong agreement between two researchers with Intraclass Correlation Coefficient (ICC) ranging from 0.89 to 0.91 for all the variables.

The assessment of the vertical position of the posterior superior alveolar artery (PSAA) in relation to other anatomical landmarks include the vertical distance between the lower border of the PSAA canal to the alveolar crest (A), vertical distance between the lower border of the PSAA canal to the maxillary sinus floor (B), and vertical distance between the maxillary sinus floor to the alveolar crest (C) (Figure 1). The horizontal position of the PSAA in relation to the sinus wall was also evaluated and categorised into intrasinus, intraosseous and superficial following Danesh-Sani definition of horizontal position of PSAA (Danesh-Sani *et al*. 2017). (Figure 2). Table 1 summarised the definition of the horizontal positions of the PSAA within the lateral wall of the maxillary sinus. The diameter of the PSAA canal was also measured (Figure 3).

The data obtained were collected and analysed using IBM® SPSS® Statistics Version 23 (IBM Corporation, Armonk, USA). Demographic data of the posterior maxilla images such as the age, gender, side, dental status and the presence of intraosseous PSAA were recorded and analysed. The inter-observer reliability was done using a two-way mixed, absolute agreement, 95% confidence interval ICC for every variable.

The prevalence of the intraosseous PSAA in the CBCT of the dentate and edentulous posterior maxilla was compared and tested using Chi-square test. The horizontal position of the intraosseous PSAA in the lateral wall of the maxillary sinus of the dentate and edentulous posterior maxilla was also compared and tested using Chi square test. Meanwhile, the vertical distances of the PSAA to the alveolar ridge and maxillary sinus floor, as well as the vertical distance of alveolar crest to the sinus floor were obtained and compared between dentate and edentulous patients using independent t-test. The diameter of the PSAA was also recorded and compared using independent t-test.

Table 1. Different horizontal position of PSAA and their definition.

Horizontal position of PSAA	Definition
Intrasinus	Below sinus wall towards the maxillary sinus
Intraosseous	Within the maxillary sinus wall
Superficial	Outside and away from maxillary sinus wall

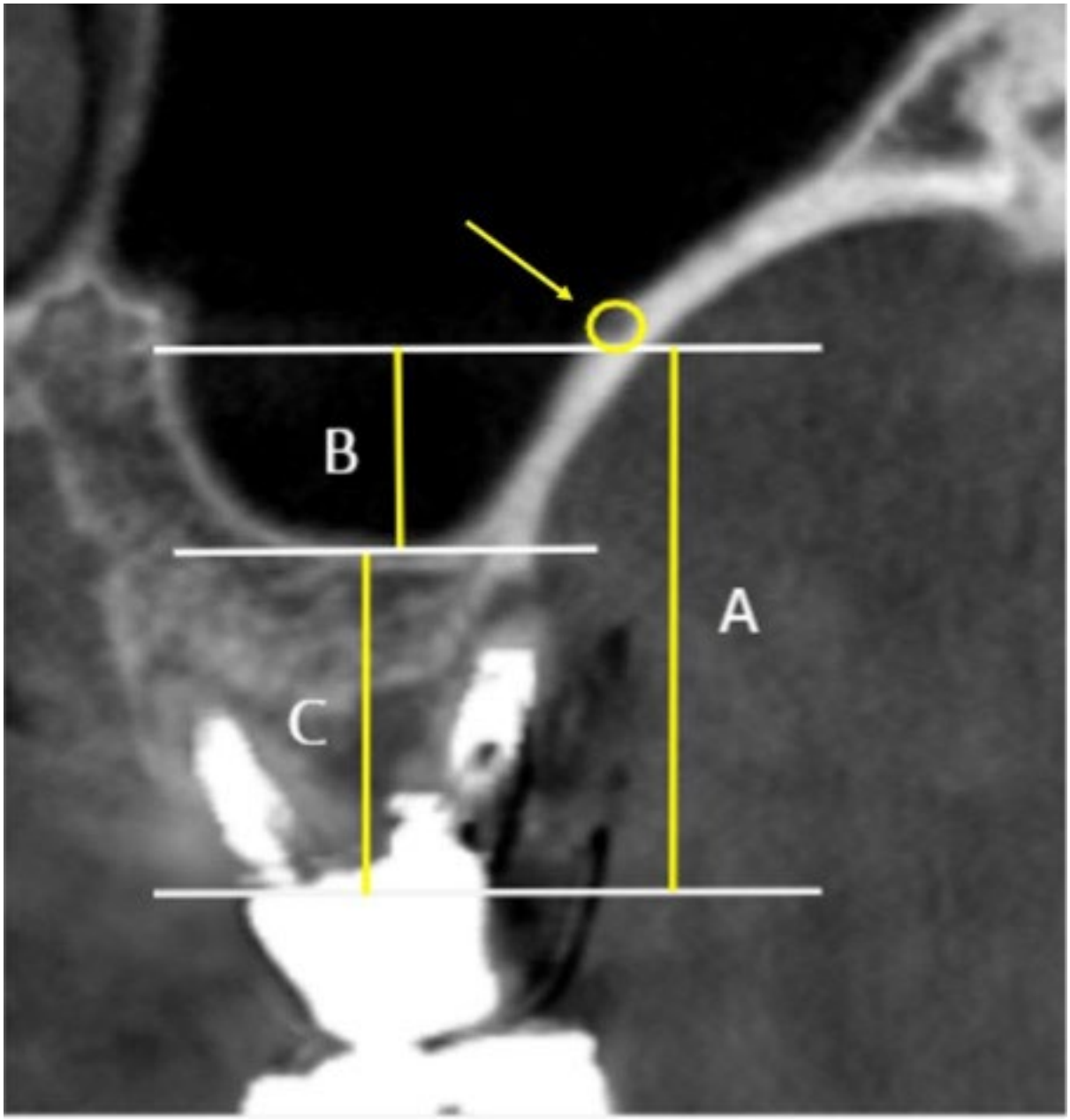

Figure 1. A magnified coronal plane from multiplanar reconstruction (MPR) view was used to detect the PSAA on the lateral wall of the posterior maxilla. The arrow is pointing towards PSAA canal that is also encircled. After identifying the PSAA canal, digital measurements for the vertical position were made on the coronal view. Horizontal lines were drawn at the lower border of the canal, maxillary sinus floor and alveolar crest. Those lines were then used to measure the vertical distance between the lower border of the canal to the alveolar crest (A), vertical distance between the lower border of the canal to the maxillary sinus floor (B), and vertical distance between the maxillary sinus floor to the alveolar crest (C).

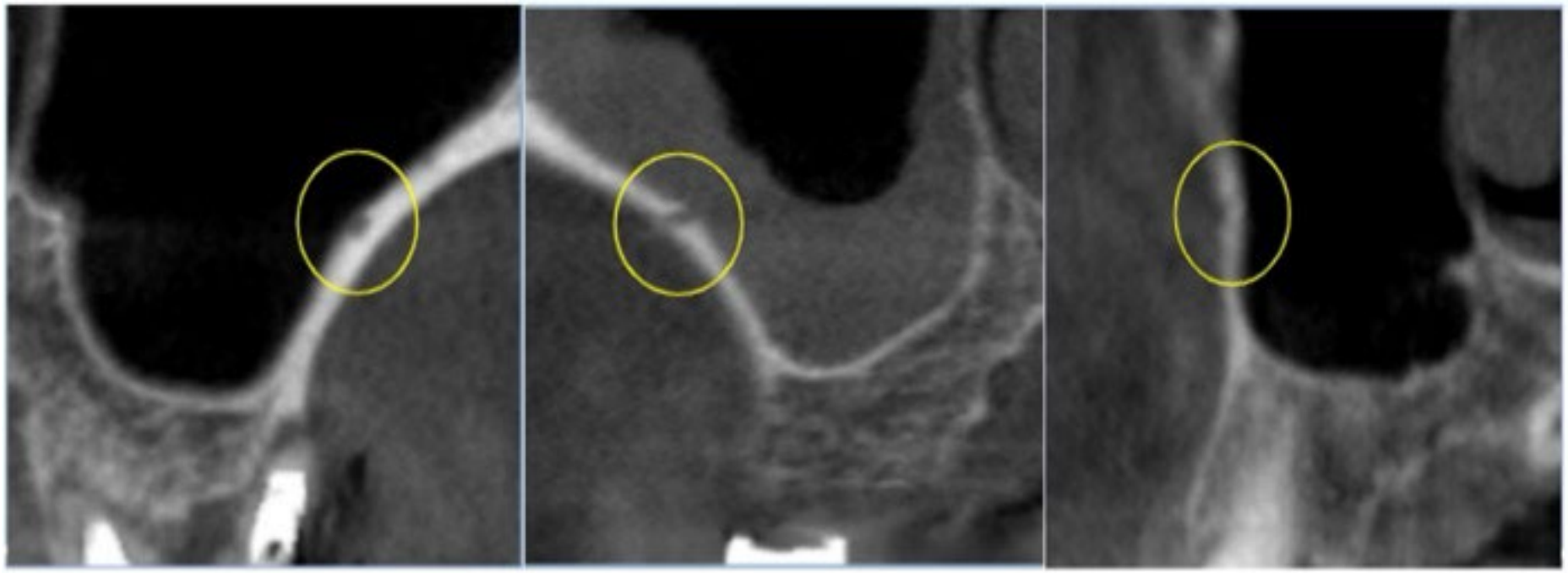

Figure 2. A magnified coronal slice of the MPR view was also used to detect the different horizontal positions of the PSAA in the CBCT images: (from left to right: intrasinus, intraosseous, superficial).

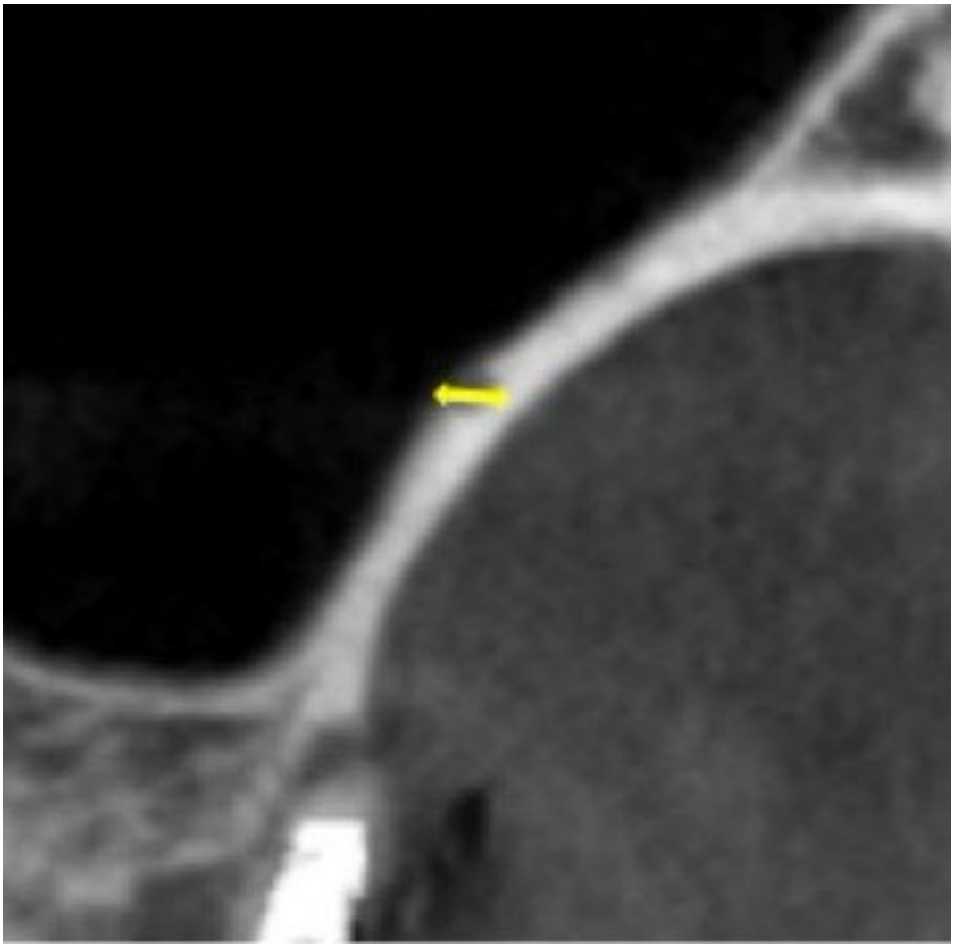

Figure 3. A magnified view of the coronal slice of the CBCT image showing the distance from a point on one side of the canal to a point on the other side going through the center in a horizontal plane was used to measure the diameter of the canal.

Results

A total of 100 CBCT scans (49 males; 51 females) were selected for observation and investigation. Eighty-six of the CBCT scans of the posterior maxilla were dentate and 14 are edentulous. The total mean age of the patients was 34 years old, ranging between 16 to 74 with median age of 24 years old. For dentate patients, the mean age was 28.56 while for edentulous patients, the mean age was 62.29 with a significantly higher age in the edentulous group ($p = 0.000$). Assessment of the gender revealed 47.7% ($n = 41$) males and 52.3% (45) females were dentate, while 57.1% (8) males and 42.9% (6) females were edentulous ($p = 0.806$) (Table 2). There were no significant differences of the gender distribution when compared between the dentate and edentulous.

Of all the posterior maxilla examined, 73.5% (147) showed the presence of the PSAA with 69.2% ($n = 119$) out of the dentate group having the PSAA present and a total of 100% (28) in the edentulous group having the PSAA present. There was a statistically significant difference for the prevalence of PSAA between dentate and edentulous posterior maxilla ($p = 0.001$, Table 3).

Table 2. Demographic data and descriptive statistics of the CBCT images of the posterior maxilla.

	Dentate			Edentulous			
	Mean	SD	Range	Mean	SD	Range	*p*-value
Age	28.56	14.28	16-71	62.29	8.37	42-74	*0.000
	n	**%**		**n**	**%**		***p*-value**
Gender							0.806
Male	41	47.7		8	57.1		
Female	45	52.3		6	42.9		

*Independent *t*-test with *p*-value <0.05
†Chi square test with *p*-value <0.05

Table 3. Prevalence of the PSAA present in the posterior maxilla.

	% of PSAA present in posterior maxilla (no. of PSAA present / total posterior maxilla)			
Presence of PSAA	**Dentate**	**Edentulous**	**Total**	***p*-value**
Present	69.2% (119/172)	100% (28/28)	73.5% (147/200)	†0.001
Absent	30.8% (53/172)	0 (0/28)	26.5% (53/200)	

†Chi square test with *p* value < 0.05

Table 4 demonstrated the horizontal position of the PSAA in the maxillary sinus between dentate and edentulous posterior maxilla. Among the 147 arteries present in the CBCT, 103 of the PSAA (70.1%) were located intraosseously. Meanwhile, 42 (28.6%) and 2 (1.4%) of the PSAA were located intrasinus and superficially, respectively. There was no statistical significant difference among the dentate and edentulous posterior maxilla when comparing their horizontal positions (p = 0.652).

The vertical distances from the lower border of the canal to the alveolar crest and sinus floor were shown in Table 5. The total mean vertical distance between the lower border of the PSAA canal and the alveolar crest is 17.62 ± 4.72 mm, with those in edentulous posterior maxilla having greater mean of 19.07 ± 5.41 mm, as compared to those in dentate posterior maxilla (17.28 ± 4.50 mm). This difference was not statistically significant with p = 0.071.

Table 4. Horizontal position of PSAA.

Horizontal position of PSAA	% of PSAA horizontal position (n / total no of PSAA)			*p*-value
	Dentate	Edentulous	Total	
Intrasinus (%)	28.6 (34/119)	28.6 (8/28)	28.6 (42/147)	0.652
Intraosseous (%)	69.7 (83/119)	71.4 (20/28)	70.1 (103/147)	
Superficial (%)	1.7 (2/119)	0 (0/28)	1.4 (2/147)	

†Chi square test with *p* value < 0.05

Table 5. Vertical distances related to the PSAA between dentate and edentulous posterior maxilla.

Vertical distance (mm)	Dentate (n=119)		Edentulous (n=28)		*p*-value
	Mean (SD)	Min Max	Mean (SD)	Min-Max	
Between lower border of canal and alveolar crest, A	17.28 (4.5)	8.04 - 29.80	19.07 (5.41)	9.20 - 30.00	0.071
Between lower border of canal and maxillary sinus, B	6.78 (3.43)	0.40 - 17.00	9.24 (4.75)	0.60 - 23.00	*0.002
Between maxillary sinus and alveolar crest, C	10.52 (0.38)	1.02 - 26.00	9.83 (0.88)	2.60 - 20.80	0.439

*Independent t-test with p-value <0.05

On the other hand, the total mean vertical distance between the lower border of the PSAA canal to the maxillary sinus floor was 7.24 ± 3.84 mm. It showed a statistically significant difference between the dentate and edentulous posterior maxilla where the distance was greater in edentulous posterior maxilla when compared to the dentate posterior maxilla, with a mean vertical distance of 9.24 ± 4.75 mm for the edentulous posterior maxilla and a mean vertical distance of 6.78 ± 3.43 mm in the dentate posterior maxilla (p = 0.002).

The assessment of the vertical distance between the maxillary sinus floor and the alveolar crest showed a total mean distance of 10.39 ± 4.23 mm, in which it demonstrated a slightly higher vertical distance in the dentate posterior maxilla (10.52 ± 0.38 mm) when compared to edentulous posterior maxilla (9.83 ± 0.88 mm). Despite the difference in the vertical height for the dentate and edentulous posterior maxilla, it was not statistically significant (p = 0.439).

As shown in Table 6, the mean diameter of the PSAA canal was 1.09 ± 0.43 mm regardless of the dental status. In the dentate and edentulous posterior maxilla, the mean diameters of the canals were measured 1.10 ± 0.44 mm and 1.02 ± 0.38 mm respectively. There was no statistical significance between dentate and edentulous posterior maxilla (p = 0.383).

Table 6. Diameter of PSAA.

	Dentate (n=119)		Edentulous (n=28)		*p*-value
	Mean (SD)	Min Max	Mean (SD)	Min Max	
Diameter of PSAA (mm)	1.10 (0.44)	0.30 - 2.04	1.02 (0.38)	0.30 - 1.80	0.383

*Independent *t*-test with *p*-value <0.05

Discussion

The importance of taking a CBCT prior to any posterior maxillary surgery to locate the PSAA has been advocated by many surgeons to ensure intraoperative haemorrhage due to the damage to the PSAA can be prevented. This current study found that the PSAA could be detected in the majority of the posterior maxillary CBCT scans (73.5%) with 69% of them being detected in dentate patients and 100% in edentulous patients. Although there is a huge variability in the detection of PSAA in the lateral wall of the maxillary sinus, the prevalence of PSAA present in our study sample were within the reported range of 64% to 92% (Anamali *et al.*, 2015; Güncü *et al.,* 2011). Our study found that the PSAA is significantly more prevalent in edentulous patients (p = 0.001) as 100% of the edentulous posterior maxilla showed the presence of intraosseous PSAA. This finding is supported by a clinical tomographic study of the intraosseous PSAA done by Dias *et al.* where there was also a significantly higher prevalence of PSAA in edentulous compared to the dentate patients (Dias *et al.*, 2019). This finding serves as an important clinical implication as these edentulous patients are the major candidates for the pre-implant sinus lifting procedure. Several studies supported the importance of detecting the PSAA using CBCT prior to any surgical procedure involving the posterior maxilla to reduce the inadvertent injury to the PSAA (Chitsazi *et al.*, 2017; Dias *et al.*, 2019; Shahidi *et al*., 2016).

When the PSAA is not detected in the maxillary sinus walls, the PSAA is possibly having an extra-osseous course where the artery may be travelling within the buccal mucosa, underneath the periosteum or inside the sinus wall. When this study assessed the horizontal position of the artery, the most common position of the artery is in intraosseous with the prevalence of 70% as compared to the other intrasinus and superficial locations. Other studies also found that the most common position of the artery was intraosseous (Chitsazi *et al.*, 2017; Shahidi *et al.*, 2016; Varela-Centelles *et al.*, 2020). There was no statistical significant difference between the dentate and edentulous groups when assessing their horizontal positions. The same result was also reported by Dias *et al*. where the intraosseous PSAA was detected more in edentulous patients as compared to dentate patients (Dias *et al.*, 2019). Other locations of the PSAA were also detected at intrasinusal (28%) and superficial near the periosteum of the buccal cortex (1.4%) in tandem with other CBCT studies (Jung *et al*., 2011; Panjnoush *et al.*, 2017) This provided an important information with regards to the surgical flap when the lateral approach of the sinus lifting procedure was planned. The superficial positions of the artery towards the buccal mucosa or the sinus lining has an increased risk of intraoperative haemorrhage as a result of injury to the artery (Ella *et al*., 2008; Hong and Mun, 2011). Knowing this anatomy gives the surgeon an awareness towards the surgical design.

It is crucial to assess the vertical locations of the artery in relation to the alveolar crest and sinus floor especially in the pre-implant prosthetic surgery. This present study found a mean vertical distance between the lower border of the canal to the maxillary sinus floor to be 7.24 ± 3.84 mm which was within the range of approximately 5 mm to 11 mm found in a few other studies (Valente, 2016; Yusof *et al*., 2020). Our statistical test has

also revealed that there was a significant difference between the dentate and edentulous posterior maxilla with the edentulous group having a greater distance to the sinus floor. The sinus pneumatization towards the extracted site that occurred after extraction or loss of posterior teeth may have contributed to the greater distance of the artery to the sinus floor (Rosano *et al.*, 2010). This information is crucial in making the surgical plan of the intended amount of height for sinus lift procedure.

On the other hand, the mean vertical distance between the lower border of the canal to the alveolar crest has been reported to have wide disparities (from 11.2 to 18.1 mm) and our result has shown to be within the reported range (17.62 ± 4.72 mm) (Güncü *et al.*, 2011, Kgiku *et al.*, 2013; Rosano *et al.*, 2011). This wide variation is likely due to the variations in the residual crest height (Varela-Centelles *et al.*, 2020). In terms of dental status, this study showed no significant difference between dentate and edentulous posterior maxilla. This finding is also similar to a study by Panjnoush *et al.* in which there was also no significant difference in this distance between dentate and edentulous patients (Panjnoush *et al.*, 2017). However, in a study by Yusof *et al.*, they stated that this distance was statistically significantly lower in the edentulous posterior maxilla.

Previous literature stated that during sinus elevation procedure, the bone window height created must be at least 13 mm in order to place a 10 - 12 mm implant and the window height should not exceed 15 mm from the alveolar crest (Yusof *et al.*, 2020). This requirement is proven to be a concern in severely atrophied ridges in edentulous patients and it was evident in their study as the mean distance of the artery from the alveolar ridge in edentulous patients was 15.1 ± 3.0 mm. In our study, the mean distance obtained for edentulous patients was 19.07 ± 5.41 mm which is evidently higher than the previous report. However, this is probably due to the patients having residual ridges that have not severely resorbed yet. This can be explained by another finding in our study where the vertical distance between the maxillary sinus floor to the alveolar crest between the dentate and edentulous posterior maxilla showed no significant difference. Therefore, the assumption can be made that the majority of the edentulous patients in this study would not face a higher risk of damaging the artery while creating a bony window during sinus elevation procedure.

In similar studies, the authors found that older patients tend to have arteries with a larger diameter. However, based on the results found by Yusof and colleagues, a narrower artery was more common in edentulous patients with a mean diameter of 1.0 mm or less whereas the mean diameter of the artery in dentate patients was 1.0 mm or more (Yusof *et al.*, 2020). The mean diameter of the canal found in the current study was 1.09 ± 0.43 mm regardless of dentition and showed no statistical significance between dentate and edentulous patients. Tehranchi *et al.* reported an almost similar mean diameter of 1.29 ± 0.39 mm (Tehranchi *et al.*, 2017). Other papers reported that the mean diameter contributes significantly to the detection of the artery canal (Güncü *et al.*, 2011, Kang *et al.*, 2013, Wallace *et al.*, 2007,). The arteries observed in this study were large enough to be detected in a CBCT scan. Unfortunately, the mean diameter obtained was already entering a risky range because when an artery is larger than 1.0 - 2.5 mm, it may have a higher risk of haemorrhage. In contrast, smaller arteries with a diameter measuring less than 1.0 mm would not cause life-threatening haemorrhage if transection of the artery occurred (Güncü *et al.*, 2011, Wallace *et al.*, 2007). Despite the diameter, damage to the artery will inadvertently lead to some bleeding that may hinder the surgical access and visualisation during sinus elevation procedure which predisposes the patients to haemorrhage (Ella *et al.,* 2008; Jung *et al.*, 2011).

Conclusion

PSAA was detected in 73.5% of the cases and intraosseous PSAA being the most common horizontal position in both dentate and

edentulous patients. Dentate patients have slightly larger arteries than edentulous patients. Precautions should be taken during procedures involving the posterior maxilla as the PSAA is located less than 18 mm from the alveolar ridge with a diameter of around 1mm. These information may help surgeons in estimating the window design to avoid damaging the arterial supply during sinus augmentation and implant placement. Therefore, this study proved that preoperative evaluation of the location of PSAA in CBCT is vital to reduce the risk of intraoperative bleeding that may complicate the treatment.

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References

Anamali, S., Avila-Ortiz, G., Elangovan, S., Qian, F., Ruprecht, A., Finkelstein, M. (2015). Prevalence of the posterior superior alveolar canal in cone beam computed tomography scans. *Clinical Oral Implants Research*, 26, e8-12.

Cheng, J., and Hacking, C. (2023). Posterior superior alveolar artery. Radiopaedia.org. https://doi.org/10.53347/rID-56563

Chitsazi, M.T., Shirmohammadi, A., Faramarzi, M., Esmaieli, F., Chitsazi, S. (2017). Evaluation of the position of the posterior superior alveolar artery in relation to the maxillary sinus using the Cone-Beam Computed Tomography scans. *Journal of Clinical and Experimental Dentistry*, 9(3), e394-e399.

Danesh-Sani, S.A., Movahed, A., ElChaar, E.S., Chong Chan, K., & Amintavakoli, N. (2017). Radiographic evaluation of maxillary sinus lateral wall and posterior superior alveolar artery anatomy: A Cone-Beam Computed Tomographic Study. *Clinical Implant Dentistry and Related Research*, 19, 151–160.

Dias, E.C., Santos, J.B., Cotrim, K.C., Brito, F.C. (2019). Tomographic evaluation of the prevalence of the intraosseous branch of the posterior superior alveolar artery. *Journal of Oral and Maxillofacial Radiology*, 7(3), 60-65.

Ella, B., Se´darat, C., Noble, R.D.C., Normand, E., Lauverjat, Y., Siberchicot, F. (2008). Vascular connections of the lateral wall of the sinus: surgical effect in sinus augmentation. *The International Journal of Oral & Maxillofacial Implants*, 23, 1047–1052.

Gofur, E.M., Al Khalili, Y. (2023). Anatomy, head and neck: internal maxillary arteries. In: StatPearls. Treasure Island (FL): StatPearls Publishing. PMID: 31194441.

Güncü, G.N., Yildirim, Y.D., Wang, H-L., Tözüjm, T.F. (2011). Location of posterior superior alveolar artery and evaluation of maxillary sinus anatomy with computerized tomography: a clinical study. *Clinical Oral Implants Research*, 22, 1164–1167.

Hong, Y.H. and Mun, S.K. (2011). A case of massive maxillary sinus bleeding after dental implant. *International Journal of Oral and Maxillofacial Surgery*, 40, 758-760.

Jung, J., Yim, J-H., Kwon, Y-D., Al-Nawas, B., Kim, G-T., Choi, B-J., Lee, D-W. (2011). A radiographic study of the position and prevalence of the maxillary arterial endosseous anastomosis using Cone Beam Computed Tomography. *International Journal of Oral & Maxillofacial Implants*, 22, 1274-1278.

Kang, S.J., Shin, S.I., Herr, Y., Kwon, Y.H., Kim, G.T., Chung, J.H. (2013). Anatomical structures in the maxillary sinus related to lateral sinus elevation: a cone beam computed tomography analysis. *Clinical Oral Implants Research*, 24, 27-81.

Kqiku, L., Biblekaj, R., Weiglein, A.H., Kqiku, X., Städtler, P. (2013). Arterial blood architecture of the maxillary sinus in dentate specimens. *Croatian Medical Journal,* 54, 180–184. https://doi.org/10.3325/cmj.2013.54.180

Padovani, L.S., Oliveira, A.M.S.D., Dutra, B.C., Costa, F.O., Oliveira, P.A.D. (2020). Important anatomical variations of the superior posterior alveolar artery: Studied by cone beam computed tomography. *Anatomia, Histologia, Embryologia*. https://doi.org/10.1111/ahe.12584

Pandharbale, A.A., Gadgil, R.M., Bhoosreddy, A.R., Kunte, V.R., Ahire, B.S., Shinde, M.R., & Joshi, S.S. (2016). Evaluation of the posterior superior alveolar artery using Cone Beam Computed Tomography. *Polish Journal of Radiology*, 81, 606–610. https://doi.org/10.12659/PJR.899221

Panjnoush, M., Ghoncheh, Z., Kaviani, H., Moradzadehkhiavi, M., Shahbazi, N., Kharrazifard, M.J. (2017). Evaluation of the position and course of the posterior superior alveolar artery by Cone-Beam Computed Tomography in an Iranian Population. *Journal Islamic Dental Association of Iran*, 29 (3).

Rosano, G., Taschieri, S., Gaudy, J.F., Weinstein, T., DelFabro, M. (2011). Maxillary sinus vascular anatomy and its relation to sinus lift surgery. *Clinical Oral Implants Research*, 7, 711–715. https://doi.org/10.1111/j.1600-0501.2010.02045.x.

Rysz, M., Ciszek, B., Rogowska, M., Krajewski, R. (2014). Arteries of the anterior wall of the maxilla in sinus lift surgery. *International Journal of Oral and Maxillofacial Surgery*, 43(9), 1127–1130.

Shahidi, S., Zamiri, B., Momeni, D.S., Salehi, S., Hamedani, S. (2016). Evaluation of anatomic

variations in maxillary sinus with the aid of Cone Beam Computed Tomography (CBCT) in a population in South of Iran. *Journal of Dentistry*, 17(1),7- 15.

Tehranchi, M., Taleghani, F., Shahab, S., Nouri, A. (2017). Prevalence and location of the posterior superior alveolar artery using cone-beam computed tomography. *Imaging Science in Dentistry*, 47(1), 39-44.

Valente, N.A. (2016). Anatomical considerations on the alveolar antral artery as related to the sinus augmentation surgical procedure. *Clinical Implant Dentistry and Related Research*, 18, 1042–1050. https://doi.org/10.1111/cid.12355

Varela-Centelles, P., Loira, M., González-Mosquera, A., Romero-Mende,z A., Seoane, J., García-Pola, M.J., *et al.* (2020). Study of factors influencing preoperative detection of alveolar antral artery by CBCT in sinus floor elevation. *Scientific Reports*, 10(1), 10820. https://doi.org/10.1038/s41598-020-67644-9

Wallace, S.S., Mazor, Z., Froum, S.J., Cho, S.C., Tarnow, D.P. (2007). Schneiderian membrane perforation rate during sinus elevation using piezosurgery: Clinical results of 100 consecutive cases. *International Journal of Periodontics & Restorative Dentistry*, 27, 413-419.

Yusof, M.Y.P.M., Mah, M.C., Reduwan, N.H., Kretapirom, K., Affendi, N.H.K. (2020). Quantitative and qualitative assessments of intraosseous neurovascular canals in dentate and posteriorly edentulous individuals in lateral maxillary sinus wall. *The Saudi Dental Journal*, 32(8), 396-402.

ORIGINAL ARTICLE

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The effect of disinfection protocols on dimensional accuracy of irreversible hydrocolloids and *Candida albicans* colonisation

Norfaezah Ahmad[1]*, Nur Dini Ahmad Zawawi[2], Nur Farah Athirah Muhammad[2], Siti Hajjar Nasir[3], Mohd Hafiz Arzmi[4,5]

[1]*Department of Prosthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Kuantan, Pahang, Malaysia.*
[2]*Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Kuantan, Pahang, Malaysia.*
[3]*Department of Orthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Kuantan, Pahang, Malaysia.*
[4]*Department of Fundamental Dental and Medical Science, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Kuantan, Pahang, Malaysia.*
[5]*Cluster of Cancer Research Initiative IIUM (COCRII), International Islamic University Malaysia, Kuantan Campus, Pahang, Malaysia.*

Abstract

Irreversible hydrocolloid is a widely used impression material in dental practices. However, improper disinfectant protocols may affect the dimensional accuracy of the cast and increase susceptibility towards cross-infection. This study investigated the effect of disinfectants and disinfection protocols on the dimensional accuracy of alginate impression and *Candida albicans* biofilm formation. For methodology, an alginate impression was developed using an acrylic maxillary edentulous master cast with 3 reference points. 60 3cm round alginate beads were synthesised and treated with 2% Aseptoprint, 1% sodium hypochlorite (NaOCl) or 3% MD 520 solutions for 2 min, 1 h, 6 h, and 24 h. For the antibiofilm assay, beads were inoculated with *C. albicans* (ATCC MYA 4901) for 24 h, and Colony-Forming Units (CFUs) were counted using a haemocytometer, then analysed via two-way Analysis of Variance (ANOVA). Dimensional accuracy was assessed by treating the developed alginate impressions in 2% Aseptoprint, 1% NaOCl, and 3% MD 520, respectively, for 2 min, 1 h, 6 h, and 24 h. Three linear measurements were obtained and compared against the master cast and analysed statistically using Friedman Tests. The results showed that a significant reduction of CFUs was recorded after disinfection with 3% MD 520 and 2% Aseptoprint ($P < 0.05$). Dimension of alginate impressions was significantly changed after 6 and 24 h of disinfection time. In conclusion, the use of 3% MD 520 and 2% Aseptoprint with 1 hour immersion time is recommended for effective alginate impression disinfection with minimal change in dimensional accuracy.

Keywords: *Candida albicans, dimensional accuracy, infection control, irreversible hydrocolloid*

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***Corresponding author**
Address:
Department of Prosthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

Telephone: +60192697997

Email address:
drfaezah@iium.edu.my

Introduction

Infection control is paramount in every dental protocol, such that healthcare professionals are compelled to practice standard infection control in clinical settings to avoid the risk of cross-infection between dental practitioners, patients, and other dental auxiliaries. The principal transmission route to dental technicians is via improperly disinfected dental impressions in the clinic. According to Arzmi *et al*. (2015), dental impressions taken using any type of materials will be contaminated with the patient's saliva and blood that contain various interkingdom microorganisms. Infectious diseases, such as Hepatitis B, have a higher risk of cross-contamination since the hepatitis B virus surface antigen is commonly detected in the saliva of infected individuals (Kamimura *et al.*, 2021). Additionally, a recent study reported that approximately 67% of materials delivered to dental laboratories are exposed to diverse infectious microorganisms (Jain & Nur, 2018). Given that the spread of infectious diseases can be prevented through proper infection control protocols, disinfection of dental impressions is considered a top priority, which can be attained through the spray or immersion technique.

In dental clinics, impression-making is a common procedure that records hard and soft tissue details for diagnostic investigation, prostheses construction, orthodontics study models, and other purposes. An excellent impression should reproduce accurate details, exhibit good tear strength, and is unaltered when removed from the mouth. Impression materials can be classified into two types: elastic and non-elastic. In addition, the elastic type of impression can be further divided into aqueous and non-aqueous. The irreversible hydrocolloid (alginate) is an example of aqueous elastic impression material and has been broadly used as an impression material in dental practices due to its low cost, hydrophilic, ease of handling, and pleasant taste and odour. Nevertheless, alginates exhibit weak dimensional stability and are more vulnerable to alterations during the disinfection process compared to elastomeric materials (Al-Harby & Ibrahim, 2011). A recent study by Joana *et al.* (2013) concluded that irreversible hydrocolloid is a potential vehicle for microbial transmission and carries two to three times more microbes than elastomeric impressions. Besides, alginates' porous nature and high water content require special considerations in the disinfection protocol (Doddamani, 2011), which imparts additional labour, cost, and inconvenience for its practical application.

A mould must be dimensionally stable and has highly detailed reproduction for the restorative treatment to be clinically successful according to Doddamani, 2011. Previously, Guiraldo *et al.* (2014) discovered that the final alginate structure is extremely sensitive to the volume of water in the fibrillar structure. Consequently, the dimensional stability of an irreversible hydrocolloid mould is highly vulnerable to changes in the water content. Irreversible hydrocolloids may undergo mould expansion by imbibition (water sorption) or mould shrinkage due to syneresis (water loss), which compromises the detailed reproduction and dimensional stability of the mould. Fahimeh *et al.* (2011) deduced that the use of the immersion technique is bound by a time limit as the material is susceptible to wet conditions.

An ideal disinfectant should possess a dual functionality, which includes serving as an effective antimicrobial agent and simultaneously preserving the dimensional accuracy and surface features of the impression material as well as the resultant gypsum cast without any side effects (Walker *et al.*, 2010 and Amin *et al.,* 2009). Practically, it is rarely possible to disinfect the impressions within the recommended disinfection time due to common setbacks in dental clinics, such as the long queue of patients. Generally, dental impressions are soaked in the disinfectant longer than the recommended immersion time. However, this practice could induce changes in the dimensional accuracy of the impression and

potentially affect the fit of future prostheses or appliances (Kotsiomiti *et al.*, 2008).

To date, numerous disinfectants are available and are utilised according to the manufacturer's instructions. Sodium hypochlorite (NaOCl), glutaraldehyde, iodophor, and phenol are among the frequently used disinfecting agents, particularly for dental impressions in dentistry. However, the suitability of certain disinfectants has been disputed due to the potential effect of the disinfectant and the extent of distortion or degradation on the impressions (Rentzia *et al.,* 2011). Thus, selecting compatible disinfection and proper protocol is essential to minimise the risk of microbial infections, simultaneously preserve the integrity and dimension of the impressions, and ensure a fitting prosthesis and accurate model construction study.

Apparently, various studies have explored the effect of disinfectants on the dimensional accuracy of alginate impressions. Nevertheless, the antimicrobial activity and performance of three types of the most common disinfectants, including Aseptoprint, NaOCl, and MD 520, have not been reported. Thus, this two-stage study was performed to investigate the effect of several disinfectants and treatment protocols on the dimensional accuracy of irreversible hydrocolloid and biofilm formation of *Candida albicans*.

Materials and Methods

Preparation of disinfectants

Three types of commonly used disinfectant solutions in clinical settings were selected for this study, namely: Aseptoprint (OCC Switzerland), sodium hypochlorite (NaOCl), and MD 520 (Durr Dental). The disinfectants were prepared as follows: 10 mL of Aseptoprint was mixed with 500 mL of water to achieve 2% Aseptoprint; 1 mL of Clorox was mixed with 100 mL of water to yield 1% NaOCl; 30 mL of MD 520 was mixed with 970 mL of water to produce 3% MD 520. The study design is an in vitro study.

Preparation of impression

An acrylic maxillary edentulous master cast was constructed with reference points A, B, and C. The reference points were made by small pointed acrylic prominences at the approximate position of the incisive papilla (A) and left and right maxillary tuberosity (B and C), as shown in Figure 1.

The alginate impression was developed using the Hydrocolor 5 alginate powder (Zhermack SpA, Italy) on a spaced and perforated special tray (Vertex, Netherlands). The alginate powder-to-water ratio was measured using respective measuring scoops according to the manufacturer's instructions. An alginate mixer (Motion F1, Taiwan) was used to blend the mixture for 10 sec to form a homogenous alginate mixture. The impressions were then immediately cast with Gypsum Type 3 (Sheralpin, Germany) mixed in a Vacuum Mixer (Motova 100, Bremen, Germany) and allowed to set at room temperature. The vibrator (Denstar 510, Korea) was used to eliminate small air bubbles on the cast surface during the pouring procedure. Finger pressure was used to fix the special tray loaded with alginate to the master cast. For standardisation, one operator repeated the same steps to all 12 impressions. The impressions were then left to set for 5 min. The experimental casts were allowed to sit at room temperature for an hour before being separated from the impressions.

Preparation of alginate beads

Rubber cups were used as the mould to synthesise 60 round alginate beads with the size of 3 cm in diameter each. The beads were then wrapped with wet gauze and sealed in plastic bags to prevent water from evaporating the beads. Then, the beads were treated with 2% Aseptoprint, 1% NaOCl or 3% MD 520 solutions at different immersion times of 2 min, 1 h, 6 h, and 24 h. The beads were soaked in distilled water at each immersion time to serve as the control. Once the disinfection is complete, the beads were stored at 4 °C.

Growth of microorganism

Candida albicans (ATCC MYA 4901) were provided by the Cluster of Cancer Research Initiative IIUM (COCRII) for this study. The yeast was revived from glycerol stock in a sterile nutrient broth (NB) and incubated at 37 °C aerobically for 24 h.

Antibiofilm assay

Approximately 5 mL of *C. albicans* suspension was inserted into new sterile containers using a pipette. A single alginate bead was then transferred into the yeast suspension and incubated at 37 °C for 24 h. Note that the bead was fully submerged in the yeast suspension to ensure full contact between the bead and the yeast. Following the incubation, the bead was removed from the suspension and rinsed with 1 mL of phosphate buffer saline (PBS) before being transferred into a new sterile container containing sterile PBS. The containers were agitated for 60 sec to remove the biofilm from the bead. Next, approximately 100 µL of each sample was pipetted and inserted onto a haemocytometer (Neubauer Assistant, Germany) to quantify the Colony-Forming Unit (CFU) of the viable *C. albicans* cell under a light microscope (Olympus, Japan). The assay was conducted in triplicates.

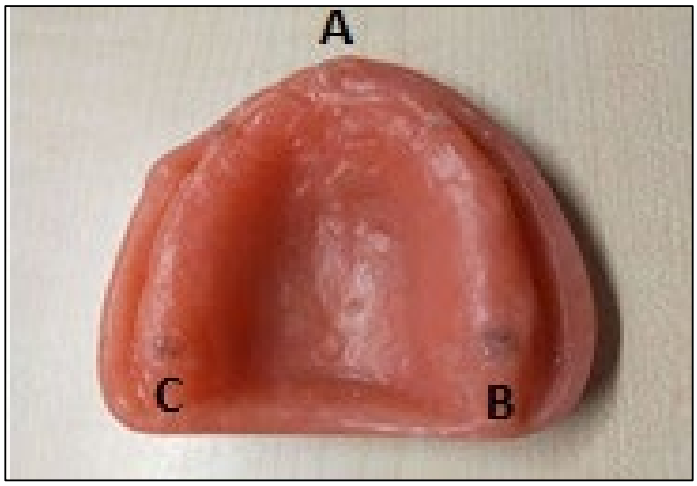

Figure 1. Maxillary edentulous master cast and the position of reference points.

Dimensional accuracy

The developed impressions were divided into three main groups. The first group of four impressions were immersed in 2% Aseptoprint, while the second group of four impressions were immersed in 1% NaOCl. The third group of four impressions were immersed in 3% MD 520. All three groups were immersed in the respective disinfectant for 2 min, 1 h, 6 h, and 24 h. Following the immersion process, all impressions were wrapped with damp gauze and sealed in a plastic bag during transportation to the dental laboratory to prevent water evaporation.

For the dimensional accuracy analysis, three readings were measured for each linear measurement (A-B, A-C, B-C) of each experimental cast, including the master cast as the control. A digital calliper (Mitutoyo 0–150 mm; Japan) with an accuracy of $\pm$0.01 mm was used for the measurement. The collected data were analysed.

Statistical analysis

The statistical analysis was conducted using SPSS Statistic software version 27. The two-way ANOVA was applied to assess the anti-biofilm activity by determining the significant difference between the disinfection protocols. A *P*-value of 0.05 was considered significant. In addition, the dimensional accuracy was evaluated using the Friedman Test at a significance value of 0.05 based on the setting in the SPSS software. The test was

performed to investigate the differences in the dimension between the master cast and the three groups of different disinfectant solutions with different immersion times.

Result

Antibiofilm activity

Table 1 shows the mean count of the viable *C. albicans* from all impressions that were immersed in the respective disinfectants. From the table, the lowest CFU count across all immersion times was recorded by the 3% MD 520 compared to other disinfectants. However, the 3% MD 520 and 2% Aseptoprint showed a significant decrease in the CFU count compared to the control group at 2 min and 1 h immersion times ($P < 0.05$). In addition, the 6 h immersion time was insignificant for all disinfectants ($P > 0.05$). In terms of the immersion time, it was found that a prolonged immersion time leads to a lower *C. albicans* count.

A linear graph of CFU count at different immersion times is illustrated in Figure 2. The graph depicts the disinfection efficacy of each disinfectant with the lowest mean of *C. albicans* count obtained using 3% MD 520 solution, followed by 2% Aseptoprint and 1% NaOCl.

Table 1. Means and standard deviations of CFU of C. albicans counted from alginate beads immersed in different disinfectants and immersion time. The study was conducted in triplicate (N = 3).

	CFU x 10^4 (mL)			
Time	**Control**	**2% Aseptoprint**	**1% NaOCl**	**3% MD 520**
2 min	3.17 (0.14)	1.90 (0.97)[a]	2.50 (0.50)	1.33 (1.50)[a]
1 h	2.83 (0.14)	1.70 (0.34)[a]	1.30 (1.20)	0.67 (0.58)[a]
6 h	1.25 (0.43)	1.30 (0.34)	1.90 (0.51)	0.67 (0.58)
24 h	1.22 (0.19)	1.10 (1.20)	1.30 (0.58)	0.00 (0.00)[a]

[a]Significant difference (P < 0.05)

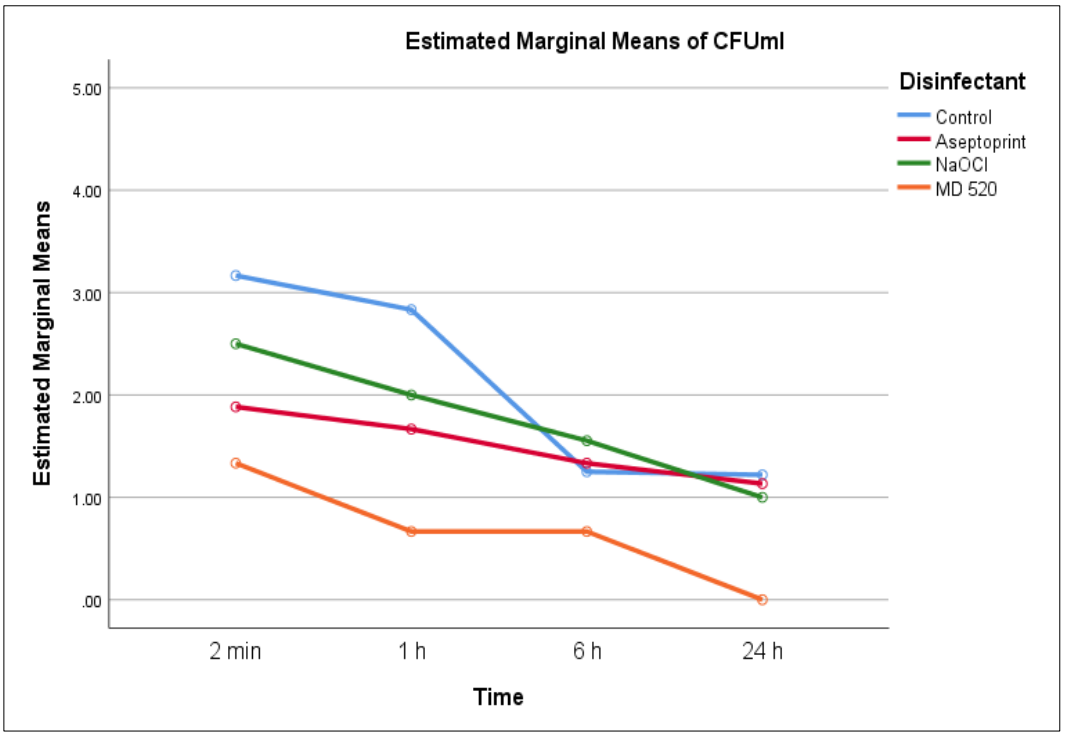

Figure 2. C. albicans count (CFU) in alginate beads immersed in different disinfectants and at different immersion times.

Dimensional accuracy

Table 2 lists the mean and standard deviation of the linear measurements of the constructed alginate impression casts that were disinfected using 2% Aseptoprint, 1% NaOCl, and 3% MD 520 at different immersion times. Generally, the dimensions of all disinfectants recorded an insignificant difference at 2 min and an hour of immersion time. However, a significant difference ($P < 0.05$) was observed in the dimensions when immersed in 1% NaOCl and 3% MD 520 for 6 h. Additionally, the measured dimension of all three disinfectants exhibited a significant difference when immersed in the disinfectants for 24 h ($P < 0.05$).

Figure 3 illustrates demonstrates the increasing patterns for all linear measurements (A-B, A-C, B-C). The results imply that the dimensions of the experimental casts increased following the immersion in all three disinfectants for 2 min, 1 h, 6 h, and 24 h compared to the constant dimension of the master cast.

Table 2. Mean and standard deviation of all linear measurements on the master cast and experimental casts constructed from alginate impressions immersed in different disinfectants and immersion times.

Disinfectant	Time	Mean distance (standard deviation) in mm
Master cast	-	48.94 (0.77)
2% Aseptoprint	2 min	49.17 (0.67)
	1 h	49.26 (0.26)
	6 h	49.37 (0.60)
	24 h	49.47 (0.59)[a]
1% NaOCl	2 min	49.14 (0.67)
	1 h	49.29 (0.61)
	6 h	49.37 (0.59)[a]
	24 h	49.45 (0.62)[a]
3% MD 520	2 min	49.15 (0.67)
	1 h	49.22 (0.65)
	6 h	49.40 (0.57)[a]
	24 h	49.46 (0.58)[a]

[a]Significant difference (P < 0.05)

Discussion

Disinfection procedure is a routine clinical practice that essentially protects dental personnel against exposure to infectious microbial diseases, including viruses; hepatitis B, hepatitis C, herpes, Human Immunodeficiency Virus (HIV), and Mycobacterium tuberculosis, when directly handling the impressions, according to Hemalatha & Ganapathy, 2018. Previously, it was reported that microorganisms were more persistent in irreversible hydrocolloid impressions, which makes it more challenging during the disinfection process (Vatansever, 2013). Additionally, a recent study by Sukhija *et al.* (2010) revealed that impressions of dentulous patients convey twice the amount of microbial load compared to that of edentulous patients. Thus, proper disinfection protocol is vital to ensure effective antimicrobial activity and to prevent cross-infection among dental practitioners. Concurrently, it is crucial to determine the optimal immersion time so that the physical properties of the irreversible hydrocolloid impressions are maintained since the slightest change in the dimensional accuracy of the constructed cast may affect the fit of future prostheses or appliances.

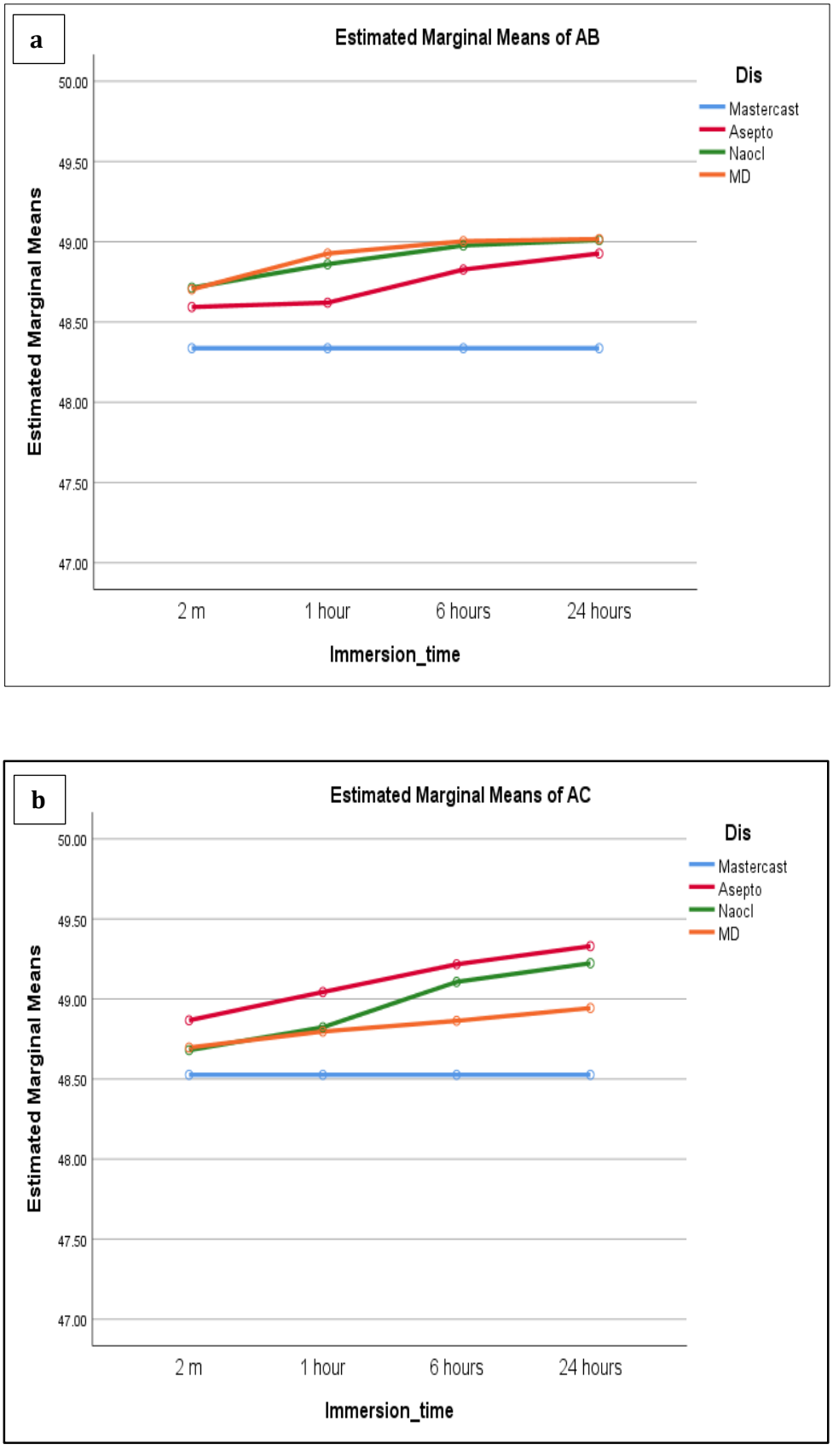

Figure 3. Means of dimensions for linear measurements A-B (a), A-C (b) and B-C(c) on casts produced from impressions immersed in different disinfectants and different immersion times.

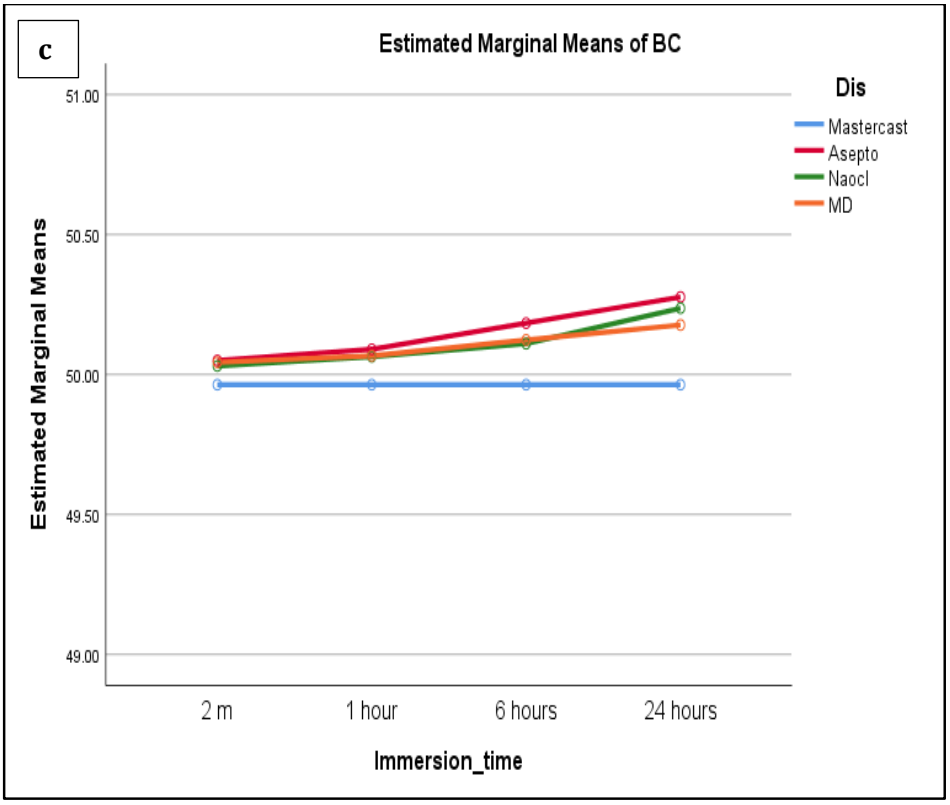

Figure 3 (continued).

C. albicans was employed in this study since it is one of the most prevalent oral microflora species. In addition, numerous studies including Dasgupta *et al.,* 2013 and Samra & Bhide (2010) have reported the presence of yeast on alginate impressions. According to Ferreira *et al*. (2017), *C. albicans* is the main causative microorganism for denture-related infections, which induces inflammation and erythematous condition of the oral mucosa or denture stomatitis, especially the upper dentures. Moreover, Badrian *et al.* (2012) stated that Candida is a common opportunistic fungal organism that causes oral candidiasis in immunocompromised patients. Among all fungi, Candida species are the most persistent colonisers in the oral cavity and have adapted to reside as a commensal (Patel, 2022), indicating the importance of effective disinfection of all impression materials prior to sending them to the laboratory.

For comparative purposes, the control group was not treated with any disinfectants but was only immersed in distilled water. As expected it was found that the fungal colony was still present after being immersed in distilled water. This is consistent with the study by Taylor *et al.* (2002), who reported that using distilled water could reduce the microbial count up to 50–90%, but not 100%. In another study, Joana *et al.* (2013) recorded that the microbial load of alginate impression decreased significantly by 48.5% after being washed with distilled water. Nevertheless, an effective disinfection procedure is still needed due to the significant presence of other microorganisms that remain on the dental impressions.

This study applied the immersion disinfection technique over the spray method. This was based on the report by Fahimeh *et al.* (2011) that considered the spraying technique's effectiveness inferior to the immersion technique due to less contact time between the impression and the disinfectant. Samra and Bhide (2010) also stated that the immersion method is the most reliable disinfection method because the surface of the impressions is fully

submerged and in direct contact with the disinfectant. Additionally, chemical disinfectants can be divided into three categories. High-level disinfectants, such as glutaraldehyde, can deactivate spores, while intermediate-level disinfectants, which include formaldehyde, chlorine-based compounds, iodophors, and alcohols phenolic compounds, may not deactivate spores but can eliminate other microorganisms. In contrast, low-level disinfectants, such as quaternary ammonium compounds and simple phenols, are unqualified to function as disinfecting agents to treat contaminated dental impressions.

For this study, the performance of two types of high-level disinfectants comprising NaOCl (a derivative of chlorine compound) and MD 520 (glutaraldehyde-based) and one intermediate-level disinfectant, namely Aseptoprint (alcohol-based) was evaluated. Based on the results, the lowest Candida count was obtained from impressions immersed in 3% MD 520 solution in 24 h, indicating the highest antibiofilm activity, followed by 2% Aseptoprint and 1% NaOCl. Hence, 1% NaOCl showed the least efficiency for the removal of *C. albicans.*

Similar findings were reported in past studies. For instance, Demajo *et al.* (2016) demonstrated the effective use of glutaraldehyde-based disinfectant (MD 520) and alcohol-based disinfectant on alginate impressions. The MD 520 eliminated all microbes compared to that of the alcohol-based disinfectant. This finding was supported by Aeran *et al.* (2015), who recorded 100% removal of microbial colonies via immersion in 2% glutaraldehyde. Another study by Ahsan *et al.* (2013) concluded that 2% glutaraldehyde exhibited a higher antimicrobial effect compared to 1% NaOCl. On the contrary, Samra *et al.* (2010) reported a contradicting result in which NaOCl immersion achieved a greater efficiency compared to that of glutaraldehyde, which might be due to the use of a higher concentration of NaOCl at 5.25%. This was in line with the American Dental Association (ADA) recommendation, which suggests NaOCl as an effective disinfectant at a 1:10 dilution with a 10-minute immersion duration to disinfect irreversible hydrocolloid impressions (ADA, 1996).

In terms of the immersion time, a longer immersion time yields a higher reduction of *C. albicans* cell count. However, Bustos *et al.* (2010) found that the immersion of impressions in 0.5% NaOCl or 2% glutaraldehyde for 5 min was sufficient to achieve effective disinfection. Besides, it is important to reduce immersion time to maintain the dimensional stability and surface integrity of the impression materials. This was demonstrated through the dimensional accuracy assessment, where the immersion in MD 520 and NaOCl for 6 h and 24 h, respectively, resulted in a discrepancy in the linear measurements compared to the master cast. However, immersion for 2 min and 1 h did not show any difference in the measured dimensions for all three disinfectants.

Previously, Taylor *et al.* (2002) stated that the immersion of alginate impressions for an hour or above substantially affected the dimensional accuracy of the materials. In another study, the effect on alginate after 60 min of immersion in 2% glutaraldehyde showed no significant different dimensional changes (Peutzfeldt & Asmussen, 1989). This finding contradicted a study by Ismail *et al.* (2017), who recorded a statistically significant difference in the dimensional accuracy of alginate impression after being disinfected with 1% NaOCl and 2% glutaraldehyde for 1 h. Meanwhile, Amalan *et al.* (2013) showed that NaOCl induced surface alterations and reduced the detailed reproduction of the irreversible hydrocolloids. However, these alterations were below the 1.5% acceptable clinical limit, as established by the ISO guideline (ADA, 1992).

In addition, Ulgey *et al.* (2020) studied the comparison of dimensional accuracy of alginate impression between 15- and 30-min immersion time and found that 15 min immersion time caused minimal distortion in all the distances of impression compared to that of 30 min. This indicates that the

dimensional accuracy correlates with immersion time and is consistent with the present study. The alginate impression experienced a higher water absorption with increasing immersion time, corresponding to the casts' increasing dimensions following the disinfection process. The structure of alginates is susceptible to expansion as a result of water absorption or shrinkage due to moisture loss via evaporation (Wadhwa *et al.*, 2013). The result is in agreement with the findings by Ghada *et al.* and Ismail *et al.*, where they recorded an increase in linear measurements after the immersion of impression in the disinfectants.

Furthermore, Joana *et al.* (2013) found that glutaraldehyde-based disinfectant was effectively applied to remove all microbial forms from the alginate impressions without altering the dimensional stability. This finding is similar to the result of the present study, where 3% of MD 520 achieved the best antibiofilm properties with the least dimensional change. Nevertheless, one of the limitations of the present study is the use of the digital calliper with +0.01 mm accuracy to measure the distance between the reference points. It is recommended that future studies should employ a more sophisticated measurement, such as a scanned digital image of the cast and software, to precisely measure the distances of the casts.

Conclusion

This study successfully demonstrated the use of 3% MD 520 with an immersion time of 1 h to achieve the highest reduction of fungal count and minimal dimensional distortion of the irreversible hydrocolloid impression. Additionally, the immersion of 2% Aseptoprint reduced fungal count more efficiently than 1% NaOCl. Although a longer immersion time was effective against high fungal count in the irreversible hydrocolloids, significant changes in dimensional accuracy were recorded with more than 6 h immersion times. Overall, 3% MD 520 is considered a promising disinfecting agent for dental impression disinfection and other dental-related treatment.

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References

ADA Council on Scientific Affairs and ADA Council on Dental Practice (1996) Infection control recommendations for the dental office and the dental laboratory. *The Journal of the American Dental Association*, 127(5), 672-680.

Aeran, H., Sharma, S., Kumar, V., Gupta, N.(2015). Use of clinical UV chamber to disinfect dental impressions: a comparative study. *Journal of Clinical and Diagnostic Research*, 9(8), 67-70.

Ahsan, M.R., Islam, K..Z, Begum, J. (2013). Study on antimicrobial effect of disinfecting solutions on alginate impression materials. *Update Dental College Journal*, 3(1), 18-23.

Al-Harby, H.A., Ibrahim, K.B.I. (2011). The effect of certain disinfectant agents on alginate impression material. *Journal of Baghdad College of Dentistry*, 23(1), 13-16.

Amalan, A., Ginjupalli, K., Upadhya, N. (2013). Evaluation of properties of irreversible hydrocolloid impression materials mixed with disinfectant liquids. *Dental Research Journal (Isfahan)*, 10, 65-73.

Amin, W.M., Muna, H.A., Sandra, K.A.T., Sahar, T.T., Mohamed, W.S., Nadia, E. (2009). The effects of disinfectants on dimensional accuracy and surface quality of impression materials and gypsum casts. *Journal of Clinical Medicine Research*, 1(2), 81-89.

Arzmi, M.H., Dashper, S., Catmull, D., Cirillo, N., Reynolds, E.C., McCullough, M. (2015). Coaggregation of *Candida albicans*, *Actinomyces naeslundii* and *Streptococcus mutans* is *Candida albicans* strain dependent. *The Yeast Community Journal*, 15(5), 38.

Badrian, H., Ghasemi, E., Khalighinejad, N., Hosseini, N. (2012). The effect of three different disinfection materials on alginate impressions by spray

method. *Improvement Science Research Network*. 2012.

Bustos, J., Herrera, R., González, U., Martínez, A., Catalán, A. (2010). Effect of immersion disinfection with 0.5% sodium hypochlorite and 2% glutaraldehyde on alginate and silicone: Microbiology and SEM study. *International Journal of Odontostomatology*, 4(2), 169-177.

Dasgupta, D., Sen, S.K., Ghosh, S., Bhattacharyya, J., Goel, P. (2013). Effectiveness of mouthrinses and oral prophylaxis on reduction of microorganisms count in irreversible hydrocolloid impression: an in vivo study. *The Journal of Indian Prosthodontic Society*, 13(4), 578–586.

Doddamani, S., Patil, R., Gangadhar, S.A. (2011). Efficacy of various spray disinfectants on irreversible hydrocolloid impression materials: An *in vitro* study. *Indian Journal of Dental Research*, 22, 764-769.

Fahimeh, H.R., Ghaffari, T., Safavi, S.H. (2011). In vitro evaluation of dimensional stability of alginate impressions after disinfection by spray and immersion methods. *Journal of Dental Research, Dental Clinic, Dental Prospects*, 4(4), 130-135.

Ferreira, G., Rosalen, P.L., Peixoto, L.R., Pérez, A., Carlo, F., Castellano, L., *et al.* (2017). Antibiofilm activity and mechanism of action of the disinfectant chloramine on Candida spp., and its toxicity against human cells. *Molecular*, 22(9), 1527.

Ghada, H.B., Khalifa, N., Nasser, M. (2018). Dimensional accuracy of alginate impressions using different method of disinfectants with varying concentrations. *Compendium of Continuing Education in Dentistry*, 39(1), 17-20.

Guiraldo, R.D., Berger, S.B., Consani, R.L., Consani, S., Carvalho, R.V., Lopes, M.B., *et al.* (2014). Characterization of morphology and composition of inorganic fillers in dental alginates. *Biomed Research International*. 178064.

Hemalatha, R. and Ganapathy, D. (2016). Disinfection of dental impression- A current overview. *Journal of Pharmaceutical Sciences and Research*, 8(7), 661–664.

Ismail, H.A., Mahross, H.Z., Shikho, S. (2017). Evaluation of dimensional accuracy for different complete edentulous impressions immersed in different disinfectant solutions. *European Journal of Dentistry,* 11(2), 242-249.

Jain, A.R., Ahmad Fauzi., N.Q. (2018). Knowledge, attitude, and practice on various disinfectants used for impression materials among dental students and dental practitioners. *Drug Invention*, 10(1), 23-28.

Joana, C.S., Tabaio, A.M., Silva, A., Pereira, T., Benedita, S.M., Vasconcelos, M. (2013). The effect of water and sodium hypochlorite disinfection on alginate impressions. *Revista Portuguesa de Estomatologia Medicine Dentaria e Cirurgia Maxilofacial.* 54(1):8–12.

Kamimura, H., Watanabe, J., Sugano, T., Kohisa, J., Abe, H., Kamimura, K., *et al.* (2021). Relationship between detection of hepatitis B virus in saliva and periodontal disease in hepatitis B virus carriers in Japan. *Journal of Infection and Chemotherapy*, 27(3).

Kotsiomiti, E., Tzialla, A., Hatjivasiliou, K. (2008). Accuracy and stability of impression materials subjected to chemical disinfection - A literature review. *Journal of Oral Rehabilitation,* 35(4):291-299.

Patel, M. (2021) Oral Cavity and *Candida albicans*: Colonisation to the development of infection. *Pathogens*, 11, 335.

Peutzfeldt, A., Asmussen, E. (1989). Effect of disinfecting solutions on accuracy of alginate and elastomeric impressions. *European Journal Oral Sciences*, 97(5), 470-475.

Rentzia, A., Coleman, D.C., Donnell, M.J. (2011). Disinfection procedures: their efficacy and effect on dimensional accuracy and surface quality of an irreversible hydrocolloid impression material. *Journal of Dentistry*, 39(2), 133-140.

Samra, R.K., Bhide, S.V. (2010). Efficacy of different disinfectant systems on alginate and addition silicone impression materials of Indian and international origin: A comparative evaluation. *The Journal of Indian Prosthodontic Society*, 10(3), 182–189.

Sukhija, U., Rathee, M., Kukreja, N., Khindria, S., Singh, V., Palaskar, J. (2010). Efficacy of various disinfectants on dental impression materials. *The Internet Journal of Dental Science*, 9, 1-6.

Vatansever, F. (2013). Can biowarfare agents be defeated with light?. *Virulence*, 4(8), 796-825.

Taylor, R.L., Wright, P.S., Maryan, C. (2002). Disinfection procedures: their effect on the dimensional accuracy and surface quality of irreversible hydrocolloid impression materials and gypsum casts. *Dental Material*, 18(2), 103-110.

Ulgey, M., Gorler, O, Yesilyurt, G. (2020). Importance of disinfection time and procedure with different alginate impression products to reduce dimensional instability. *Journal of Clinical Practice*, 23(3), 284-290.

Wadhwa, S.S., Mehta, R., Duggal, N., Vasudeva, K. (2013). The effect of pouring time on the dimensional accuracy of casts made from different irreversible hydrocolloid impression materials. *Contemporary Clinical Dentistry*, 4(3), 313–318.

Walker, M.P., Burckhard, J., Mitts, D.A., Williams, K.B. (2010). Dimensional change over time of extended storage alginate impression materials. *The Angle Orthodontist*, 80(6), 1110-1115.

ORIGINAL ARTICLE Open Access

Comparison of the perceived image quality of intraoral orthodontic photographs taken with DSLR camera and mobile phone camera: A double-blinded prospective study

Lawrence Tan Soon Lee[1], Nurina Ezza Zulkiflee[2], Noraini Abu Bakar[1]*

[1]*Department of Orthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia.*
[2]*Kulliyyah of Dentistry, International Islamic University Malaysia.*

Abstract

Clinical orthodontic photography is a vital skill that every orthodontist should master to record the patients' details and to permit the orthodontist to carefully plan, monitor and execute the treatment. With the advancement of technology, some clinicians opt to take intraoral photographs with their mobile phone rather than DSLR camera. Hence, this study aimed to answer one main question: whether there was any significant difference in the perceived quality image between intraoral photos taken with a mobile phone and a standard DSLR camera. The cameras used were a DSLR (Nikon D300s with AF-S Micro NIKKOR 105mm lens and NIKON R1C1 Twin Flash) and Mobile Phone (Apple I-Phone 11 with Selfie Ring Light). Assessment of 20 sets of intraoral photographs (100 individual images) by five IIUM orthodontists using a perceived quality Likert scale of Zero (0) to Ten (10). The assessors and the lead investigator were blinded to the source of the photographs. Reliability was evaluated using a test-retest method on 4 sets of intraoral photographs (20 individual images), a few weeks after their initial assessment. There was no significant difference (p=0.35) in perceived quality of intraoral photographs taken between DSLR and mobile phone, with the mean value of 7.34 and 7.12 respectively. Reliability was good (ICC=0.549). This prospective study showed that there was no statistical difference between the perceived quality of intraoral orthodontic photographs taken with a DSLR camera and a Mobile Phone camera.

Keywords: *double-blinded prospective study, DSLR camera, mobile phone, intraoral photographs, perceived image, quality*

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***Corresponding author**
Address:
Department of Orthodontics, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia

Telephone: +60127140094

Email address:
nor_aini@iium.edu.my

Introduction

Photography has been an integral part in dentistry. In orthodontics, photography is vital in order to record patients' details for treatment plan, treatment monitoring and execution of the treatment. It also provides tools for communication between patients and clinician in order to provide a better understanding of the patient's dental problems by displaying the photos.

The gold standard of intraoral photography is by using the Digital Single Lens Reflex (DSLR) camera together with a macro lens and a macro flash/light. Mobile phone (MP) photography however has come a long way in terms of technological advances in sensor quality, resolution, and lens sophistication,

giving much improved image quality over the last few years. It is relatively compact and lighter than a DSLR camera hence younger generation dentists prefer it over conventional cameras (Samawi, 2012). This could be due to the fact that smartphone cameras are more practical, whereby a smartphone is cheaper, lighter and easier alternative than a DSLR camera. It possesses the ability to record high quality photographs and videos. Cameras are chosen due to their availability, popularity, and quality of image (Moussa *et al.*, 2021). Therefore, many dentists nowadays have moved from using DSLR camera to MP as it is more convenient for them.

DSLR cameras have specific settings and characteristics that dictate the protocols of capturing a photograph (Desai & Bumb, 2013). It allows the photographer to control and change settings such as aperture, exposure time, and International Organization for Standardization (ISO) sensitivity (Hardan, 2020). MP cameras perform mainly automatic adjustments allowing the user to take a picture no matter the circumstances which can be both beneficial and disadvantageous at the same time (Majumder & Deen, 2019). On one hand, MP facilitates the process of taking a picture but on the other hand, if the user does not know how to properly manipulate the camera, the photograph can be captured in conditions that compel image distortion (Lee *et. al.*, 2014). In fact, barrel effect is one of the problems that dentists face. It happens when the camera is too close to the subject and results in distorted image proportions (Hardan, 2020). Hence, it was unclear whether MP produces the same standard of image quality compared with DSLR in orthodontic photography. Therefore, this research general objective was to compare whether there was any difference, in the perception of quality of intraoral orthodontic photographs, taken with a DSLR camera or mobile phone camera.

The null hypothesis was there was no difference between the perceived quality of intraoral orthodontic photographs taken with a DSLR camera and photographs taken with a MP camera.

Materials and Methods

Study design

Prospective (double-blinded) quantitative study.

Sample size determination

A sample size was calculated using Epi Info-Sample size for comparing Two Means/Mean Difference (https://www.openepi.com/SampleSize/SSMean.htm). Using the study by Liu et. al. (2020), that had a Mean Score (SD) of 9.41 (0.36), with alpha at 0.05 and beta at 0.2, while noting a mean difference of about 0.47 (5%) to be considered significant, a sample size of 10 sets of intraoral orthodontic photographs will be minimally needed.

Sampling technique

Simple random sampling.

Inclusion/exclusion criteria

Patients with normal range of malocclusions, undergoing conventional orthodontic treatment with upper and lower fixed appliances with or without extractions were included. Patients that had a cleft, dentofacial deformity, impacted teeth, severe hypodontia, undergoing/undergone special treatments (alveolar bone grafts, orthognathic, multi-disciplinary treatments) were excluded.

Study population

The study population was composed of orthodontic patients, who required intraoral orthodontic photographs taken as part of orthodontic records, taking into account the inclusion and exclusion criteria.

Ethical approval

Ethical approval IREC 2022-013 was received from the IIUM Research Ethics Committee (IREC).

Materials

The cameras used were a DSLR (Nikon D300s with AF-S Micro NIKKOR 105mm lens and Nikon R1C1 Twin Flash; year of manufacture: 2011) and a MP (I-Phone 11 with Selfie Ring Light) using back camera 12 Megapixels, used in an orthodontic clinic

with standard intraoral retractors and mirrors. In this study, I-Phone 11 was chosen simply because it is regarded as one of the phones able to take good quality of photos during the time period of the study. The selfie ring light is to mimic the ring flash from the DSLR camera.

Figure 1. From the left is a DSLR Nikon D300S, followed by AF-S Micro NIKKOR 105mm lens and Nikon R1C1 Twin Flash.

The Nikon D300S is a 12.3-megapixel DX format digital single-lens reflex (DSLR) camera. The Nikon D300S has been tested by a number of independent reviewers with favourable reviews. AF-S Micro NIKKOR 105mm lens is the lenses that shine at the 45-degree angle (or similar angles). This narrow focal length can remove perspective distortion that usually seen with wide-angle lenses at similar distances. The lens has a 1:1 magnification ratio which allows a full-size reproduction of the image on the camera sensor. This enables a close-up view of intraoral structures while also preventing distortions to the image. However, lighting can be compromised with close-up photography. The addition of Nikon's R1C1 wireless close-up speedlight system allows capturing most out of the close-up, micro and general flash photography by providing flexible, even lighting of the subjects with the added convenience of wireless control.

Figure 2. From the left is I-phone 11 and followed by the Selfie Ring Flash.

The I-Phone 11 was a premium MP at the time of the study, which is able to obtain pictures at 12 megapixels, the same as Nikon D300S. The wide-angled camera in the I-Phone 11 has a larger sensor with 100 percent more focus pixels that enables new low light capabilities such as a night mode that is designed to take much brighter pictures in low lighting conditions. The selfie ring light was used to mimic the ring flash from the DSLR camera. The ring light allowed for three different settings of white light intensity: low, medium and high.

Camera settings

DSLR was set manually with aperture and shutter speed adjusted according to ambient lighting. MP was set automatically with only exposure compensation and ring light intensity adjusted according to ambient lighting.

Intraoral photography

The five standard views for intraoral photography that are usually taken by an orthodontist which are frontal, right buccal, left buccal, upper occlusal and lower occlusal views were taken for each patient (Kalpana *et al.*, 2018). A total of 100 intraoral images (10 patients) taken from DSLR camera and another 100 intraoral images (10 patients) from MP camera.

Camera operator

All the intraoral photos were taken by one operator (specialist orthodontist) using both DSLR and MP on 20 patients. This was done to eliminate confounding factors associated with calibration and standardization of multiple operators. The image was focused manually for the DSLR camera while for the I-Phone, the auto focus function was used. All the photos were taken in one clinic, with similar setting to reduce setting-bias involved in taking intraoral photography. The photos were all saved as JPEG files. The camera operator was responsible in processing and arranging them to the normal standard of orthodontics photography. The digital manipulation of the photographs was limited to cropping and rotational correction for neatness.

Consent

All 20 patients consented to the intraoral photography.

Double-blinded procedures

Only the camera operator knew about the images and the source of camera. The photos were re-labelled to be Patient 1 to 20 (100 images in total) with patients' details were kept confidential and the information of the source of cameras was kept blinded from the researcher and the assessors. The photos were then uploaded in the I-Pad (8th Generation) and was handed over to the primary investigator. The primary investigator and the assessors were blinded to which of the sets of photographs were taken with DSLR or Mobile Phone. The camera operator only released the information once all the data has been collected and analysed.

Figure 3. Five standard views of orthodontic intraoral photography.

Figure 4. Intraoral orthodontics photographs taken by DSLR camera.

Figure 5. Intraoral orthodontics photographs taken by MP camera.

Assessors

The assessors were five (5) specialist orthodontists from the Kulliyyah of Dentistry (IIUM). All the assessors had no prior information or connection to the photographs and the patients were not known to them. A standard procedural instruction prior to assessment of the photographs was given to the assessors by the primary investigator.

The sets of photographs were shown using a Tablet (I-Pad). A full screen was used for each set. Each photograph set was labelled 1-20 and a score was given for the perceived quality of all photographs.

When responding to the Likert scale, the assessor specified their level of perceived quality for each set of photography without knowing the source of the camera. The score was written by the assessor on the data collection form. The complete form was then handed over to the primary investigator.

Perceived quality scale

A Likert-type rating scale of zero (0), being the poorest quality, to ten (10), being the highest quality, was used in this study.

Reliability test

To examine the intra examiner agreement, a reliability test was done using a test-retest method. The assessors will be requested to redo the assessment as above, on 4 sets of photographs, a few weeks after their initial assessment (T2). The scores for the same sets of photographs, at the initial assessment (T1) were compared.

Statistical analysis

Data was entered into a computer using MS Excel or using statistical software (SPSS, Version 22). Mean and SD were used to describe the average score for both DSLR photographs and MP photographs. Scores were tabulated according to individual assessor as well as a combined total. Reliability scores (T1 and T2) were also tabulated according to assessor as well as a combined total. Data was summarized and described as above and then tested for Normality. As data was Normally distributed. Data was analyzed using an Intraclass Correlation Coefficient to assess reliability and an Independent Sample t-test to assess statistical difference.

Results

Perceived quality of intraoral orthodontic photographs taken with DSLR and mobile phone cameras

Mean and Standard Deviation were used to describe the average score of perceived quality for both DSLR photographs and MP photographs. Table 1 shows scores that were tabulated according to individual assessor as well as the combined total. Figure 6 shows the mean (7.34) and standard deviation (1.08) of DSLR photographs meanwhile Figure 7 shows the mean (7.12) and standard deviation (1.26) of MP photographs.

Table 1. Mean and Standard Deviation of DSLR and MP photographs according to assessor.

Assessor	Score DSLR (Mean, SD)	Score (Mean, SD) MP
Orthodontist 1	6.40 (0.80)	6.20 (1.07)
Orthodontist 2	7.70 (0.78)	7.00 (0.77)
Orthodontist 3	6.60 (0.80)	7.50 (0.67)
Orthodontist 4	8.10 (0.30)	8.10 (0.70)
Orthodontist 5	7.90 (1.13)	6.80 (1.72)
Total	7.34 (1.08)	7.12 (1.26)

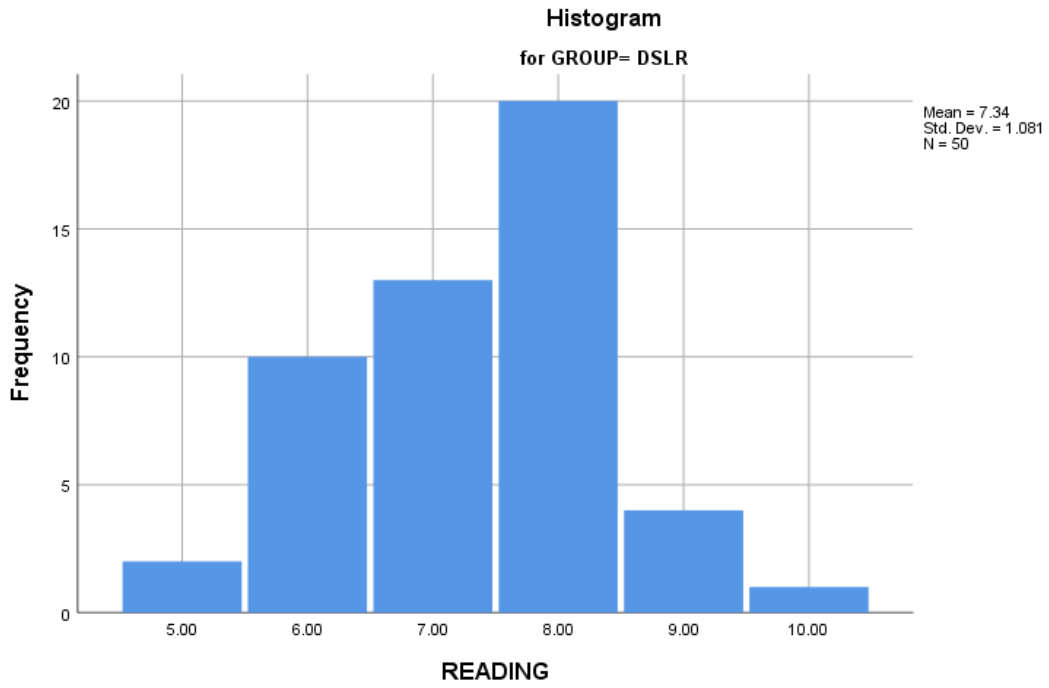

Figure 6. Score (mean, SD) for DSLR photographs

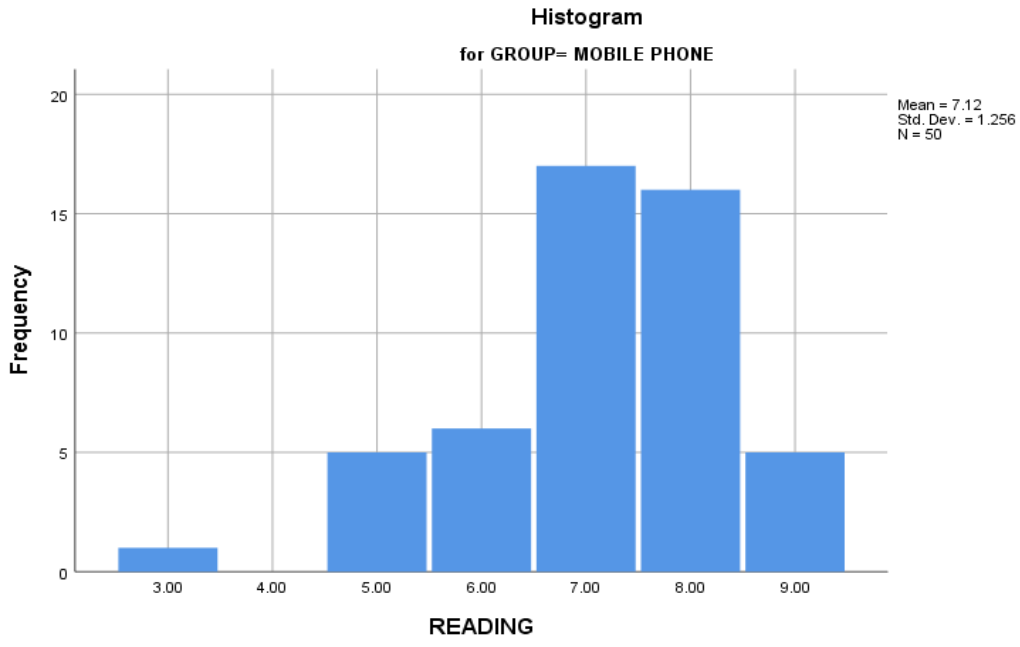

Figure 7. Score (mean, SD) for MP photographs

Comparison of the difference in perception of quality of intraoral orthodontics photography between DSLR camera or mobile phone camera

The comparison of the mean score of the assessment of DSLR and MP photographs is shown in Figure 8. The mean for both DSLR and MP groups demonstrated similar scores, 7.34 and 7.12 respectively.

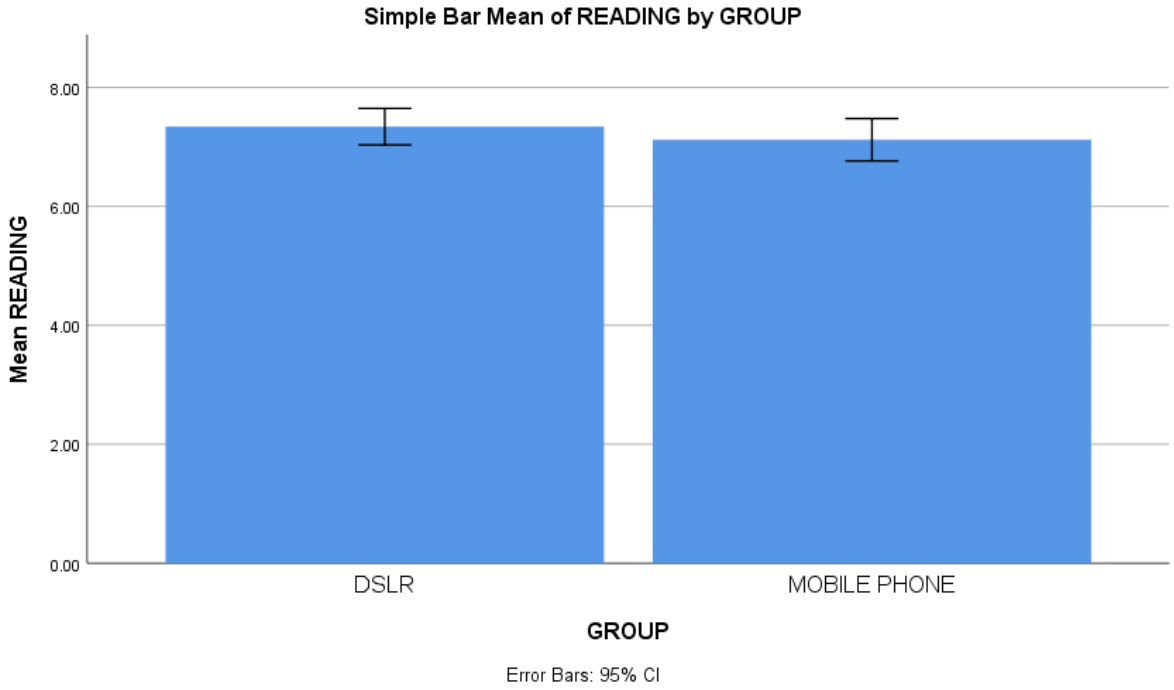

Figure 8. Comparison of the mean score of the assessment of DSLR and MP photographs.

Table 2. Statistical difference between perceived quality of intraoral orthodontic photographs taken with a DSLR camera and photographs taken with a MP camera

Variable	Mean (SD)		t-statistic (df)	p-value
Percieved Quality of Intraoral Orthodontic Photographs	DSLR (N=50)	Mobile Phone (N=50)	0.95 (97)	0.35 (>0.05)
	7.34 (1.08)	7.12 (1.26)		

Table 2 shows the statistical comparison between the DSLR scores and the MP scores. As the data was Normally distributed, an independent samples t-test was used, giving a p-value = 0.35. As such, there was not enough evidence to reject the null hypothesis and it can be concluded that there was no difference between the perceived quality of intraoral orthodontic photographs taken with a DSLR camera and photographs taken with a MP camera.

Reliability of the assessors

The Reliability was evaluated using a test-retest method to ensure good intra examiner

agreement. The five assessors were requested to redo the assessment on 4 sets of photographs, a few weeks after their initial assessment (T2). The scores for the same sets of photographs, at the initial assessment (T1) were compared. The Reliability scores (T1 and T2) were tabulated according to assessor as well as a combined total (Table 3).
The mean, median and skewness was used to establish the normally distribution of the result and Levene's test confirmed the homogeneity of variances. Data were analyzed using Intraclass Correlation Coefficient to assess the reliability (Table 4).

Table 4 shows the obtained Intraclass Correlation Coefficient was 0.549 with 95% confidence interval (ranges between 0.148 and 0.794). Therefore, the level of reliability ranged from fair to good reliability.

Table 3. Reliability scores (T1 and T2) according to assessor

Assessor	Score T1 (Mean, SD)	Score T2 (Mean,SD)
Orthodontist 1	6.00 (1.00)	5.00 (0.71)
Orthodontist 2	7.50 (0.50)	8.50 (0.87)
Orthodontist 3	7.80 (0.43)	7.30 (0.83)
Orthodontist 4	8.00 (0.71)	7.80 (0.43)
Orthodontist 5	7.50 (0.87)	7.50 (0.50)

Table 4. Reliability analysis using Intraclass Correlation Coefficient

	Intraclass Correlation[b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.549[a]	.148	.794	3.350	19	19	.006
Average Measures	.709[c]	.258	.885	3.350	19	19	.006

Discussion

This study aimed to compare whether there was any difference, in the perception of quality of intraoral orthodontic photographs, taken with a DSLR camera and a MP camera. The results shows that there was no difference between the two. The outcome of this study supported the result from the previous study by Prasad & Sivakumar (2020).

Clinicians who wish or need to take intraoral photographs can perhaps take heart from the findings of this study. The result offers further reassurance for clinicians to use a MP

camera for intraoral photography, especially in orthodontics. This is due to the fact that MP are more practical. MP are also lighter, and easier to use. Dental surgeons are not specifically trained in professional photography, hence, many of them may not be interested in learning and owning an expensive DSLR camera and all the specific accessory equipment necessary when wanting to take good intraoral photographs. This is essentially the opinion given by Samawi (2017).

On the other hand, every dental surgeon or clinician would own a MP, probably at least a mid-range model with very acceptable camera specifications. Learning and using a MP is a skill that would have already been learnt prior to entering Dental School. Therefore, using a MP camera for intraoral photography would probably not be such a learning-curve as it would be when learning how to use a DSLR camera. Recommendations on MP camera set-up for orthodontic photography is already in the literature as in an article by Shahrul *et. al.* (2022).

Thus, the ability to use a MP to obtain good quality intraoral orthodontic photographs without a steep investment in time, effort and money would probably be welcomed by most clinicians. Maintenance and service would probably be easier too due to their ubiquitous presence in society.

This study has a number of limitations and possibilities for improvement in future studies. As the aim of the study was to test perception, which varies between people, a larger sample and a wider pool of assessors would probably increase the strength of the study. Another possible improvement would be to standardize the photographs taken from the same patients with different cameras. This would eliminate another confounding factor hence enable a better comparison between the cameras.

In this study, only one type of mobile phone camera which is the I-Phone 11 was used to compare the quality image of intraoral orthodontics photographs with the gold standard camera which was the Nikon DSLR camera. The Selfie Ring Light used as the lighting component in this study is basic. It served the purpose of illuminating the intraoral area without shadowing. An extra lighting component that achieves this would still be needed with any MP. Further refinement of the lighting technology, for example the addition of a diffuser and more control of the lighting intensity, may make the quality of photographs even better.

Further research can be suggested such as repeating the study using other types of phones, lighting components and accessories, in different clinics. All these further studies may be useful to validate the findings of this study. Photographs obtained from multiple clinics would also possibly improve the generalizability of the results as the sample would be obtained from many alternate real-world clinical environments.

Conclusion

This study showed that the perceived quality of intraoral photographs taken with a DSLR camera, and a mobile phone camera were similarly good. There was also no statistical difference between the perceived quality of either of the two groups of photographs.

Clinical significance

The result gives orthodontic clinicians more confidence to use mobile phones to take intraoral photographs for general clinical purposes especially in orthodontics. This might be because mobile phones are more accessible and more practical compared to DSLR cameras, which are more expensive, heavier, and rather more cumbersome to use.

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References

Desai, V., Bumb, D. (2013). Digital dental photography: a contemporary revolution. *International Journal of Clinical Pediatric Dentistry*. 6(3):193-196.

Hardan, L. (2020). *Protocols for mobile dental photography with auxiliary lighting*. Quintessence Publishing.

Kalpana, D., Rao, S.J., Joseph, J.K., Kurapati, S.K.R. (2018). Digital dental photography. *Indian Journal of Dental Research*, 29,507-512.

Lee, S., Kim, B., Lee, J. and Sasian, J., (2014). Accurate determination of distortion for smartphone cameras. *Applied Optics*, 53 (29), H1–H6.

Liu, M., Zhang, J.D., Ye, H.Q., Zhao, Y.J., Zhao, X.B., Zhao, W.Y., *et al.* (2020). Application and exploration of Smile Lite MDP portable photography system in aesthetic photography of anterior teeth. *Journal of Peking University (Health Sciences)*, 52(1),187-192.

Majumder, S. and Deen, M.J. (2019). Smartphone sensors for health monitoring and diagnosis. Sensors, 19 (9), 2164.

Moussa, C., Hardan, L., Kassis, C., Bourgi, R., Devoto, W., Jorquera, G., *et al.* (2021). Accuracy of dental photography: professional vs. smartphone's camera. *BioMed Research International*, 2021, 3910291V.

Prasad, A.S., Sivakumar, A. (2020). Smartphone vs DSLR dental photography among orthodontists. *Indian Journal of Public Health Research & Development*, 11 (6).

Samawi, S. (2012). Clinical digital photography in orthodontics: professional photographic records in daily practice. *Jordan Dental Journal*, 18 (1).

Samawi, S. (2017). There's something about MDP (mobile dental photography). Retrieved from https://theorthodonticnotefile.blog/2017/08/10/theres-something-about-mdp-mobile-dental-photography/

Shahrul, A. I., Shukor, N., & Norman, N. H. (2022). Technique for orthodontic clinical photographs using a smartphone. *International Journal of Dentistry*, 2022, 2811684.

REVIEW ARTICLE Open Access

Single nucleotide polymorphism of leptin and leptin receptor genes in oral cancer - A systematic review

Siti Hana Ilyana Hasanbasri[1], Nur Armidha Nadihah Amir Sabri[1], Khairani Idah Mokhtar[2]*, Basma Ezzat Mustafa[2], Mohamad Shafiq Mohd Ibrahim[3], Pram Kumar Subramaniam[4,5]

[1] Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[2]Department of Fundamental Dental and Medical Sciences, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[3]Department of Paediatric Dentistry and Dental Public Health, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[4]Department of Oral Maxillofacial Surgery and Oral Diagnosis, Kulliyyah of Dentistry, International Islamic University Malaysia, Kuantan Campus, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.
[5]Oral Dental and Maxillofacial Surgery Unit, Sultan Ahmad Shah Medical Centre, International Islamic University Malaysia, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Abstract

Oral cancer is one of the serious health problems diagnosed worldwide including Malaysia. While much research has been done on the gene polymorphism of leptin and leptin receptor genes in other cancers, few researchers have considered oral cancer. Hence, this study aims to provide an insight into the association of a single nucleotide polymorphism of leptin and leptin receptor genes with oral cancer, as well as its contribution in increasing the risk for oral cancer development. Literature searches were conducted in six databases including Scopus, ScienceDirect, Web of Science, PubMed, Google Scholar, and Dimensions; focusing on articles published between 2000 to 2020. All relevant articles were screened accordingly using search terms "leptin", "leptin receptor", "single nucleotide polymorphism" and "oral cancer". A total of 2699 articles were retrieved. After following the inclusion and exclusion criteria, only four articles were included in this systematic review highlighting the three commonly studied polymorphic variant of leptin and leptin receptor which are *LEP* -2548 G/A, *LEPR* Gln223Arg, and *LEPR* K109R. Single nucleotide polymorphism of leptin and leptin receptor genes specifically *LEPR* Gln223Arg and *LEP* -2548 G/A may increase the risk of development of oral cancer. There were limited sources available to support the findings. Further research and investigations are needed to explore the mechanism of leptin and leptin receptor genes in the development of oral cancer.

Keywords: *leptin, leptin receptor, oral cancer, oral squamous cell carcinoma, single nucleotide polymorphism*

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***Corresponding author**
Address:
Department of Fundamental Dental and Medical Sciences, Kulliyyah of Dentistry, International Islamic University Malaysia,Jalan Sultan Ahmad Shah,25200 Kuantan, Pahang, Malaysia.

Telephone:+60139278770
Email address:
drkhairani@iium.edu.my

Introduction

Oral cancer is one of the serious health problems diagnosed worldwide including Malaysia. Globally, the prevalence of oral cancer is high and has a poor prognosis, making this disease a public health problem. Oral squamous cell carcinoma (OSCC) is the most common type of oral cancer. Oral cancer may be caused by several factors, such as chewing tobacco, smoking, alcohol

consumption, human papillomavirus (HPV) infection, and multiple genetic alterations. The current clinical screening rule which encompasses general examination including intraoral examination with comprehensive medical history, appears to be insufficient for prevention, since approximately 30% of OSCC patients had done screening in the last three years. Oral cancer prevention could be more effective if the population at risk could be identified prior to developing oral cancer and more attention was paid to them (Yapijakis *et al.,* 2009).

Leptin (LEP) is a protein from the cytokine family, consisting of 167 amino acids and is a common hormone of regulating energy expenditure by inhibiting hunger. It is an adipocyte-specific hormone which is predominantly secreted from adipose tissue, and barely in the placenta, salivary glands, and skeletal muscle. Leptin is a pleiotropic cytokine involved in diverse physiological and pathological processes such as angiogenesis, tumor growth, thrombosis, metastasis as well as proinflammatory immune response in multiple organs (Sobrinho Santos *et al.,* 2017; Hung *et al.,* 2019). The function of leptin gene *(LEP)* is achieved when it binds to its receptor, the leptin receptor protein (Ahima & Osei, 2004). Leptin receptor (LEPR) is a type I cytokine receptor, encoded by the *LEPR* gene and acts as a receptor for the hormone LEP (Rong *et al.,* 2019). LEPR is a single transmembrane-domain receptor; composed of extracellular, transmembrane, and intracellular sections, commonly found in the cell membranes of various tissues throughout the body, in which neurons of hypothalamus are the most abundant region. The role of LEP in oral region is confined to induce wound healing and taste sensitivity, by nurturing keratinocyte proliferation and taste bud cells respectively (Yapijakis *et al.,* 2009). Thus, LEP/LEPR signaling may be implicated in stimulating angiogenesis, facilitating cell proliferation, and preventing epithelial cell apoptosis (Tilg & Moschen, 2006).

LEP has been commonly associated with diseases such as obesity and it was widely studied in numerous papers. Due to the nature of *LEP* associating with various pathological processes, unregulated expression of *LEP* will cause detrimental effects towards the body and its functions. In addition, countless studies have demonstrated that *LEP* is one of the causes of development of some types of cancer such as breast cancer (Atoum *et al.,* 2020). Previous studies on human and rodent cell lines exhibited clear association of *LEP* and *LEPR* with increased cancer cells, metastasis development and growth of blood vessels in benign and malignant tumors of various regions including breast, kidney, pancreas, adipose tissue, liver, colon and glia (Yapijakis *et al.,* 2009). While much research has been done on the gene polymorphism of *LEP* and *LEPR* in other cancers, few researchers have considered its' polymorphism in oral cancer.

Single nucleotide polymorphisms (SNPs) are changes in DNA involving single nucleotide either A, G, C or T. SNPs are by far the most common source of genetic variation. The use of SNPs in specific genes such as *LEP* gene and *LEPR* gene has resulted in the genetic association of these genes with increased risk of carcinogenesis in the oral region. Both *LEP* and *LEPR* play critical roles in mediating physiological responses and oncogenesis which may be of use as candidate biomarkers for oral cancer (Hung *et al.,* 2019).

There are some common polymorphic alleles which have been studied in oral cancer, but the role of the variants in the development and progression of oral cancer are still not well understood. Nonetheless, these polymorphisms have also been associated with the incidence of other types of cancer (Rodrigues *et al.,* 2015; Yang & Niu 2018; Rong *et al.,* 2019). Further studies about polymorphisms of *LEP* and *LEPR* genes in relation to oral cancer provide the opportunities to detect and intervene the progression of the disease in the earlier stage via screening and prevention. Hence, this study aims to provide an insight into the association of single nucleotide polymorphisms of *LEP* and *LEPR* genes with oral cancer, as well as its contribution in increasing the risk for oral cancer

development. This would benefit the medical practitioner in preventing the development of oral cancer at an early stage and provide greater attention.

Materials and Methods

Selection procedure

Preferred Reported Items for Systematic Reviews and Meta-Analyses (PRISMA-P) 2020 was used as the guideline for the selection procedure of related articles. Its objective is to enhance the quality of guidelines of systematic review, which is interchangeable to the effect gained by several reporting guidelines. Articles that were found during screening from all the databases were removed if duplications were found and the keywords were not included in the title of the articles. Only the articles that fulfilled the intended criteria were assessed and reviewed for eligibility and were chosen for this study.

Formulation of review question

This review question was constructed according to PICO formulation which exemplifies population of studies (P), intervention or exposure (I), comparison of intervention or exposure (C), and outcome of interest (O) (Methley *et al.,* 2014). It is usually accustomed to recognize key components that are used in systematic reviews for evidence-based medicine and is advocated by the Cochrane Collaboration in the *Cochrane handbook for Systematic Reviews of Intervention.* Therefore, the formulated question for this systematic review was "What is the association of polymorphism of leptin and leptin receptor genes with oral cancer?"

Search strategy

A comprehensive electronic search was performed using the following databases: Scopus, ScienceDirect, Web of Science, PubMed, Google Scholar and Dimensions. The databases were chosen due to their reliability in healthcare and medical-related issues. Throughout the search, the following key terms were used: ("leptin" OR "leptin receptor") AND ("oral cancer" OR "oral squamous cell carcinoma") AND ("single nucleotide polymorphism" OR "polymorphism"). The Boolean words such as "AND" and "OR" were applied to improve the specificity of search articles. Identical search strategies were applied in all databases. The data collection was done from January to September 2022 looking into articles published from 2000 to 2020.

Inclusion and exclusion criteria

The inclusion criteria of the articles selected included articles published in English, the type of articles were research and some related review articles published from the year of 2000 to 2020. This was implemented to gain access to the maximum number of papers available on this topic. Any other criteria that were not included in the listed standards were excluded from the study. Book series, chapters in books, magazines, case studies and conference articles; both abstract and proceeding were also excluded.

Data extraction

The screening process (title, abstract and full text) was done independently by the authors. Any differences in opinion that arose were undertaken by the authors through discussion. The articles were selected for qualitative synthesis and were thoroughly read by the researcher to identify the key data. There was no risk assessment of bias done between the authors.

Results

A total of 2699 articles were retrieved from six different databases. Of those, 2499 articles were removed due to being published in a form other than research or related review articles. 183 duplicates were removed and a total of 17 full-text articles were assessed. 13 of the selected articles did not fulfil the inclusion criteria and thus, only four articles that fulfilled all the inclusion criteria were included in the systematic review. Figure one depicts the PRISMA diagram flow for this review.

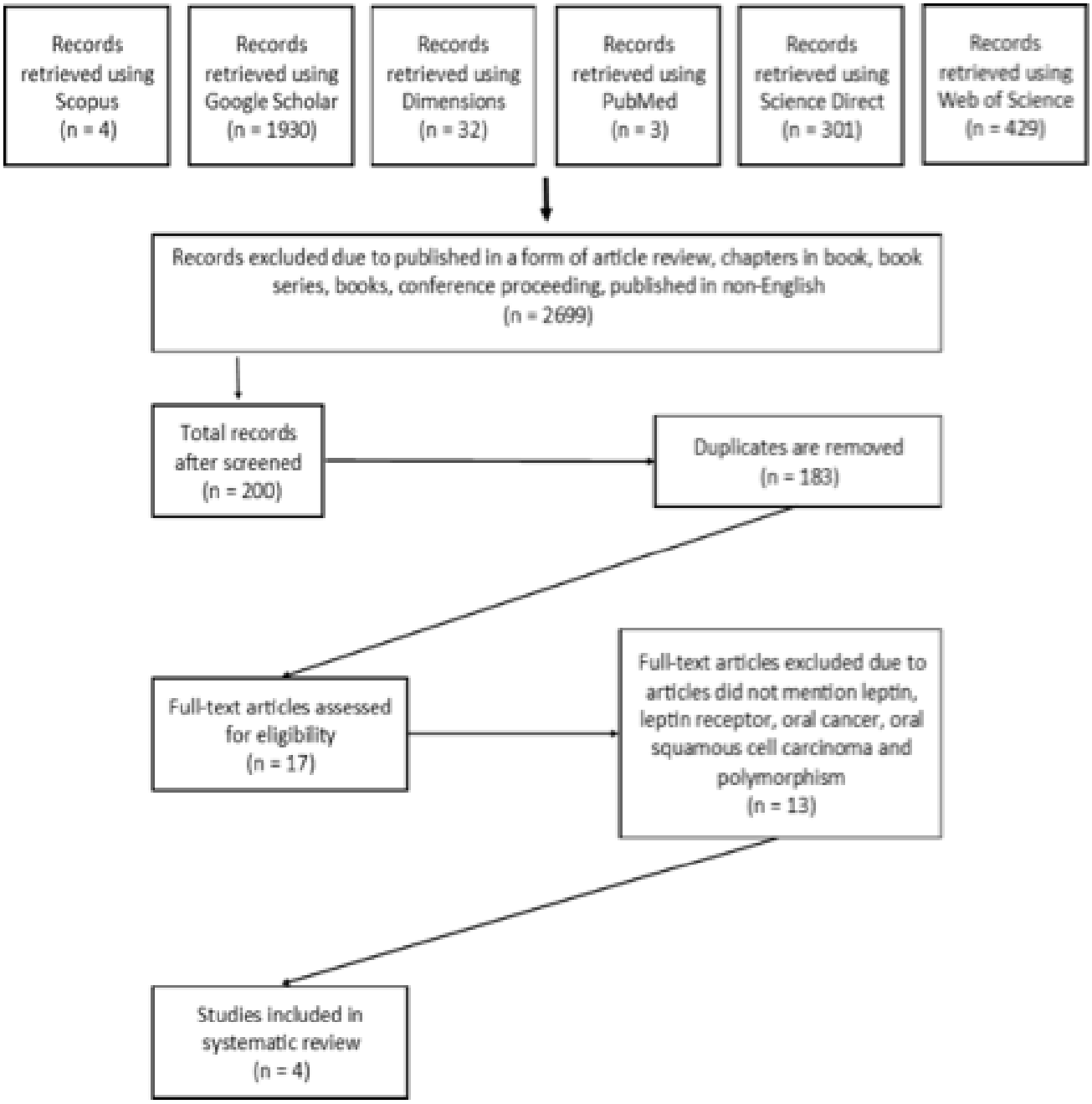

Figure 1. The PRISMA diagram.

All the included articles were based on case-control studies done in different populations and geographical areas (Table I). There were three polymorphisms mentioned by the articles, including *LEP* -2548 G/A, *LEPR* Gln223Arg (*LEPR* A688G) and *LEPR* K109R. Out of four articles, three of them studied *LEP* -2548 G/A polymorphism while two of them studied *LEPR* Gln223Arg polymorphism while one of the studies analysed *LEPR* K109R respectively. These findings correlate with the common polymorphisms found in other cancer types.

Table 1. Criteria of included studies.

Author	Study Design	Population	Total Sample Size	Polymorphisms Studied	Ref seq
Hung *et al.,* (2019)	Case-control study	Taiwanese	1127	*LEP -2548 G/A* *LEPR Q223R* *LEPR K109R*	rs7799039 rs1137101 rs1137100
Yapijakis *et al.,* (2009)	Case-control study	Greeks and Germans	302	*LEP -2548 G/A* *LEPR Q223R*	*NS*
Domingos *et al.,* (2014)	Case-control study	Brazilians	139	*LEPR Gln223Arg*	rs1137101
Hussain *et al.,* (2015)	Case-control study	Indians	534	*LEP -2548 G/A* *LEPR A688G (Q223R)*	*NS*

NS= Not stated

LEP -2548 G/A

Out of four articles, two articles showed association of polymorphism of *LEP* -2548 G/A with risk of oral cancer (Table II). An AA allele was proved to have low risk for OSCC, however it can develop to a poorer clinical stage of OSCC, if present. In comparison to AA allele, AG and GG allele possess higher risk for development of OSCC (Hung *et al.,* 2019). This finding was supported with evidence of association of AA allele with a risk for advanced stages of OSCC when looking into other criteria such as cancer stage and family history of either cancer or thrombophilia (Yapijakis *et al.,* 2009). A study showed an increase of AA and GA allele in oral cancer patients which correlates with escalating risk for oral cancer (Hussain *et al.,* 2015). Hussain *et al.,* (2015) also observed the frequency of mutant allele A to be significantly increased (p = 0.0002) in OSCC patients compared to control. However, study done by Hung *et al.,* (2019) observed no significant differences between AA, AG and GG alleles in oral cancer patients in comparison to the control group (Hung *et al.,* 2019).

LEPR Gln223Arg

Three out of four articles agree that there was an association of LEPR Gln223Arg with increased risk of oral cancer (Table III). GG genotype seems to be the common polymorphism found in OSCC which predisposes to higher risk of cancer while AA genotype was found in potentially malignant oral lesion (PMOL) (Domingos *et al.,* 2014). This was supported by a study that claimed there was an association of G allele with increased risk of development of oral cancer. In addition, this study also found that G allele was frequently observed in patients with early cancer stages (Yapijakis *et al.,* 2009). Another article stated that *LEPR* Gln223Arg polymorphism was associated with the risk of oral cancer relapse whereby this article found different evidence in which polymorphic variant GG is responsible for increasing the risk for oral cancer development (Hussain *et al.,* 2015). They observed higher frequency of G allele in OSCC patients in comparison to the controls ($p \leq 0.0001$) when analysing the leptin receptor A668G (Gln223Arg) gene polymorphism. In terms of genotypic frequency, a high increase of GG homozygous alleles ($p \leq 0.0001$) and a slight rise of AG heterozygous alleles ($p=0.007$) was observed in OSCC patients compared to the controls. However, Hung *et al.,* (2019) observed no association between all *LEPR* genotypes with risk for oral cancer in their study.

Table 2. Summary on studies of *LEP*-2548 G/A polymorphism.

Studies	Group	*LEP* genotype (*LEP -2548 G/A*)		
		GG (%)	GA (%)	AA (%)
Yapijakis *et al.,* (2009)	Control	21.7	65.1	13.2
	OSCC	22.3	52.0	26.7
	p value	-	*NS*	*NS*
Hussain *et al.,* (2015)	Control	49.5	40.3	10.0
	OSCC	33.3	50.3	16.3
	p value	-	*0.001**	*0.002**
Hung *et al.,* (2019)	Control	5.7	37.9	56.4
	OSCC	7.4	40.4	52.2
	p value	*0.574*	*0.274*	-

NS= not significant

LEPR K109R

Out of four articles, only one article mentioned *LEPR* K109R polymorphism which revealed no significant difference in the genotypic distribution between the control group and oral cancer patients (Hung *et al.,* 2019) (Table IV).

Discussion

This paper summarizes the findings whether the polymorphic variant of *LEP* and *LEPR* genes have an influence for oral cancer development by measuring the genetic constitution of healthy subjects as control in comparison to oral cancer patients.

LEP -2548 G/A (rs7799039) polymorphism takes place as a result of a G to A substitution at nucleotide -2548 in the promoter region of *LEP* gene. This polymorphism is related to increased LEP production and secretion, resulting in increased circulating LEP and over gene expression. The overall obtained data exhibits an association of *LEP* -2548 AA variant with a poorer clinical stage of oral cancer. This is approved by the fact that LEP functions in promoting growth and invasiveness of cancer (Yapijakis *et al.,* 2009). Besides, A allele shows abundant number in patients with advanced clinical stages of cancer in comparison to G allele or AG allele (Hung *et al.,* 2019). However, this does not indicate that *LEP* -2548 G/A increases the risk for oral cancer as the study showed no correlation between this polymorphism with the risk of oral cancer development (Yapijakis *et al.,* 2009).

Table 3. Summary on studies of *LEPR* Gln223Arg polymorphism.

Studies	**Group**	***LEPR* genotype (*LEPR* Gln223Arg)**		
		GG (%)	**GA (%)**	**AA (%)**
Domingos *et al.,* (2014)	Control	12.4	42.7	44.9
	OSCC	24.0	28.0	48.0
	p value		*0.011**	
Hung *et al.,* (2019)	Control	78.9	19.3	1.8
	OSCC	78.5	20.6	0.9
	p value	-	*0.607*	*0.945*
Yapijakis *et al.,* (2009)	Control	4.0	52.6	43.4
	OSCC	12.0	58.7	29.3
	p value	*0.0028**	*0.0497**	-
Hussain *et al.,* (2015)	Control	63.1	31.5	5.26
	OSCC	48.3	35.9	15.6
	p value	*<0.0001**	*0.007**	-

Table 4. Summary on studies of *LEPR* K109R polymorphism.

Studies	**Group**	***LEPR* genotype**		
		GG (%)	**GA (%)**	**AA (%)**
Hung *et al.,* (2019)	Control	70.7	26.6	2.7
	OSCC	72.0	25.9	2.1
	p value	-	*0.922*	*0.889*

The *LEPR* Gln223Arg (rs1137101) polymorphism or known as *LEPR* Q223R occurs due to non-conservative A to G substitution at codon 223 in exon six of *LEPR* gene (Domingos *et al.,* 2014). This variation of polymorphism decreases binding of LEP, consequently, impedes the LEP signaling. The results reveal an association of the G allele of this polymorphic variant with increased risk for oral cancer. In addition, the GG genotype was seen only in those early cancer stage patients, excluding the advanced cases (Yapijakis *et al.,* 2009). However, in comparison to G allele, A allele was significantly associated with PMOL (Domingos *et al.,* 2014). PMOL is a lesion with a potential to differentiate into malignant tumor. Another article found different evidence in which polymorphic variant GG is the one that is responsible in increasing the risk for oral cancer development (Hussain *et al.,* 2015).

The *LEPR* K109R (rs1137100) polymorphism is an A to G substitution in exon four. This polymorphic variant is not well studied yet, therefore limited sources are available to discuss in depth. According to Hung *et al.,* (2019), there was no correlation between all genotypes of *LEPR* K109R polymorphism with oral cancer risk. However, there was no available data to support the claim.

From the articles selected, two articles show association of polymorphism of *LEP* -2548 G/A with risk of oral cancer. Three out of four articles agree that there was an association of *LEPR* Gln223Arg with increased risk of oral cancer. Out of four articles, only one article mentioned *LEPR* K109R polymorphism which revealed no association with oral cancer.

Conclusion

Single nucleotide polymorphism of *LEP* and *LEPR* genes specifically *LEP* -2548 G/A and *LEPR* Gln223Arg may increase the risk of development of oral cancer. However, there is very limited data to support the findings from this review. The association of polymorphism in *LEP* gene and its receptor is more significant when other criteria were analyzed such as stages of cancer, family history of cancer or having tobacco. Additionally, the source of population as well as demographic factors might also affect the outcome of the analysis. Hence, additional research and investigations are needed to explore and understand the mechanism of *LEP* and *LEPR* genes in the development and progression of oral cancer, although these polymorphisms may be used as a genetic marker for susceptibility and to monitor the progress of cancer progression in the oral cavity,

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Conflict of Interest

None.

References

Ahima, R.S., & Osei, S.Y. (2004). Leptin signaling. *Physiology & Behavior*, 81(2), 223–241.

Atoum, M.F., Alzoughool, F., & Al-Hourani, H. (2020). Linkage between obesity leptin and breast cancer. *Breast Cancer (Auckl)*. 14: 1178223419898458.

Domingos, P. L., Farias, L. C., Pereira, C. S., das Gracas Pena, G., Reis, T. C., Silva, R. R. *et al.* (2014). Leptin receptor polymorphism Gln223Arg (rs1137101) in oral squamous cell carcinoma and potentially malignant oral lesions. SpringerPlus, 3:683.

Hung, W. C., Tsai, C. M., Lin, C.W., Chuang, C. Y., Yang, S. F., & Weng, C. J. (2019). Leptin -2548 G/A polymorphisms are associated to clinical progression of oral cancer and sensitive to oral tumorization in non-smoking population. *Journal of Cellular Biochemistry*, 120(9), 15145-15156.

Hussain, S.R., Naqvi, H., Gupta, S., Mahdi, A. A., Kumari, P., Waseem, M., et al. (2015). A study on oncogenic role of leptin and leptin receptor in oral squamous cell. *Tumour Biology*, 36(8), 6515–6523.

Methley, A. M., Campbell, S., Chew-Graham, C., McNally, R., & Cheraghi-Sohi, S. (2014). PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. *BMC Health Services Research*, 14(579).

Rodrigues, P. R. S., Maia, L. L., Santos, M., Peterle, G. T., Alves, L. U., Takamori, J. T. et al. (2015). Leptin receptor expression and GLN223ARG polymorphism as prognostic markers in oral and

oropharyngeal cancer. *Genetics and Molecular Research*, 14(4), 14979-14988.

Rong, G., Tang, W., Wang, Y., Qiu, H., & Chen, S. (2019). Investigation of leptin receptor RS1137101 G>A polymorphism with cancer risk: Evidence from 35936 subjects. *Bioscience Reports*, 39(6): BSR20182240.

Sobrinho Santos, E. M., Guimaraes, T. A., Santos, H. O., Cangussu, L. M., de Jesus, S. F., Fraga, C. A. et al., (2017). Leptin acts on neoplastic behaviour and expression levels of genes related to hypoxia, angiogenesis, and invasiveness in oral squamous cell carcinoma. *Tumor Biology*, 39(5):1010428317699130.

Tilg, H., & Moschen, A. (2006). Adipocytokines: mediators linking adipose tissue, inflammation and immunity. *Nature Reviews Immunology*, 6(10), 772–783.

Yang, Y., & Niu, T. (2018). A meta-analysis of associations of LEPR Q223R and K109R polymorphisms with type 2 diabetes risk. *PLoS One*,13(1): e0189366.

Yapijakis, C., Kechagiadakis, M., Nkenke, E., Serefoglou, Z., Avgoustidis, D., Vylliotis, A. *et al.* (2009). Association of leptin -2548G/A and leptin receptor Q223R polymorphisms with increased risk for oral cancer. *Journal of Cancer Research and Clinical Oncology*, 135(4), 603-612.

REVIEW ARTICLE Open Access

Endodontic management and outcome of non-surgical root canal treatment for radix entomolaris associated mandibular molar teeth: A scoping review of case reports

Sobrina Mohamed Khazin[1]*, Musliana Mustaffa[1], Marlena Kamaruzaman[2], Diyana Kamarudin[3]

[1]*Restorative Dentistry Department, Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200, Kuantan, Pahang, Malaysia.*
[2]*Faculty of Dentistry, Universiti Teknologi Mara, UiTM Sungai Buloh Campus, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia.*
[3]*Faculty of Industrial Management, Universiti Malaysia Pahang, Gambang Campus, Lebuh Persiaran Tun Khalil Yaakob, 26300, Kuantan, Pahang, Malaysia.*

Abstract

Radix entomolaris (RE) is an anatomical variant of the permanent mandibular molar (MM) with various complex anatomy. However, there is limited literature on the guideline on endodontic management of RE, resulting in unclear understanding on the endodontic treatment outcomes. Hence, this study aimed to map current case reports on endodontic treatment modalities, occurrence of endodontic mishaps, and outcome of MM associated with RE. A systematic search was performed in PubMed, Google Scholar, Scopus, Science Direct, PLOS, and Lilac databases for English articles published between 2000 and 2022 that met the inclusion criteria. The search yielded 1435 results; after screening was completed, only 58 articles were included in the study and critically appraised using JBI critical appraisal tool. Amongst the modifications made in endodontic management of RE were utilising angulated periapical radiograph supplemented with cone-beam computed tomography, extending the access cavity distolingually, and maintaining a small apical size of #25. There were 12% incidence of endodontic mishaps (separated instrument, ledge, missed canal, and extruded sealer) on RE. The success and survival rate of MM associated with RE were 58.7% and 40% respectively, at an average of 8.4 months. The basic management of MM with RE is similar to that of other MM. However, emphasis should be made on RE identification to prevent endodontic mishaps that can influence the endodontic treatment outcome.

Keywords: *curved canal, distolingual root, endodontic mishap, prognosis, treatment protocol*

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***Corresponding author**
Address:
Restorative Dentistry Department, Kulliyyah of Dentistry, International Islamic University Malaysia, Bandar Indera Mahkota, 25200, Kuantan, Pahang, Malaysia
Telephone: +6013 948 7099, +609 571 6400 ext 2956
Email address:
sobrina@iium.edu.my

Introduction

Non-surgical root canal treatment (NSRCT) is one of the treatment modalities to prevent and heal apical periodontitis through chemomechanical debridement and three-dimensional obturation of the root canal system, and adequate coronal seal (Schilder, 1974). The former majorly relies on the awareness of the morphology and anatomical variations of the root canal system (Wu *et al*., 2017).

Variations of the permanent mandibular molar (MM) have been frequently reported, such as the presence of supernumerary root located lingual to the distal root, which is known as radix entomolaris (RE). RE itself has several classifications based on the

location of the cervical part (Carlsen & Alexandersen, 1990), the curvature (De Moor *et al*., 2004), and the shape and length of RE (Song *et al.*, 2010).

Due to the different RE variants, endodontic treatment may pose a clinical challenge especially in identifying, locating, accessing, and preparing the root canal system. Inadequacy in understanding the variations can cause failure in removing infected pulpal tissue and microorganisms, leading to persistent infection and post-treatment disease (Byström *et al.*, 1987), which will influence the outcome of NSRCT.

There have been numerous case reports on RE management; however, literature on the guideline for RE treatment protocol is limited. Hence, the aim of this study is to map current case reports on the treatment modification, occurrence of endodontic mishap, and outcome of NSRCT on MM associated with RE.

Materials and Method

Protocol guideline

The methodology of the scoping review adhered to the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) protocol guideline (Tricco *et al.*, 2018) (Figure 1).

Formulation of search questions

The review questions were formulated according to the PCC formulation (P: permanent mandibular molar, C: root canal treatment on RE, C: treatment modification and outcome of root canal treatment in terms of success, survival, failure, and occurrence of mishap). The questions generated for this study to guide the scoping review are as follows: "What are the endodontic modifications made to treat permanent mandibular molar with radix entomolaris?" and "Will the modifications affect the outcome of NSRCT in terms of success, survival, failure, and occurrence of endodontic mishaps?".

Eligibility criteria and search strategy

A systematic search on case reports was performed in PubMed, Google Scholar, Scopus, Science Direct, PLOS, and Lilac databases with the latest date of search execution in August 2022. The search was limited to English publications from 2000 to 2022. The terms used in the search were ("radix entomolaris" OR "distolingual root" OR "supernumerary root") AND ("endodontics" OR "root canal treatment").

Study selection and data collection

The three stages of screening (title, abstract and full text) were done independently by two of the authors (S.M.K., M.M.). All full articles available through the initial search were analysed and the articles were selected based on the following criteria:

1. Case report or case series;
2. NSRCT conducted on teeth associated with radix entomolaris on MM;
3. Outcome of treatment mentioned with follow-up period.

Disagreements on study inclusion were discussed until consensus was obtained. The reasons for article rejection were recorded (Figure 1).

Data were extracted by both reviewers independently using a customized data collection sheet. The data collection sheet was piloted on several articles and modified accordingly until a final format was agreed upon by the authors. The extracted data were classified into 6 groups: Demographic data of patients, pre-operative factors, diagnostic method to determine presence of RE, treatment protocol, mishap, and outcome (Supplementary Table 1). Any disagreement was discussed, and data were excluded if agreement could not be reached.

Appraisal for included studies

The methodological quality of the included studies was assessed by two authors (S.M.K., M.M.) using the Joanna Briggs Institute (JBI) Critical Appraisal Tools: Checklist for Case Reports (Moola *et al.,* 2020) (Supplementary

Table 2). JBI Critical Appraisal Tool incorporate appraisal of research evidence, to determine the possibility of bias in the research design, conduct, and analysis. Kappa score among the authors showed a high level of agreement on the included studies (κ > 0.90).

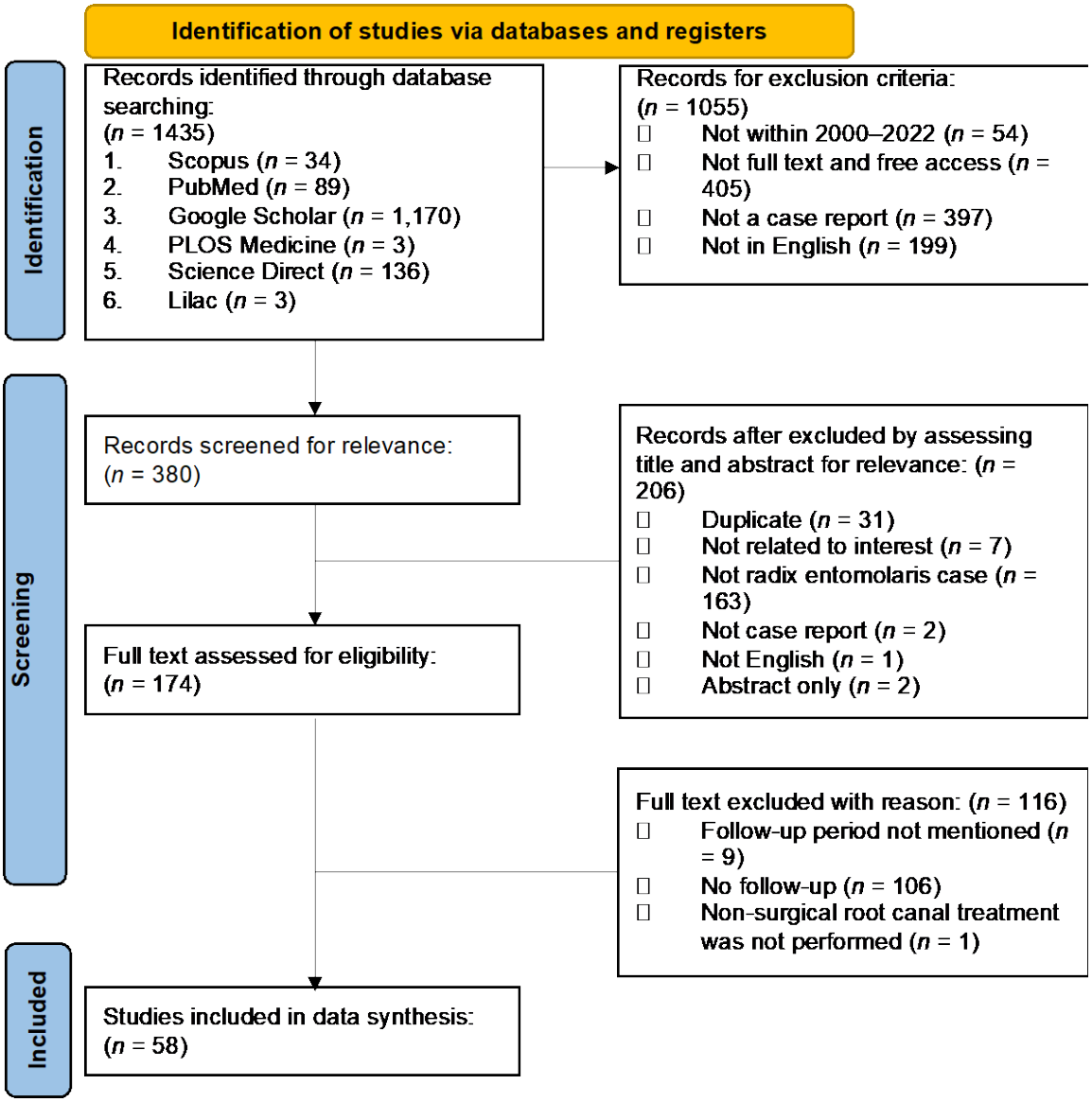

Figure 1. Flow diagram of the study according to PRISMA-ScR protocol guideline.

Results

Search results, study selection, and data extraction

Initially, 1,435 articles with the search terms were identified in the literature search. The studies were then assessed based on the inclusion and exclusion criteria, resulting in 380 potentially eligible studies for inclusion. The titles and the abstracts of the articles were screened to select for the relevant studies to be included in the review, and only 174 articles were eligible. After full-text screening, another 116 articles were excluded because no follow-up period was mentioned or NSRCT was not performed. Hence only 58 articles qualified to be included in the review (Figure 1).

Study characteristics

The 58 articles included were case reports on NSRCT of MM with RE published between 2000 and 2022 with follow-up period between 0.5 to 24 months (SD = 5.73). The case reports detailed 75 treated cases from various countries (Figure 2) on patients with age between 10 and 56 years old (SD = 11.801). The types of RE treated were type I (n = 5), type II (n = 2) and type III (n = 7) based on the classification by De Moor *et al.* (2004). Out of 75 cases, 23 were of tooth that has been endodontically initiated or treated previously and 11 were associated with missed canal. The characteristics of the included studies are reported in Table 1.

Figure 2. Distribution of cases reported based on country.

Diagnosis of radix entomolaris

From the 75 cases, 71 cases investigated the presence of RE (Table 2), where 94.7% of them used intraoral periapical radiograph (IOPA). Some reports supplemented the IOPA with pulpal floor observation using a dental operating microscope (DOM) (14.7%), cone-beam computed tomography (CBCT) (16%), spiral computed tomography (5.3%), or panoramic radiograph (6.7%). Five cases reported on utilising modified IOPA angulation with mesial angulations instead of distal angulations.

Table 1. Characteristics of included case reports (N = 75).

No	Author (date)	Demographic data			Pre-operative factor			Treatment		
		Age, Gender	Race and Country	Medical condition	Tooth	Diagnosis	Findings	Canal preparation method	Obturation method	Post-endodontic restoration
1	Abella *et al.* (2011)	52 F	Caucasian, Spain	Healthy	46	Symptomatic irreversible pulpitis, normal apical tissue	RE type: III Cavity: Class I Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files Glide path: K-file Canal prep: Mtwo rotary files Irrigation: 4.2% NaOCl Needle: Closed end	Final irrigation: 17% EDTA and 4.2% NaOCl Activated: Passive US Obturation: Thermoplasticised GP Sealer: AH plus	Orifice seal: Flowable resin composite Definitive restoration: Indirect resin composite
2	Agarwal *et al.* (2019) (Case 1)	18 F	Not mentioned, India	Healthy	46	Pulpal necrosis, symptomatic chronic apical periodontitis	Cavity: Class I (grossly decayed) Pre-op pain: Intermittent upon mastication Mobility: No PPD: Normal TTP: Yes	Isolation: Rubber dam Coronal flare: PTU SX rotary file WLD: Apex locator and IOPA Canal prep: PTN rotary files to X2 Irrigation: Normal saline,	Final irrigation: 2% CHX Activated: US Obturation: Cold lateral compaction Sealer: AH Plus	Dressing: IRM Definitive restoration: Plan for crown but patient refused

								3% NaOCl, 17% EDTA Intracanal medicament: CaOH		
3	Arora *et al.* (2018) (Case 1)	27 M	Not mentioned, India	Not mentioned	46	Previously treated, apical periodontitis	Cavity: Class II Pre-op pain: Severe upon eating and drinking	Glide path: K-file 15 WLD: Apex locator and IOPA Canal prep: PTN rotary files Irrigation: 1.3% NaOCl Visit: Single	Final irrigation: 17% EDTA Obturation: Cold lateral condensation	Definitive restoration: Resin composite
4	Attam *et al.* (2012) (Case 2)	22 M	Indian, India	Not mentioned	36	Pulpal necrosis, chronic apical periodontitis	Cavity: Class II (disto-occlusal) TTP: Yes PPD and mobility: Normal	Glide path: K-file 15 WLD: IOPA Canal prep: PTU rotary files Irrigation: 1% NaOCl	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Full metal crown
5	Bains *et al.* (2009)	50 M	Indian, India	Not mentioned	46	Previously treated, apical periodontitis associated with missed canal	Pre-op pain: Spontaneous especially upon mastication Cavity: Amalgam with secondary	Isolation: Rubber dam Previous GP: Removed using H-file 15, 20, 25, 30 and organic solvent Canal prep: PTU files to F2	Obturation: Single cone Sealer: AH Plus	Dressing: IRM Definitive restoration: Amalgam

							caries on distal PPD: Deep at distolingual	Irrigation: 3% NaOCl		
6	Banode *et al.* (2016)	25	Not mentioned, India	Healthy	46	Irreversible pulpitis, symptomatic apical periodontitis	Cavity: Mesio-occlusal deep caries TTP: Yes	Isolation: Rubber dam Coronal flare: PTU SX file Canal prep: K3XF files to 25/04 Irrigation: 5% NaOCl	Obturation: Cold lateral compaction	Definitive restoration: Direct resin composite and crown
7	Bansal *et al.* (2015) (Case 2)	18 M	Not mentioned, India	Not mentioned	46	Pulpal necrosis, symptomatic apical periodontitis	Cavity: Mesio-occlusal caries TTP: Yes Pre-op pain: Yes	Canal prep: PTU rotary files to F3	Obturation: Single cone Sealer: AH Plus	Not mentioned
8	Bhargav *et al.* (2017) (Case 1)	38 F	Not mentioned, India	Healthy	46	Symptomatic irreversible pulpitis, apical periodontitis	RE type: I Cavity: Class I Pre-op pain: Yes	Isolation: Rubber dam Glide path: K-file Canal prep: Mtwo rotary files Irrigation: 5% NaOCl Visit: 2 Intracanal medicament: CaOH	Final irrigation: EDTA and saline Obturation: Cold lateral compaction	Definitive restoration: Direct resin composite

9	Bhargav *et al.* (2017) (Case 2)	38 F	Not mentioned, India	Healthy	36	Irreversible pulpitis, apical periodontitis	RE type: I Cavity: Class I Pre-op pain: No	Isolation: Rubber dam Glide path: K-file Canal Prep: Mtwo rotary files Irrigation: 5% NaOCl Visit: 2	Final irrigation: EDTA and saline Obturation: Cold lateral compaction	Definitive restoration: Direct resin composite
10	Bonaccorso & Tripi (2008)	54 F	Not mentioned, Italy	Healthy	46	Pulp necrosis, normal apical tissue	Cavity: Class II Pre-op pain: No	Isolation: Rubber dam Canal prep: BioRaCe rotary files Irrigation: 5% NaOCl and 15% EDTA Visit: 1	Final irrigation: Saline Obturation: Warm GP Sealer: SybronEndo	Orifice seal: Adhesive pulp canal sealer (Estelite Sigma) Definitive restoration: Metal post and PFM crown
11	Choi *et al.* (2018)	46 M	Korean, Korea	Mental retardation	46	Previously initiated therapy, chronic apical abscess associated with endo-perio lesion and separated instrument	RE type: III Cavity: Class I Pre-op pain: Yes Pre-op PPD: 10 mm	Isolation: Rubber dam Coronal flare: PTU rotary files Canal prep: PTU rotary files Irrigation: 5.25% NaOCl Needle: US irrigation tip Visit: 2	Final irrigation: 5.25% NaOCl and saline Activated: Passive US Obturation: Continuous wave Sealer: AH plus	Definitive restoration: PFM crown

12	Chowdhury & Hassan (2014)	13 M	Not mentioned, India	Not mentioned	36	Symptomatic apical periodontitis	Cavity: Class II Pre-op pain: Yes Pre-op PPD: Normal	Isolation: No Coronal flare: PTU hand files Glide path: K-file Canal prep: PTU hand files Irrigation: 2.5% NaOCl Visit: 1	Activated: No Obturation: GP cone	Definitive restoration: Amalgam
13	De Moor *et al.* (2004) (Case 1)	25 M	Caucasian, Belgium	Not mentioned	46	Symptomatic irreversible pulpitis, symptomatic apical periodontitis	RE type: I Cavity: Class II (large) Pre-op pain: Yes Pre-op PPD: Normal	Isolation: Rubber dam Coronal flare: GG bur Canal prep: Crown-down/step-back using FlexoFile Irrigation: 2.5% NaOCl Visit: 1	Activated: No Obturation: Hybrid GP condensation Sealer: AH26	Definitive restoration: Amalgam
14	De Moor *et al.* (2004) (Case 2A)	19 F	Caucasian, Belgium	Healthy	46	Pulp necrosis, symptomatic apical periodontitis	RE type: II Cavity: Class II (large) Pre-op pain: No Pre-op PPD: Normal	Isolation: Rubber dam Coronal flare: PTU hand files Canal prep: PTU hand files Visit: 2 Intracanal medicament: CaOH (UltraCal)	Activated: No Obturation: Hybrid GP condensation Sealer: AH26	Definitive restoration: Not mentioned (direct composite from radiograph)

15	De Moor *et al.* (2004) (Case 2B)	19 F	Caucasian, Belgium	Healthy	36	Pulp necrosis, symptomatic apical periodontitis	RE type: II Cavity: Class I (large) Pre-op pain: No Pre-op PPD: Normal	Isolation: Rubber dam Coronal flare: PTU hand files Canal prep: PTU hand files Visit: 2 Intracanal medicament: CaOH (UltraCal)	Activated: No Obturation: Hybrid GP condensation Sealer: AH26	Definitive restoration: Not mentioned (direct composite from radiograph)
16	De Moor *et al.* (2004) (Case 3)	25 M	Caucasian, Belgium	Not mentioned	46	Previously treated, acute apical abscess associated with missed canal and short obturation	RE type: III Cavity: PFM crown Pre-op pain: Yes Pre-op PPD: No Pre-op AB and analgesics: Yes	Isolation: Rubber dam Canal prep: ProFile rotary files Irrigation: EDTA and 2.5% NaOCl Intracanal medicament: CaOH	Final irrigation: 2.5% NaOCl Activated: No Obturation: Thermomechanical (hybrid) condensation	Orifice seal: Ketac Fil (GIC) Definitive restoration not mentioned
17	De Moor *et al.* (2004) (Case 4)	46 F	Caucasian, Belgium	Not mentioned	46	Pulp necrosis, chronic apical abscess	RE type: III Cavity: PFM crown Pre-op pain: No Pre-op PPD: Pre-op sinus and localised swelling	Isolation: Rubber dam Glide path: FlexoFile Canal prep: ProFile rotary files Irrigation: 2.5% NaOCl, EDTA Visit: 2	Activated: No Obturation: Thermomechanical (hybrid) condensation	Orifice seal: Ketac Fil (GIC) Definitive restoration not mentioned

								Intracanal medicament: CaOH (UltraCal)		
18	de Souza *et al.* (2017)	15 M	Not mentioned, Brazil	Healthy	46	Previously initiated therapy, symptomatic apical periodontitis	Cavity: Class II (radicular extension) Pre-op pain: Yes Pre-op PPD: normal	Isolation: Rubber dam Coronal flare: WaveOne files Glide path: K-file 10, 15 Canal prep: WaveOne files Irrigation: 2.5% NaOCl Visit: 1	Final irrigation: 17% EDTA Activated: No Obturation: Single cone thermoplastic obturation Sealer: Zinc oxide sealer (Vidrion R)	Orifice sealer: GIC Definitive restoration: Direct composite
19	Garg *et al.* (2011)	22 F	Indian, India	Healthy	47	Pulp necrosis, acute apical periodontitis	Cavity: Grossly decayed (Class I) Pre-op pain: Yes Pre-op PPD: Normal	Isolation: Rubber dam Coronal flare: PTU rotary files Glide path: K-file 15 Canal prep: PTU rotary files Irrigation: 2.5% NaOCl Visit: 2	Activated: No Obturation: GP cone Sealer: AH plus	Orifice sealer: Ketac Fil GIC Definitive restoration: Amalgam and crown
20	Gonapa *et al.* (2022)	24 M	Not mentioned, India	Not mentioned	48	Previously initiated therapy, chronic apical abscess	Cavity: Class I Pre-op pain: No	Glide path: K-file 15 Canal prep: PTU rotary files until F3	Final irrigation: 17% EDTA Obturation: Single cone	Orifice sealer: Not mentioned Definitive restoration: Direct

								for MB, ML, F5 for DB Irrigation: 3% NaOCl Visit: Multiple Intracanal medicament: CaOH	Sealer: Bioceramic sealer (MTA EndoSeal)	composite and PFM crown
21	Gupta *et al*. (2014)	16 M	Indian, India	Healthy	46	Pulp necrosis, symptomatic apical periodontitis	Cavity: Class I Pre-op pain: Sharp pain on chewing	Isolation: Rubber dam Coronal flare: PTU rotary files Canal prep: PTU rotary files	Not mentioned	Not mentioned
22	Khirtika & Ramesh (2017) (Case 1)	23 M	Not mentioned, India	Not mentioned	46	Not mentioned	Pre-op pain: Yes	Glide path: K-file 10 WLD: Apex locator Canal prep: PRU rotary files Irrigation: NaOCl and saline	Obturation: Cold lateral compaction	Definitive restoration: Resin composite
23	Kimura & Matsumoto (2000)	31 F	Not mentioned, Japan	Not mentioned	46	Previously initiated therapy, asymptomatic apical periodontitis associated with missed canal	Pre-op pain: No TTP: No	Isolation: Rubber dam with disinfection of crown with iodine and alcohol	Obturation: Cold lateral compaction Sealer: Canals N	Not mentioned

								Coronal flare: Peeso reamer WLD: Apex locator Canal prep: Files and reamers Irrigation: 5% NaOCl and 3% hydrogen peroxide Intracanal medicament: CaOH		
24	Kohli *et al*. (2019)	22 M	Not mentioned, India	Not mentioned	46	Pulpal necrosis, symptomatic apical periodontitis	Cavity: Deep caries TTP: Yes	Isolation: Rubber dam WLD: Apex locator Canal prep: PTN rotary files to X2 Irrigation: 3% NaOCl and 17% EDTA Intracanal medicament: CaOH	Obturation: Single cone	Definitive restoration: Direct composite
25	Kusumo *et al*. (2019)	21 M	Not mentioned, Indonesia	Healthy	36	Previously initiated therapy, normal apical tissue	Cavity: Disto-Occlusal Pre-Op Pain: Yes TTP: No	Isolation: Rubber dam Coronal flare: One Flare rotary file	Final irrigation: 2% CHX Obturation: Single cone Sealer: AH Plus	Definitive restoration: Indirect composite onlay

									Glide path: K-file 10, One G rotary file WLD: Apex locator and IOPA Canal prep: One Curve rotary file Irrigation: 3% NaCOl, 17% EDTA, 2% CHX Intracanal medicament: CaOH		
26	Law & Beaumont (2004) (Case 1)		16 M	Caucasian, USA	Healthy	46	Irreversible pulpitis, asymptomatic apical periodontitis associated with perio-endo lesion	Cavity: Occlusal amalgam and sealant Pre-op pain: Yes Pre-op swelling and sinus tract: No TTP: No Pre-op PPD: 5 mm on distal Mobility: Class I	Visit: Single	Not mentioned	Definitive restoration: Amalgam
27	Law & Beaumont (2004) (Case 2)		16 M	Caucasian, USA	Healthy	46	Irreversible pulpitis, asymptomatic apical	Cavity: Occlusal sealant	Visit: Single	Not mentioned	Definitive restoration: Amalgam followed by

						periodontitis. Associated with perio-endo lesion	Pre-op pain: Yes Pre-op swelling and sinus tract: no TTP: No Pre-op PPD: 14mm on distal with Class II furcation involvement Mobility: Class I			periodontal surgery
28	López-Rosales *et al*. (2015)	45 M	White, Spain	Not mentioned	37	Pulp necrosis, symptomatic apical periodontitis	RE type: AC type III Cavity: Class II (MO) Pre-op pain: Intermittent acute spontaneous pain	Isolation: Rubber dam Coronal flare: PTU rotary files Glide path: k-file 10, PathFile Canal prep: PTU rotary files Irrigation: 5.25% NaOCl Needle: Gauge 30 Visit: Single	Final irrigation: NaOCl and 17% EDTA Activated: US Obturation: Carrier based GP Sealer: pulp canal sealer (Sybron Endo)	Orifice sealer: Flowable composite. Definitive restoration not mentioned
29	Mangal *et al*. (2016)	28 F	Not mentioned, India	Healthy	46	Previously treated, symptomatic apical	TTP: Yes Pre-op pain: Spontaneous	GP removal: H-file and GP solvent, separated	Final irrigation: 2% CHX Obturation: Single cone	Dressing: Zinc oxide eugenol cement

						periodontitis associated with separated instrument at mesial root canal		instrument not removed WLD: Apex locator Canal prep: Mtwo rotary files to 25/06 Irrigation: 3% NaOCl, 0.9% saline Intracanal medicament: CaOH	Sealer: AH Plus	
30	Martins *et al*. (2014)	33 F	Caucasian, Portugal	Healthy	37	Irreversible pulpitis, normal apical tissue	Pre-Op Pain: Spontaneous TTP: No	Isolation: Rubber dam WLD: Apex locator Canal prep: PTU rotary files Irrigation: 5.25% NaOCl Intracanal medicament: CaOH	Final irrigation: 17% EDTA and 5.25% NaOCl Obturation: Single cone Sealer: AH Plus	Dressing: Cavit
31	Marya *et al*. (2014) (Case 1)	42 M	Not mentioned	Healthy	36	Irreversible pulpitis, symptomatic apical periodontitis	Pre-op pain: Yes TTP: Yes Cavity: Temporary restoration disto-oclussal	Isolation: Rubber dam WLD: Apex locator and IOPA Canal prep: PTU hand files to F2	Obturation: Cold lateral compaction Sealer: AH Plus	Not mentioned, post-obturation radiograph suggests amalgam restoration

								Irrigation: 2.5% NaOCl		
32	Marya *et al*. (2014) (Case 2)	15 M	Not mentioned	Not mentioned	36	Irreversible pulpitis, symptomatic apical periodontitis	Pre-op pain: Yes Cavity: Large occlusal restoration TTP: Yes	Isolation: Rubber dam Glide path: K-file 15 WLD: Apex locator and IOPA Canal prep: PTU hand files to F2 Irrigation: 2.5% NaOCl, saline	Obturation: Single cone Sealer: AH Plus	Not mentioned, post-obturation radiograph suggests amalgam restoration
33	Meidyawati & Suprastiwi (2016)	39 F	Not mentioned, Indonesia	Not mentioned	36	Symptomatic apical periodontitis	Pre-op pain: Upon chewing TTP: Yes Cavity: Disto-oclussal	Glide path: K-file 15 WLD: Apex locator and IOPA Canal prep: PTN rotary files to X2 Intracanal medicament: CaOH	Obturation: Warm vertical compaction Sealer: AH Plus	Definitive restoration: Indirect composite onlay
34	Mirikar *et al*. (2009)	16 M	Not mentioned, India	Not mentioned	36	Previously initiated therapy, apical periodontitis associated with furcal perforation	PPD: Normal	Perforation repair: Disinfected with 2.5% NaOCl, dried and repaired with MTA	Obturation: Cold lateral compaction Sealer: AH Plus	Definitive restoration: Composite

								Coronal flare: PTU files Glide path: K-file 10, 15, 20 WLD: Apex locator and IOPA Irrigation: 2.5% NaOCl		
35	Mirza *et al*. (2018)	22 F	Not mentioned, Pakistan	Not mentioned	36	Endo-perio lesion	Cavity: Class 1 Pre-op pain: No Pre-op PPD: 5 mm at mesial and distal	Canal prep: PTU rotary files Irrigation: Normal saline Visit: Multiple Intracanal medicament: CaOH	Final irrigation: 0.12% CHX Obturation: GP point	Orifice sealer: Composite Definitive restoration: PFM crown
36	Mittal & Narang (2012)	21 M	Not mentioned, India	Healthy	36	Irreversible pulpitis, symptomatic apical periodontitis	Pre-op pain: Yes Cavity: Distal caries Pre-op swelling: No Mobility: No PPD: Normal TTP: Yes	Isolation: Rubber dam Coronal flare: PTU SX rotary file WLD: Apex locator and IOPA Canal prep: PTU rotary files Irrigation: 5.25% NaOCl, 17% EDTA	Final irrigation: Saline, 2% CHX Obturation: Single cone Sealer: AH 26	Definitive restoration: Composite

								Intracanal medicament: CaOH		
37	Mohamed Khazin & Mustaffa (2022)	36 M	Malay, Malaysia	Healthy	46	Asymptomatic irreversible pulpitis with asymptomatic apical periodontitis	Cavity: Class II (MOB) Pre-op pain: No	Isolation: Rubber dam Glide path: K-file 8, 10, and 15, followed by rotary PathFile 013, 016, 019. Canal prep: PTN rotary files to size X2 Irrigation: 3% NaOCl, agitation with EndoActivator	Final irrigation: 17% EDTA and 0.2% CHX Activated: EndoActivator Obturation: Warm vertical compaction (thermoplasticised GP) Sealer: AH Plus	Definitive restoration: PFM crown
38	Nagaveni *et al*. (2015) (Case 1A)	14 M	Not mentioned, India	Not mentioned	36	Chronic apical abscess	Cavity: Disto-occlusal	Glide path: K-file 10 Irrigation: 2.5% NaOCl, saline Intracanal medicament: CaOH	Obturation: Lateral compaction Sealer: AH 26	Definitive restoration: Metal post followed by stainless-steel crown
39	Nagaveni *et al*. (2015) (Case 1B)	14 M	Not mentioned, India	Not mentioned	46	Reversible pulpitis	Cavity: Disto-occlusal	Glide path: K-file 10 Irrigation: 2.5% NaOCl, saline Intracanal medicament: CaOH	Obturation: Lateral compaction Sealer: AH 26	Definitive restoration: Metal post followed by stainless-steel crown

40	Nagaveni *et al*. (2015) (Case 2)	15 F	Not mentioned, India	Not mentioned	46	Apical periodontitis	Cavity: Disto-occlusal deep caries	Canal prep: Stepback Irrigation: 2.5% NaOCl, saline Intracanal medicament: CaOH	Obturation: Cold lateral compaction Sealer: AH 26	Definitive restoration: Metal crown
41	Nagaveni *et al*. (2015) (Case 3)	10 M	Not mentioned, India	Not mentioned	36	Apical periodontitis	Cavity: Occlusal deep caries	Canal prep: Stepback Irrigation: 2.5% NaOCl, saline Intracanal medicament: CaOH	Obturation: Cold lateral compaction Sealer: AH 26	Definitive restoration: Stainless-steel crown
42	Nahar (2019) (Case 1)	20 F	Not mentioned, India	Not mentioned		Apical periodontitis	Pre-op pain: Yes	Isolation: Rubber dam Disinfection: Hypo 5% (sodium thiosulphate) Glide path: K-file 10 WLD: Apex locator and IOPA Canal prep: HyFlex CM rotary files to 30/04 Irrigation: 20 mL (type not mentioned)	Obturation: Cold lateral compaction	Definitive restoration: Composite

43	Nahar (2019) (Case 2)	25 F	Not mentioned, India	Not mentioned	46	Irreversible pulpitis	Pre-op pain: Yes	Isolation: Rubber dam Disinfection: Hypo 5% (sodium thiosulphate) Glide path: K-file 10 WLD: Apex locator and IOPA Canal prep: HyFlex CM rotary files to 30/04 Irrigation: 20 mL (type not mentioned)	Obturation: Cold lateral compaction	Definitive restoration: Composite
44	Naidu *et al*. (2013)	25 M	Not mentioned, India	Not mentioned	36	Apical periodontitis	Pre-op pain: Yes Cavity: Disto-occlusal	Isolation: Rubber dam WLD: IOPA Canal prep: PTU rotary files Irrigation: NaOCl Intracanal medicament: formocresol		Definitive restoration: PFM crown
45	Oberländer (2012) (Case A)	19 F	Not mentioned, Germany	Healthy	36	Previously treated, symptomatic apical periodontitis	Pre-op pain: Yes TTP: Yes PPD: 10 mm midbuccal	Isolation: Rubber dam GP removal: PTU revision rotary files	Final irrigation: 5% NaOCl, 70% ethanol, 17% EDTA, 70% ethanol	Definitive restoration: Composite

						associated with separated instrument, short obturation, and missed canal.		Separated instrument removal: US tips WLD: Apex locator Canal prep: PTU rotary files to F3 Irrigation: 5% NaOCl, alcohol, 2% CHX Intracanal medicament: CaOH Visit: 3	Obturation: Warm vertical compaction	
46	Oberländer (2012) (Case B)	19 F	Not mentioned, Germany	Healthy	46	Previously treated, symptomatic apical periodontitis associated with short obturation and missed canal.	Pre-op pain: Yes TTP: Yes	Isolation: Rubber dam GP removal: PTU revision rotary files Separated instrument removal: US tips WLD: Apex locator Canal prep: PTU rotary files to F3 Irrigation: 5% NaOCl, alcohol, 2% CHX	Final irrigation: 5% NaOCl, 70% ethanol, 17% EDTA, 70% ethanol Obturation: Warm vertical compaction	Definitive restoration: Composite

47	Pandey *et al*. (2018)	50 F	Not mentioned, India	Healthy	36	Symptomatic irreversible pulpitis, symptomatic apical periodontitis	Pre-Op Pain: Yes TTP: Yes Cavity: Deep Caries	Isolation: Rubber dam Glide path: K-file 10 WLD: Apex locator and IOPA Canal prep: HyFlex CM rotary files to 30/04 Irrigation: 3% NaOCl Intracanal medicament: CaOH	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Crown
48	Parsa & Rapala (2016)	13 M	Not mentioned, India	Healthy	36	Pulp necrosis, chronic apical periodontitis	Cavity: occlusal caries Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU hand files Glide path: K-file 10 Canal prep: PTU hand files Irrigation: 2.5% sodium hypochlorite	Obturation: Single cone	Definitive restoration: GIC and stainless-steel crown
49	Patil *et al*. (2013)	21 M	Not mentioned, India	Not mentioned	36	Chronic irreversible pulpitis with apical periodontitis	Cavity: Class I (deep occlusal caries) Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Steel crown

							Canal prep: PTU rotary files Irrigation: 3% NaOCl and normal saline		
50	Petrova *et al*. (2020)	28 M	European, Bulgaria	Healthy	36	Previously treated. Associated with missed canal and separated instrument.	Cavity: Class I (deep occlusal caries) Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files Glide path: S1 PTU rotary file Canal prep: The MB, ML, and DL root canals were instrumented using WaveOne Gold Primary rotary files and WaveOne Gold Medium rotary file was used for the DB canal. Irrigation: 5.25% NaOCl, 17% EDTA and normal saline	Activated: US and Endo Activator were used in each root canal for 60 seconds each Obturation: Single cone Sealer: Eugenol-based	Definitive restoration: Flowable resin composite
51	Pires & Martins (2019) (Case 1)	34 F	European, Portugal	Healthy	46	Previously treated, symptomatic	Cavity: Large and deep restoration	Isolation: Rubber dam	Obturation: Single cone	Not mentioned – possibly

					apical periodontitis associated with missed canal	Pre-op pain: Yes	Coronal flare: PTU rotary files Canal prep: until F2 PTU rotary file Intracanal medicament: CaOH		crown based on follow up radiograph
52	Qureshi *et al*. (2017) (Case A)	24 F	Indian, India	Healthy	46	Previously initiated therapy, symptomatic apical periodontitis	RE type: Type I Pre-op pain: Yes TTP: yes Cavity: Temporary restoration disto-occlusal	Isolation: Rubber dam Canal prep: PTU files and K-file WLD: apex locator and IOPA Irrigation: 2.5% NaOCl, 17% EDTA Intracanal medicament: CaOH	Obturation: Single cone cold condensation Sealer: AH Plus	Definitive restoration: Composite
53	Qureshi *et al*. (2017) (Case B)	24 F	Indian, India	Healthy	47	Irreversible pulpitis, symptomatic apical periodontitis	RE type: Type I Pre-op pain: Yes TTP: Yes Cavity: Deep caries	Isolation: Rubber dam Canal prep: PTU files and K-file WLD: Apex locator and IOPA Irrigation: 2.5% NaOCl, 17% EDTA	Obturation: Single cone cold condensation Sealer: AH Plus	Definitive restoration: Composite

								Intracanal medicament: CaOH		
54	Schumacher (2008)	17 F	Western European, Germany	Healthy	46	Pulpal necrosis, symptomatic apical periodontitis	Pre-op pain: Yes Mobility: Yes TTP: Yes Pre-op swelling and sinus tract: No PPD: 6 mm lingual Cavity: Deep restoration	Isolation: Rubber dam WLD: Apex locator, IOPA Canal prep: K-FlexoFile and H-file with balanced fore and circumferential filling to ISO 45 Irrigation: 2.5% NaOCl Intracanal medicament: CaOH	Final irrigation: NaOCl. EDTA, 2% CHX Activated: Passive US Obturation: Lateral compaction Sealer: AH Plus	Definitive restoration: Composite
55	Segura-Egea *et al*. (2002)	24 F	Caucasian, Spain	Not mentioned	46	Previously treated, associated with missed canal	Cavity: Disto-occlusal amalgam restoration, mesio-occlusal resin composite restoration Pre-op pain: Yes	Coronal flare: GG burs size 3 and 4 Canal prep: GP was removed with a heated plugger, Hedstrom files and chloroform. Canal preparation with K-FlexoFile	Obturation: Cold lateral compaction Sealer: AH Plus	Definitive restoration: Not mentioned, no crown at follow-up visit seen via radiograph

							Irrigation: 5% NaOCl and EDTA		
56	Shahbaz *et al*. (2022)	15 M	Not mentioned, India	Not mentioned	36	Pulpal necrosis, symptomatic apical periodontitis	Cavity: Caries not mentioned specifically Pre-op pain: Yes	Coronal flare: PTG rotary files Glide path: K-file 10 Canal prep: GP was removed with a heated plugger, Hedstrom files and chloroform. Canal preparation with K-FlexoFile Irrigation: 2.5% NaOCl and 17% EDTA Intracanal medicament: CaOH	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Porcelain jacket crown
57	Sinha & Sinha (2014) (Case 1)	24 M	Not mentioned, India	Not mentioned	46	Apical periodontitis	Pre-op pain: Yes Cavity: Deep caries Class II	Isolation: Rubber dam Glide path: K-file 15 WLD: Apex locator and IOPA Canal prep: PTU rotary files to F2	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Amalgam

								Irrigation: 5.25% NaOCl, 17% EDTA		
58	Sinha *et al*. (2016) (Case 2)	32 F	Not mentioned, India	Not mentioned	46	Previously initiated therapy, apical periodontitis associated with missed canal	Pre-op pain: Yes Cavity: Distal caries Mobility: No PPD: Normal	Isolation: Rubber dam Glide path: K-file 10 WLD: Apex locator, IOPA Canal prep: PTU rotary files to F2 Irrigation: 5.25% NaOCl	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Amalgam
59	Srinivasan *et al*. (2015)	15 F	Not mentioned, India	Not mentioned	46	Previously initiated therapy, apical periodontitis associated with perforation	Cavity: Class I with orthodontic molar band	Isolation: Rubber dam Coronal flare: S1, S2 PTU rotary files Perforation repair: MTA white WLD: Apex locator, IOPA Canal prep: Mtwo rotary files to 25/06 Irrigation: 2.5% NaOCl, saline	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Resin-modified GIC
60	Štamfelj (2014)	14 M	Caucasian, Slovenia	Asthma, on oral antihistamine, inhaled	36	Previously initiated therapy, asymptomatic	RE type: III Cavity: Mesio-occlusal	Isolation: Rubber dam	Activated: US Obturation: Single cone Sealer: AH Plus	Definitive restoration: Resin composite

				corticosteroid and short-acting beta2-agonist		apical periodontitis associated with sclerosed RE	temporary restoration Pre-op pain: No	Coronal flare: SX PTU rotary file Canal prep: PTU rotary files Irrigation: US irrigated 20% disodium edetate and 2.5% NaOCl used in an alternating manner Intracanal medicament: CaOH		
61	Štamfelj *et al*. (2016)	47 F	Caucasian, Slovenia	Healthy	36	Previously treated, asymptomatic apical periodontitis associated with short obturation	Pre-op pain: Yes Cavity: Mesio-distal occlusal composite TTP: No PPD: Normal Pre-op swelling: Yes	Isolation: Rubber dam GP removal: Eucalyptus oil Glide path: K-file Coronal flare: SX PTU file WLD: Apex locator Canal prep: K-file hand files Irrigation: 2.5% NaOCl Intracanal medicament: CaOH	Obturation: Cold lateral condensation Sealer: AH Plus	Definitive restoration: Composite

62	Subramaniam Ramachandran *et al*. (2019)	35 M	Indian, India	Healthy	36	Previously initiated therapy, symptomatic apical periodontitis	Pre-op pain: Yes TTP: Yes	Isolation: Rubber dam Coronal flare: PTG SX rotary file WLD: Apex locator and IOPA Canal prep: PTG rotary files Irrigation: 5.25% NaOCl, 17% EDTA Intracanal medicament: CaOH	Final irrigation: NaOCl Obturation: Warm vertical compaction Sealer: Calcium hydroxide sealer (Sealapex)	Definitive restoration: Composite
63	Tian *et al*. (2015)	23 F	Chinese, China	Healthy	47	Pulp necrosis, apical periodontitis	Pre-op swelling: Extraoral sinus Cavity: GIC Disto-occlusal buccal TTP: No Mobility: Grade I PPD: Normal RE type: III	Isolation: Rubber dam Needle: 27G Irrigation: 3% perhydrol, 17% EDTA, 2.5% NaOCl Intracanal medicament: CaOH WLD: Apex locator, IOPA Canal prep: TF and Mtwo rotary files to 25/08 Visit: Multiple	Obturation: Continuous wave Sealer: AH Plus	Not mentioned

64	Tsujimoto (2021)	40 M	Japanese, Japan	Not mentioned	36	Irreversible pulpitis	Pre-op pain: Yes PPD: Normal	Isolation: Rubber dam Coronal flare: SX PTG and US diamond file Negotiation: D-finder files WLD: Apex locator Canal prep: PTG files Visit: Single	Obturation: Thermoplasticised GP	Definitive restoration: Metal crown
65	Turki (2019)	20 F	Not mentioned, Saudi Arabia	Not mentioned	46	Previously initiated therapy, symptomatic apical periodontitis associated with missed canal.	Cavity: temporary restoration Pre-op pain: no	Isolation: Rubber dam Coronal flare: GG burs Canal prep: Crown-down using GG burs and K3 Endo rotary files Irrigation: 2.5% NaOCl Intra-canal medicament: CaOH	Obturation: Cold lateral compaction Sealer: AH26	Definitive restoration: Full coverage crown but not mentioned specifically
66	Vanti *et al.* (2019) (Case A)	35 F	Not mentioned, India	Not mentioned	46	Not mentioned	Pre-op pain: Yes	Isolation: Rubber dam WLD: IOPA Canal prep: PTU rotary files Irrigation: NaOCl, saline	Final irrigation: 2% CHX Obturation: Cold lateral compaction	Definitive restoration: Composite

67	Vanti *et al.* (2019) (Case B)	35 F	Not mentioned, India	Not mentioned	36	Not mentioned	Pre-op pain: Yes	Isolation: Rubber dam WLD: IOPA Canal prep: PTU rotary files Irrigation: NaOCl, saline	Final irrigation: 2% CHX Obturation: Cold lateral compaction	Definitive restoration: Composite
68	Verma (2009)	50 F	Asian, Not mentioned	Not mentioned	36	Previously initiated associated with missed canal.	Cavity: Amalgam restoration Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: ProFile rotary files Canal prep: ProFile rotary files Irrigation: 2.5% NaOCl Intracanal medicament: CaOH	Obturation: Single cone Sealer: AH Plus	Definitive restoration: Full coverage crown but not mentioned specifically
69	Vijay *et al.* (2011)	25 M	Not mentioned, India	Not mentioned	37	Irreversible pulpitis, symptomatic apical periodontitis	Pre-op pain: Yes Cavity: Large occlusobuccal TTP: Yes	Isolation: Rubber dam Coronal flare: Fissure bur WLD: Apex locator and IOPA Canal prep: PTU rotary files to F2 Irrigation: 5.25% NaOCl, saline	Final irrigation: Saline Obturation: Single cone Sealer: AH Plus	Definitive restoration: Plan for crown

								Visit: 3		
70	Vinay Kumar & Shaktidar (2014) (Case A)	12 F	Indian, India	Healthy	46	Pulpal necrosis, symptomatic apical periodontitis	Cavity: Deep caries Pre-op pain: Yes TTP: Yes Pre-op swelling and sinus tract: No	Isolation: Not done Coronal flare: GG burs Glide path: K-file 10 Canal prep: PTU rotary files to F2 Irrigation: 1% NaOCl and saline Intracanal medicament: CaOH	Obturation: Single cone Sealer: Zinc oxide eugenol sealer	Definitive restoration: GIC and stainless-steel crown
71	Vinay Kumar & Shaktidar (2014) (Case B)	12 F	Indian, India	Healthy	36	Pulpal necrosis, symptomatic apical periodontitis	Cavity: Deep caries Pre-op pain: Yes TTP: Yes Pre-op swelling and sinus tract: No	Isolation: Not done Coronal flare: GG burs Glide path: K-file 10 Canal prep: PTU rotary files to F2 Irrigation: 1% NaOCl and saline Intracanal medicament: CaOH	Obturation: Single cone Sealer: Zinc oxide eugenol sealer	Definitive restoration: GIC and stainless-steel crown
72	Vivekananda *et al.* (2014) (Case 2)	56 F	Not mentioned, India	Not mentioned	36	Pulp necrosis with chronic	Cavity: Class I (deep	Isolation: Rubber dam	Final irrigation: 17% EDTA	Definitive restoration: Amalgam

						apical periodontitis	occlusal caries) Pre-op pain: Yes	Coronal flare: PTU rotary files Glide path: K-file 8, 10 Canal prep: PTU rotary files Irrigation: 2.5% NaOCl Intracanal medicament: CaOH	Obturation: Single cone Sealer: AH26	
73	Vivekananda *et al.* (2014) (Case 3)	35 M	Not mentioned, India	Not mentioned	46	Symptomatic irreversible pulpitis	Cavity: Class II (deep distal caries) Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files Glide path: K-file 8, 10 Canal prep: PTU rotary files Irrigation: 2.5% NaOCl Intracanal medicament: CaOH	Final irrigation: 17% EDTA Obturation: Single cone Sealer: AH26	Definitive restoration: Amalgam
74	Vivekananda *et al.* (2014) (Case 4)	28 F	Not mentioned, India	Not mentioned	46	Acute irreversible pulpitis	Cavity: Class I (deep mesio-lingual caries) Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files	Final irrigation: 17% EDTA Obturation: Single cone Sealer: AH26	Definitive restoration: Amalgam

							Glide path: K-file 8, 10 Canal prep: Rotary NiTi files (specific system not mentioned) Irrigation: 2.5% NaOCl		
75	Yadav *et al*. (2016)	35 M	Not mentioned, India	Healthy	46	Symptomatic irreversible pulpitis, apical periodontitis	Cavity: Distal caries Pre-op pain: Yes	Isolation: Rubber dam Coronal flare: PTU rotary files Canal prep: PTU rotary files Irrigation: 5% NaOCl and 17% EDTA Intracanal medicament: CaOH	Final irrigation: 5% NaOCl, 17% EDTA and normal saline Obturation: Single cone Sealer: AH Plus	Definitive restoration: Fibre-reinforced composite, gingivectomy and crown lengthening surgery, and restored with metal onlay

CaOH: calcium hydroxide, CHX: chlorhexidine, DB: distobuccal, DL: distolingual, EDTA: ethylenediaminetetraacetic acid, F: female, GG: Gates Glidden, GIC: glass ionomer cement, GP: gutta percha, IOPA: intraoral periapical radiograph, IRM: Intermediate restorative material, M: male, MB: mesiobuccal, ML: mesiolingual, NaOCl: sodium hypochlorite, NiTi: nickel–titanium, PFM: porcelain fused to metal, PPD: periodontal probing depth, PTG: ProTaper Gold, PTN: ProTaper Next, PTU: ProTaper Universal, RE: radix entomolaris, TTP: tender to percussion, US: ultrasonic, WLD: working length determination

Table 2. Pre-operative investigation to identify radix entomolaris.

Type of investigation	Author	Type of investigation	Author
Single parallel IOPA	Abella *et al*. (2011) Attam *et al.* (2012) Banode *et al.* (2016) Bansal *et al.* (2015) Bhargav *et al.* (2017) Bonaccorso & Tripi (2008) Choi *et al.* (2018) De Moor *et al.* (2004) Gonapa *et al*. (2022) Kimura & Matsumoto (2000) Law & Beaumont (2004) López-Rosales *et al*. (2015) Mangal *et al*. (2016) Meidyawati & Suprastiwi (2016) Mirikar *et al*. (2009) Mohamed Khazin & Mustaffa (2022) Nagaveni *et al*. (2015) Naidu *et al*. (2013) Oberländer (2012) Pandey *et al*. (2018) Parsa & Rapala (2016) Patil *et al*. (2013) Petrova *et al*. (2020) Pires & Martins (2019) Qureshi *et al*. (2017) Segura-Egea *et al*. (2002) Shahbaz *et al.* (2022) Sinha & Sinha (2014) Sinha *et al*. (2016) Srinivasan *et al*. (2015) Štamfelj (2014) Štamfelj *et al*. (2016) Subramaniam Ramachandran *et al*. (2019) Tian *et al*. (2015) Tsujimoto (2021) Turki (2019) Verma (2009) Vijay *et al*. (2011) Vinay Kumar & Shaktidar (2014) Vivekananda Pai *et al*. (2014) Yadav *et al*. (2016)	**Single angulated IOPA**	
		Mesial angulation	Chowdhury & Hassan (2014) De Moor *et al.* (2004) Gupta *et al*. (2014) Marya *et al*. (2014) Mirza *et al*. (2018)
		Direction not mentioned	Garg *et al*. (2011)
		Multiple angulated IOPA	
		Mesial and distal angulation	Agarwal *et al.* (2019) Arora *et al.* (2018) Marya *et al.* (2014) Mittal & Narang (2012) Vanti *et al.* (2019) Vinay Kumar & Shaktidar (2014)
		Direction not mentioned	Bains *et al.* (2009) De Moor *et al.* (2004) Khirtika & Ramesh (2017) Kohli *et al*. (2019) Nahar (2019) Schumacher (2008)
		Cone-beam computed tomography	Abella *et al*. (2011) Banode *et al.* (2016) Choi *et al.* (2018) Gonapa *et al*. (2022) López-Rosales *et al*. (2015) Mangal *et al*. (2016) Martins *et al*. (2014) Pandey *et al*. (2018) Qureshi *et al*. (2017) Tian *et al*. (2015) Tsujimoto (2021)
Panoramic radiograph	López-Rosales *et al*. (2015) Tsujimoto (2021)	**Spiral computed topography**	Bhargav *et al.* (2017) Garg *et al*. (2011) Mittal & Narang (2012) Shahbaz *et al.* (2022)

IOPA: intraoral periapical radiograph

Modification of access cavity

From the 75 cases, 59 cases reported modification made to the access cavity (Table 3), in which the access cavity was enlarged towards the distolingual side using either ultrasonic tips or burs and a trapezoidal access cavity was created instead of rectangular or triangular shape. Some reports mentioned modification of the access cavity, but the details were not specified. Six cases reported on using either DG-16, micro-opener, or endodontic explorer to locate the orifice of RE canal, and 2 cases reported on using the map of the chamber floor to guide in locating the orifice.

Preparation and obturation of RE

Only 33 cases mentioned the glide path preparation (Table 1), and majority of cases used small sized K-files. A small number of cases reported using FlexoFile (1.3%), a combination of K-files with PathFile (1.3%), S1 ProTaper Universal (1.3%), and One G rotary file (1.3%).

Seventy cases reported the preparation technique used on the RE (Table 4). Only 4 cases reported using a different technique when preparing RE compared to other canals. Two cases used engine-driven files on other canals, but used manual hand files on RE, while 1 case did the opposite. Another case used a different type of engine-driven files on RE.

Only 26 out of 75 cases reported the final apical size prepared. Majority reported an apical size of #25 (22.7%), followed by #30 (10.7%) and #20 (1.3%) (Table 5).

Seventy cases reported on the obturation technique used on RE (Table 2). Majority used single cone technique (44%) followed by cold lateral compaction technique (29.3%), warm vertical compaction technique (5.3%), continuous wave technique (2.7%) and carrier-based gutta percha (2.7%).

Endodontic mishap related to radix entomolaris

The pooled incidence of endodontic mishap on RE was 12% with the highest incidence being separated instrument (4%), followed by ledge (2.7%), extruded sealer (2.7%), and missed canal (2.7%). The management and outcome of the mishaps are summarised in Table 6. Furthermore, among the cases that were previously endodontically initiated or treated, 11 of them were referred for further intervention due to missed RE (14.7%).

Outcome

The success rate for NSRCT on MM associated with RE was 58.7% (44 out of 75 cases) at an average follow-up period of 8.4 months. The success criteria were determined clinically (no signs and symptoms) and radiographically (no periapical lesion or a periapical index of 2 or less). Seventeen cases were categorised as healing (22.7%) as there was presence of periapical lesion but clinically asymptomatic. Another 13 cases were asymptomatic at follow-up; however, no radiographical description was given to rule out residual periapical lesion, hence healing and asymptomatic cases were pooled together to be considered as survived at the rate of 40%. One case was categorised as failed (1.3%) due to the presence of clinical symptoms (Table 7).

Table 3. Access cavity modification.

Modification	Author	Modification	Author
Extension of access cavity		**Extension of access cavity**	
Trapezoidal	Arora *et al.* (2018) Choi *et al.* (2018) De Moor *et al.* (2004) Garg *et al.* (2011) Gupta *et al.* (2014) Khirtika & Ramesh (2017) Marya *et al.* (2014) Meidyawati & Suprastiwi (2016) Nagaveni *et al.* (2015) Nahar (2019) Parsa & Rapala (2016) Schumacher (2008) Sinha & Sinha (2014) Sinha *et al.* (2016) Tian *et al.* (2015) Vanti *et al.* (2019) Vijay *et al.* (2011) Vinay Kumar & Shaktidar (2014) Vivekananda Pai *et al.* (2014) Yadav *et al.* (2016)	Extended distolingually	Attam *et al.* (2012) Bains *et al.* (2009) Bonaccorso & Tripi (2008) Chowdhury & Hassan (2014) De Moor *et al.* (2004) López-Rosales *et al.* (2015) Mangal *et al.* (2016) Marya *et al.* (2014) Qureshi *et al.* (2017) Segura-Egea *et al.* (2002) Shahbaz *et al.* (2022) Subramaniam Ramachandran *et al.* (2019)
Armamentarium		**Guidance to locate RE orifice during access cavity**	
Ultrasonic tips	Abella *et al.* (2011) Mohamed Khazin & Mustaffa (2022) Patil *et al.* (2013) Shahbaz *et al.* (2022)	Map of pulpal floor	Martins *et al.* (2014) Marya *et al.* (2014)
Endo Access bur	Agarwal *et al.* (2019) Banode *et al.* (2016)	Micro-opener	Kusumo *et al.* (2019)
Endo Z bur	Bains *et al.* (2009) Mangal *et al.* (2016) Marya *et al.* (2014) Pandey *et al.* (2018) Segura-Egea *et al.* (2002)	DG-16	Banode *et al.* (2016) Nahar (2019) Pandey *et al.* (2018)
GG bur	Vinay Kumar & Shaktidar (2014)	Endodontic explorer	Vijay *et al.* (2011)

GG: Gates Glidden, RE: radix entomolaris

Table 4. Modifications to the type of endodontic files used for root canal preparation of radix entomolaris.

Files used on other canals	Modification to RE	Author
ProTaper Next	K-file	Mohamed Khazin & Mustaffa (2022)
K-FlexoFile	ProTaper Gold (rotary)	Shahbaz *et al*. (2022)
ProTaper (rotary)	SS hand file	Štamfelj (2014)
One Curve	ProTaper (rotary)	Vinay Kumar & Shaktidar (2014) (case A)
Files and reamers	No modifications	Kimura & Matsumoto (2000)
SS hand file	No modifications	Nagaveni *et al*. (2015) (Case 2, 3)
K-file	No modifications	Štamfelj *et al*. (2016)
ProTaper Universal (hand)	No modifications	Chowdhury & Hassan (2014); De Moor *et al.* (2004) (Case 2A, 2B); Bains *et al*. (2009); Marya *et al*. (2014) (Case 1, 2); Mirikar *et al*. (2009); Qureshi *et al*. (2017) (Case A, B)
FlexoFile	No modifications	De Moor *et al.* (2004) (Case 1); Segura-Egea *et al*. (2002); Schumacher (2008)
ProTaper Universal (rotary)	No modifications	Choi *et al.* (2018); Garg *et al*. (2011); Gonapa *et al*. (2022); Gupta *et al*. (2014); López-Rosales *et al*. (2015); Mirza *et al*. (2018); Martins *et al*. (2014); Mittal & Narang (2012); Vivekananda *et al.* (2014) (Cases 2,3,4); Parsa & Rapala (2016); Pires & Martins (2019) (Case 1); Yadav *et al*. (2016); Attam *et al.* (2012) (Case 2); Bansal *et al.* (2015) (Case 2); Vinay Kumar & Shaktidar (2014) (Case B); Naidu *et al*. (2013); Oberländer (2012) (Cases A,B); Vijay *et al*. (2011); Sinha & Sinha (2014); Sinha *et al*. (2016) (Case 2); Vanti *et al.* (2019) (Cases A,B)
ProFile	No modifications	De Moor *et al.* (2004) (Cases 3,4); Verma (2009)
BioRaCe	No modifications	Bonaccorso & Tripi (2008)
PRU	No modifications	Khirtika & Ramesh (2017)
Mtwo	No modifications	Abella *et al*. (2011); Bhargav *et al.* (2017) (Cases 1,2); Mangal *et al*. (2016); Srinivasan *et al.* (2015)
WaveOne	No modifications	de Souza *et al.* (2017)
One Gold	No modifications	Petrova *et al*. (2020)
K3 Endo	No modifications	Turki (2019)
ProTaper Next	No modifications	Agarwal *et al.* (2019) (Cases 1,2); Kohli *et al*. (2019); Meidyawati & Suprastiwi (2016)
K3XF	No modifications	Banode *et al.* (2016)
One Curve	No modifications	Vinay Kumar & Shaktidar (2014) (Case A); Kusumo *et al*. (2019)
HyFlex CM	No modifications	Nahar (2019) (Cases 1,2); Pandey *et al*. (2018)
ProTaper Gold (rotary)	No modifications	Subramaniam Ramachandran *et al*. (2019); Tsujimoto (2021)
TF	No modifications	Tian *et al*. (2015)

SS: stainless-steel, RE: radix entomolaris, CM: controlled memory, TF: twisted files

Table 5. Modification made to radix entomolaris on apical size preparation.

Other canals	Modification on RE	Author
F2	F1	Vijay *et al*. (2011)
20/06	No modification	Abella *et al*. (2011)
X2	25/02	Mohamed Khazin & Mustaffa (2022)
Not mentioned	F2	Shahbaz *et al*. (2022)
		Vinay Kumar & Shaktidar (2014) (Case A)
25/07	No modification	Petrova *et al*. (2020)
F2	No modification	Pires & Martins (2019)
		Bains *et al.* (2009)
		Marya *et al*. (2014) (Cases 1, 2)
		Sinha & Sinha (2014)
X2	No modification	Agarwal *et al.* (2019)
		Kohli *et al*. (2019)
		Meidyawati & Suprastiwi (2016)
25/04	No modification	Banode *et al.* (2016)
25/06	No modification	Mangal *et al*. (2016)
		Srinivasan *et al*. (2015)
25/08	No modification	Tian *et al*. (2015)
30/04	30/06	Nahar (2019) (Cases 1, 2)
		Pandey *et al*. (2018)
45/02	30/02	Schumacher (2008)
F3	No modification	Gonapa *et al*. (2022)
		Bansal *et al.* (2015)
		Oberländer (2012) (Cases A, B)

RE: radix entomolaris

Table 6. Management and outcome of endodontic mishaps on RE.

Author	Management	Outcome
Separated endodontic file		
Vinay Kumar & Shaktidar (2014) (Case B)	4 mm ProTaper F2 rotary file separated and removal was attempted using Masserann kit but was unable to be retrieved. Left in situ at 4 mm apical, RE was obturated up to separated fragment.	S
Mirikar *et al*. (2009)	NiTiFlex #30 hand file separated. Instrument was retrieved using ultrasonic tip. RE was cleaned, prepared, and obturated to full working length.	H
Ledge		
Mohamed Khazin & Mustaffa (2022)	Ledge was bypassed and RE prepared using stepback technique. RE cleaned, prepared, and obturated to full working length. 70% isopropyl alcohol was used to improve GP rigidity and maintain GP in pre-curved state to bypass the ledge during obturation.	S

Štamfelj (2014)	Ledge was bypassed and RE prepared manually with pre-curved stainless-steel files, and obturated to full working length.	H
Missed canal		
Kusumo *et al*. (2019)	RE was missed during first visit, causing intra-appointment flare-up. RE was identified on the next visit and negotiated, prepared, cleaned, and obturated to full working length.	S
Mangal *et al*. (2016)	RE was missed during first visit causing intra-appointment flare-up. RE was identified on the next visit and negotiated, prepared, cleaned, and obturated to full working length.	A
Extruded sealer		
Oberländer (2012) (Case A)	None	S
Vivekananda Pai *et al*. 2014 (Case 4)	None	S
Pre-operative mishap by previous operator		
Choi *et al.* (2018)	Separated file on RE (unknown) with small taper. Instrument was bypassed, and RE was cleaned, prepared, and obturated to full working length	S
Mirikar *et al*. (2009)	Perforation of chamber floor. Perforation site was disinfected with 2.5% NaOCl, dried, and repaired with MTA.	H
Srinivasan *et al*. (2015)	Perforation of chamber floor. GP points placed at all canals, MTA white was used to repair perforation, wet cotton pellet was placed to allow MTA to set, and tooth was temporised.	H
Bains *et al.* (2009)	Missed RE canal. RE was identified, negotiated, prepared, cleaned, and obturated to full working length.	A
De Moor *et al.* (2004)		S
Kimura & Matsumoto (2000)		H
Oberländer (2012) (Case A)		S
Oberländer (2012) (Case B)		H
Petrova *et al*. (2020)		S
Pires & Martins (2019)		S
Segura-Egea *et al*. (2002)		H
Sinha *et al*. (2016)		A
Turki (2019)		H
Verma (2009)		H

A: asymptomatic, H: healing, GP: gutta percha, MTA: mineral trioxide aggregate, NaOCl: sodium hypochlorite, RE: radix entomolaris, S: success.

Table 7. Outcome and mishaps of non-surgical root canal treatment on mandibular molar with radix entomolaris.

Follow-up (months)	Author	Outcome	Mishap on RE
0.5	Vijay *et al*. (2011)	S	
1	Gonapa *et al*. (2022)	F	
	Mangal *et al*. (2016)	A	MC
	Marya *et al*. (2014) (Case 1)	A	
	Marya *et al*. (2014) (Case 2)	A	
	Pandey *et al*. (2018)	H	
	Qureshi *et al*. (2017) (Case A)	H	
	Qureshi *et al*. (2017) (Case B)	S	
	Sinha & Sinha (2014) (Case 1)	A	
	Sinha *et al*. (2016) (Case 2)	A	MC
2	Kusumo *et al. (2019)*	S	MC
	Meidyawati & Suprastiwi 2016	S	
	Mirikar *et al.* (2009)	H	P, SI
3	Banode *et al.* (2016)	A	
	Kimura & Matsumoto (2000)	H	MC
	Naidu *et al*. (2013)	H	
	Vanti *et al.* (2019) (Case A)	S	
	Vanti *et al.* (2019) (Case B)	S	
	Nahar (2019) (Case 1)	H	
	Nahar (2019) (Case 2)	S	
	Kohli *et al*. (2019)	S	
6	Vivekananda Pai *et al*. (2014) (Case 2)	H	
	Vivekananda Pai *et al*. (2014) (Case 3)	S	
	Agarwal *et al.* (2019) (Case 1)	S	
	Arora *et al.* (2018) (Case 1)	S	
	Bansal *et al.* (2015) (Case 2)	A	
9	Bains *et al.* (2009)	A	MC
	Tian *et al*. (2015)	S	
10	Turki (2019)	H	MC
	Martins *et al*. (2014)	A	
12	Abella *et al*. (2011)	S	
	Bhargav *et al.* (2017) (Case 1)	S	
	Bhargav *et al.* (2017) (Case 2)	S	
	Chowdhury & Hassan (2014)	S	
	De Moor *et al.* (2004) (Case 1)	S	
	De Moor *et al.* (2004) (Case 2A)	S	
	De Moor *et al.* (2004) (Case 2B)	S	
	De Moor *et al.* (2004) (Case 3)	S	MC
	De Moor *et al.* (2004) (Case 4)	S	
	de Souza *et al.* (2017)	S	
	Garg *et al*. (2011)	S	
	Gupta *et al*. (2014)	S	
	Mohamed Khazin & Mustaffa (2022)	S	Ledge
	Vivekananda Pai *et al*. (2014) (Case 4)	S	ES
	Parsa & Rapala (2016)	S	
	Petrova *et al*. (2020)	S	MC
	Štamfelj (2014)	H	Ledge
	Khirtika & Ramesh (2017)	S	
	Law & Beaumont (2004) (Case 1)	S	
	Law & Beaumont (2004) (Case 2)	S	
	Nagaveni *et al*. (2015) (Case 1A)	A	
	Nagaveni *et al*. (2015) (Case 1B)	A	

	Vinay Kumar & Shaktidar (2014) (Case A)	S			Nagaveni *et al*. (2015) (Case 2)	A	
	Vinay Kumar & Shaktidar (2014) (Case B)	S	SI	14	López-Rosales *et al*. (2015)	S	
	Oberländer (2012) (Case A)	S	MC, ES		Segura-Egea *et al*. (2002)	H	MC
	Oberländer (2012) (Case B)	H	MC	15	Yadav *et al*. (2016)	S	
	Subramaniam Ramachandran *et al*. (2019)	A		18	Bonaccorso & Tripi (2008)	S	
	Srinivasan *et al*. (2015)	H	P		Choi *et al.* (2018)	S	SI
	Štamfelj *et al*. (2016)	H			Mirza *et al*. (2018)	S	
	Tsujimoto (2021)	S			Verma (2009)	H	MC
	Nagaveni *et al*. (2015) (Case 3)	A		19	Pires & Martins (2019) (Case 1)	S	MC
7	Mittal & Narang (2012)	H		24	Patil *et al*. (2013)	S	
8	Attam *et al.* (2012) (Case 2)	H			Shahbaz *et al.* (2022)	S	

A: asymptomatic, ES: extruded sealer, F: failed, H: healing, MC: missed canal, P: perforation, S: successful, SI; separated instrument.

Discussion

Diagnostic challenge

Based on clinical assessment, the anatomical variations of MM play a significant role in anticipating the presence of RE as highlighted by Calberson *et al.* (2007) and Kim *et al*. (2013). RE presence can be suspected when certain clinical features are present such as 1) additional tubercle or sixth cusp, 2) wider buccolingual measurement at the distal surface of the crown, 3) slightly wider intercuspal distance between the distolingual cusp with distobuccal and mesiolingual cusp, and 4) presence of cervical prominence or convexity (Calberson *et al*., 2007; Kim *et al*., 2013). However, the teeth can also present with pathological conditions (such as dental caries or tooth surface loss) or have intracoronal or extracoronal restoration, thus compromising thorough assessment.

Further radiographical assessment is indicated to assess RE presence such as the use of IOPA at different angulations (Chowdhury & Hasan, 2014; De Moor *et al.* 2004; Garg *et al*., 2011; Gupta *et al*., 2014; Mirza *et al*., 2018). However, the curvature from the buccolingual direction cannot be assessed effectively due to the limitation of a two-dimensional radiograph. On that note, utilising the CBCT could help in evaluating the curvature of other roots including RE, thus anticipating the complexity of endodontic procedure and the likely prognosis. Majority of cases included in this review did not use CBCT for identification but relied solely on IOPA. According to the European Society of Endodontology (ESE), using CBCT during routine endodontic treatment is indicated for further investigation, in the case of anatomically complex root canal system (Patel *et al*., 2019). The use of CBCT was highlighted in several of the case reports included in this review. Determining the presence of RE in MM may be of major importance to achieve a favourable treatment outcome (Rodríguez-Niklitschek *et al.*, 2015).

Nonetheless, CBCT is not always necessary if clinical examination such as observation under DOM and conventional radiograph are able to provide adequate information for treatment to be rendered (Patel *et al*., 2014). Additional information can be gained by using angulated IOPA; it has been shown that 25° mesial-horizontal angled IOPA is the most effective to identify type II and III RE, while type I RE is easily identifiable with various horizontal angulations of periapical radiograph (Wang *et al*., 2011).

The anatomy of MM with RE at the level of cementoenamel junction may differ than that without RE. The presence of dentinal shelf may block the location of RE canal orifice and hinder its direct view (Abella *et al*., 2012). Some of the case reports also mentioned that observing the pulpal floor using DOM can facilitate in locating the canal orifice of RE (Mohamed Khazin & Mustaffa, 2022; Patil *et al*., 2013; Petrova *et al*., 2020; Pires & Martins, 2019; Vivekananda Pai *et al*., 2014). However, a sound knowledge on the presence of RE is needed to prevent RE misidentification as a second canal of a distal root (Madhuram *et al*., 2011).

Modification to access cavity

Due to the anatomical location of RE and the blocked orifice, modification is to be made by extending the access cavity towards the distolingual and taking a trapezoidal shape instead of a triangular shape (Figure 3), which was mentioned in majority of cases reported (Table 3). The modification can be made using endodontic ultrasonic tips or endodontic access opening burs (Abella *et al*., 2011; Mohamed Khazin & Mustaffa, 2022; Patil *et al*., 2013; Petrova *et al*., 2020; Segura-Egea *et al*., 2002; Shahbaz *et al*., 2022). However, care must be taken not to over enlarge the orifice as there is risk of perforation due to slender root anatomy (Figure 4).

Figure 3. Clinical photograph of mandibular molar with radix entomolaris. Red arrow showing extension of access cavity towards distolingual to accommodate identification, preparation, and obturation of RE (Taken with permission from Mohamed Khazin & Mustaffa 2022).

Figure 4. Sagittal view of cone-beam computed tomography image of mandibular molar with radix entomolaris. Red arrow showing slender and acute root curvature.

Preparation and obturation of RE

RE is known for being slender and curved buccolingually. To prevent mishaps such as perforation, ledge, or separated instrument, achieving glide path is necessary. However, in most of the cases reported in this review, glide path was not emphasised. Glide path can be achieved using manual or rotary instruments. A recent systematic review documented that achieving glide path prior to canal preparation significantly reduces the incidence of canal transportation especially when using rotary system (Plotino *et al*., 2020). A previous study found that the use of manual file reduces the likelihood of instrument separation during canal preparation (Patiño *et al*., 2005); however, several recent studies have shown that using rotary or manual glide path files have no

difference in influencing file fracture rate (Plotino *et al*., 2020).

Larger apical size preparation has been shown to provide better canal cleaning and significantly reduce debris accumulation in curved canals (Pivoto-João *et al*., 2020), while still maintaining central ability and absence of canal transportation (Poly *et al*., 2019). The type of file used plays an important role to achieve said outcome, such as using a heat-treated nickel–titanium file with small taper (de Carvalho *et al.*, 2022). A previous study found little difference in the amount of wall touched by files when apical canal was prepared between size #30 and #50, but sizes larger than #40 does increase the amount of irrigation reaching the apical third (de Gregorio *et al.*, 2013) and larger taper files result in more dentinal removal especially in curved canal (de Carvalho *et al.*, 2022). Majority of the cases reported in this review had apical canal preparation at #25; the decision to maintain the apical size at #25 was probably to reduce unnecessary dentinal removal especially in a slender and curved RE, considering the type of file used had large taper (6%–7%) and majority of the files used were not heat-treated files (Tables 4 and 5).

Endodontic mishaps on RE

RE has several anatomical variations, hence procedural errors such as furcal or strip perforation, weakening of roots, vertical root fracture, root canal fattening and transportation, loss of working length, and instrument separation can occur in RE (Duman *et al*., 2019).

The pooled incidence of endodontic mishap on RE in this review was close to that reported in a previous study, where mishaps performed by endodontic residents and endodontists were 7.7% and the highest mishap rate was due to separated instrument, followed by missed canal, and ledge (Bozkurt *et al.*, 2021). Other studies that observed mishap incidences performed by undergraduate students showed vast difference ranging from 31.9%–63.9%, with the highest incidence being over-instrumentation (Alhekeir *et al*., 2013; Haug *et al*., 2018).

Two cases included in this review reported chamber floor perforation during access cavity that was referred by a previous operator. Both teeth were repaired with mineral trioxide aggregate. Nonetheless, both teeth did not have a successful outcome. The outcome of perforation depends on its size and location, and the repair duration. In the included study, both cases had large perforation located at crestal level, hence reducing the prognosis of the treatment despite being treated promptly (American Association of Endodontists, 2017).

The pooled incidence of missed canal included in this review was 17.4% which was low compared to that from a CBCT study by Mashyakhy *et al*. (2021). They found that the incidence of missed canal in MM was 25%. Nonetheless, 18.2% of the cases were missed distolingual canal, which is close to the findings in the present review. All the cases that had missed canal had persistent apical periodontitis that required further intervention, which are similarly seen in the cases reported in this review.

Other mishaps that were reported in this review such as ledge, separated instrument, and sealer extrusion, did not have a detrimental effect on the outcome of the NSRCT. Separated instrument, sealer extrusion, sealer type, and extension of apical filling material have been shown to not have a significant effect on NSRCT outcome unless accompanied by pre-operative apical periodontitis (Ricucci *et al*., 2016; Spili *et al*., 2005). Similarly for ledge, if it is able to be bypassed and instrumentation and irrigation are able to reach apical terminus, it has no effect on NSRCT outcome (Lambrianidis, 2006).

Without adequate pre-operative assessment and sound knowledge on MM variations, particularly on the presence of RE, its location and curvature, the risk of procedural errors during NSRCT can increase. However, these procedural errors can be managed successfully with adequate

clinical skills and experience of the clinicians (Mohamed Khazin & Mustaffa, 2022).

The outcomes of endodontic treatment on MM with RE

More than half of the case reports included in this review showed successful outcome with no clinical and radiographical signs of pathology (58.7%). Nonetheless, it varied tremendously with previous outcome study which ranges between 80%–83% (Ng *et al*., 2011). This vast difference in outcome is most likely because the cases included in the present review are difficult endodontic cases due to the presence of RE, unlike the previous study where outcome based on case difficulty was not segregated. Furthermore, the average follow-up period was less than one year. According to ESE, the outcome of NSRCT should be assessed at least after one year (ESE, 2006). For cases that had a follow-up period of at least 12 months, 27 of 33 cases (81.8%) were successful. Healing or asymptomatic cases that had a follow-up period of less than 12 months might require more time for the apical periodontitis to heal following NSRCT and should be reviewed further for a minimum period of 4 years (ESE, 2006).

Currently, there is no evidence on the prognostic indicators determining the treatment outcomes of MM with RE, which could be attributed to the nature of existing studies that are primarily case reports, case series, retrospectives, and reviews. Therefore, it is rather difficult to make a robust conclusion pertaining to the factors contributing the treatment outcomes. Perhaps future research can focus on this aspect so that clinicians can anticipate various factors that may affect the overall treatment outcomes.

Conclusion

When treating MM, thorough clinical and radiographical examination is needed to rule out RE. Early identification of RE can help in prevention of mishaps. Clinicians should have sound knowledge and understanding on the presence of RE across different populations, root canal morphology associated with RE that may complicate the endodontic procedure, CBCT and magnification device usage, as well as clinical skills and experience in managing MM with RE to improve the endodontic treatment outcomes.

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References

Abella, F., Mercadé, M., Duran-Sindreu, F., Roig, M. (2011). Managing severe curvature of radix entomolaris: Three-dimensional analysis with cone beam computed tomography. *International Endodontic Journal*, 44(9), 876–885. https://doi.org/10.1111/j.1365-2591.2011.01898.x

Abella, F., Patel, S., Durán-Sindreu, F., Mercadé, M., Roig, M. (2012). Mandibular first molars with disto-lingual roots: review and clinical management. *International Endodontic Journal*, 45(11), 963–978. https://doi.org/10.1111/j.1365-2591.2012.02075.x

Agarwal, P., Sharma, A., Abraham, D., Singh, A., Jala, S., Pratima, M. (2019). Successful endodontic management of three rooted mandibular 1st molars: radix entomolaris – A case series. *International Journal of Dental Science and Innovative Research*, 2(1), 167–175. https://www.researchgate.net/publication/354554667

Alhekeir, D.F, Al-Sarhan, R.A., Mokhlis, H., Al-Nazhan, S. (2013). Endodontic mishaps among undergraduate dental students attending King Saud University and Riyadh Colleges of Dentistry and Pharmacy. *Saudi Endodontic Journal*, 3(1), 25–30. https://doi.org/10.4103/1658-5984.116277

American Association of Endodontists. (2017). Treatment options for the compromised tooth: A decision guide. Retrieved from https://www.aae.org/specialty/wp-content/uploads/sites/2/2017/07/2014treatmentoptionsguidefinalweb.pdf

Arora, A., Arya, A., Chauhan, L., Thapak, G. (2018). Radix entomolaris: Case report with clinical implication. *International Journal of Clinical Pediatric Dentistry*, 11(6), 536–538. https://doi.org/10.5005/jp-journals-10005-1572

Attam, K., Nawal, R.R., Utneja, S., Talwar, S. (2012). Radix entomolaris in mandibular first molars in Indian population: a review and case reports. *Case Reports in Dentistry*, 2012, 1–7. https://doi.org/10.1155/2012/595494

Bains, R., Loomba, K., Chandra, A., Loomba, A., Bains, V.K., Garg, A. (2009). The radix entomolaris: a case report. *Endo: Endodontic Practice Today*, 8(2), 121–125.

Banode, A.M., Gade, V., Patil, S., Gade, J. (2016). Endodontic management of mandibular first molar with seven canals using cone-beam computed tomography. *Contemporary Clinical Dentistry*, 7(2), 255–257. https://doi.org/10.4103/0976-237X.183055

Bansal, P., Nikhil, V., Shekhar, S. (2015). Three distal root canals in mandibular first molar with different canal configurations: Report of two cases and literature review. *Saudi Endodontic Journal*, 5(1), 51–55. https://doi.org/10.4103/1658-5984.149090

Bhargav, K., Sirisha, K., Jyothi, M., Boddeda, M.R. (2017). Endodontic management of contralateral mandibular first molars with six root canals. *Journal of Conservative Dentistry*, 20(4), 282–285. https://doi.org/10.4103/JCD.JCD_257_16

Bonaccorso, A., Tripi, T.R. (2008). Root canal treatment of a three-rooted mandibular first molar: a case report. *Quintessence*, 2(3), 211–217.

Bozkurt, D.A., Terlemez, A., Özcan, M. (2021). Assessment of technical quality of 9562 endodontic cases treated by undergraduate students and endodontics specialists. *Brazilian Dental Science*, 24(1), 1–9. https://doi.org/10.14295/bds.2020.v23i4.2240

Byström, A., Happonen, R.P., Sjögren, U., Sundqvist, G. (1987). Healing of periapical lesions of pulpless teeth after endodontic treatment with controlled asepsis. *Dental Traumatology*, 3(2), 58–63. https://doi.org/10.1111/j.1600-9657.1987.tb00543.x

Calberson, F.L., De Moor, R.J., Deroose, C.A. (2007). The radix entomolaris and paramolaris: Clinical approach in endodontics. *Journal of Endodontics*, 33(1), 58–63. https://doi.org/10.1016/j.joen.2006.05.007

Carlsen, O., Alexandersen, V. (1990). Radix entomolaris: identification and morphology. *Scandinavian Journal of Dental Research*, 98(5), 363–373. https://doi.org/10.1111/j.1600-0722.1990.tb00986.x

Choi, S.-H., Yoon, N.-K., Jang, J.-H., Kim, Y.-H., Chang, H.-S., Hwang, Y.-C., et al. (2018). Endodontic treatment of tooth with morphological anomalies using cone-beam computed tomography. *Oral Biology Research*, 42(1), 53–61. https://doi.org/10.21851/obr.42.01.201803.53

Chowdhury, S.S., Hasan, M.N. (2014). Radix Entomolaris in mandibular molars: An endodontic challenge. *Update Dental College Journal*, 4(1), 49–52. https://doi.org/10.3329/updcj.v4i1.21175

de Carvalho, K.K.T., Petean, I.B.F., Silva-Sousa, A.C., de Camargo, R.V., Mazzi-Chaves, J.F., Silva-Sousa, Y.T.C., et al. (2022). Impact of several NiTi-thermally treated instrumentation systems on biomechanical preparation of curved root canals in extracted mandibular molars. *International Endodontic Journal*, 55(1), 124–136. https://doi.org/10.1111/iej.13649

de Gregorio, C., Arias, A., Navarrete, N., del Rio, V., Oltra, E., Cohenca, N. (2013). Effect of apical size and taper on volume of irrigant delivered at working length with apical negative pressure at different root curvatures. *Journal of Endodontics*, 39(1), 119–124. https://doi.org/10.1016/j.joen.2012.10.008

De Moor, R.J.G., Deroose, C.A.J.G., Calberson, F.L.G. (2004). The radix entomolaris in mandibular first molars: an endodontic challenge. *International Endodontic Journal*, 37(11), 789–799. https://doi.org/10.1111/j.1365-2591.2004.00870.x

de Souza, S.N., Marques, A.A.F., Sponchiado-Júnior, E.C., Roberti Garcia, L.D.F., da Frota, M.F., de Carvalho, F.M.A. (2017). Technological advances in endodontics: Treatment of a mandibular molar with internal root resorption using a reciprocating single-file system. *General Dentistry*, 65(3), e5–e8.

Duman, S.B., Duman, S., Bayrakdar, I.S., Yasa, Y., Gumussoy, I. (2019). Evaluation of radix entomolaris in mandibular first and second molars using cone-beam computed tomography and review of the literature. *Oral Radiology*, 36(4), 320–326. https://doi.org/10.1007/s11282-019-00406-0

European Society of Endodontology. (2006). Quality guidelines for endodontic treatment: Consensus report of the European Society of Endodontology. *International Endodontic Journal*, 39(12), 921–930. https://doi.org/10.1111/j.1365-2591.2006.01180.x

Garg, A.K., Tewari, R.K., Agrawal, N., Akhtar, S. (2011). Endodontic management of three-rooted mandibular second molar with the aid of spiral computed tomography: A case report. *Endo: Endodontic Practice Today*, 5(3), 215–221.

Gonapa, P., Rambabu, T., Podugu, U.K., Gondi, D., Rathod, T. (2022). Radicectomy of radix entomolaris: An alternative treatment approach for persistent periapicallesion assisted by cone-beam computed tomography and operating microscope. *Journal of Conservative Dentistry*, 25(2), 206–210. https://doi.org/10.4103/jcd.jcd_372_21

Gupta, V., Govil, S., Shah, A.F. (2014). Incongruity in human permanent mandibular molar: A case report. *International Journal of Medical and Dental Case Reports*, 1, 1–3. https://doi.org/10.15713/ins.ijmdcr.5

Haug, S.R., Solfjeld, A.F., Ranheim, L.E., Bårdsen, A. (2018). Impact of case difficulty on endodontic mishaps in an undergraduate student clinic. *Journal of Endodontics*, 44(7), 1088–1095. https://doi.org/10.1016/j.joen.2018.03.012

Khirtika, S.G., Ramesh, S. (2017). Management of radix endomolaris and paramolaris in mandibular molars: A case series. *Journal of Advanced Pharmacy Education & Research*, 7(3), 357–361. https://www.researchgate.net/publication/322919942

Kim, K.R., Song, J.S., Kim, S.-O., Kim, S.H., Park, W., Son, H.-K. (2013). Morphological changes in the crown

of mandibular molars with an additional distolingual root. *Archives of Oral Biology*, 58(3), 248–253. https://doi.org/10.1016/j.archoralbio.2012.07.015

Kimura, Y., Matsumoto, K. (2000). Mandibular first molar with three distal root canals. *International Endodontic Journal*, 33(5), 468–470. https://doi.org/10.1046/j.1365-2591.2000.00343.x

Kohli, T., Gupta, A., Kawatra, A.S., Abraham, D. (2019). Endodontic management of radix entomolaris in a mandibular third molar. *Endodontology*, 31(2), 179–182. https://doi.org/10.4103/endo.endo_15_19

Kusumo, A.N.H., Ratih, D.N., Mulyawati, E. (2019). Root canal treatment of mandibular molar with accessory root canal: A case report. *Advances in Health Sciences Research*, 32, 1–4.

Lambrianidis, T. (2006). Ledging and blockage of root canals during canal preparation: causes, recognition, prevention, management, and outcomes. *Endodontic Topics*, 15(1), 56–74. https://doi.org/10.1111/j.1601-1546.2009.00235.x

Law, A.S., Beaumont, R.H. (2004). Resolution of furcation bone loss associated with vital pulp tissue after nonsurgical root canal treatment of three-rooted mandibular molars: A case report of identical twins. *Journal of Endodontics*, 30(6), 444–447. https://doi.org/10.1097/00004770-200406000-00017

López-Rosales, E., Castelo-Baz, P., De Moor, R., Ruíz-Piñón, M., Martín-Biedma, B., Varela-Patiño, P. (2015). Unusual root morphology in second mandibular molar with a radix entomolaris, and comparison between cone-beam computed tomography and digital periapical radiography: A case report. *Journal of Medical Case Reports*, 9(1). https://doi.org/10.1186/s13256-015-0681-x

Madhuram, K., Keerthana, S., Rajkumar, S., Sankari, S.L. (2011). Radix entomolaris: Report of two cases. *Indian Journal of Multidisciplinary Dentistry*, 1(4), 227–230.

Mangal, S., Mathew, S., Ramesh, P., Gupta, T. (2016). Retreatodontics aided with CBCT: A case report. *Journal of Dental and Orofacial Research*, 12(2), 43–46.

Martins, J.N.R., Ascenso, J., Caramês, G. (2014). Endodontic treatment of a mandibular second molar with four roots – A case report and literature review. *Giornale Italiano di Endodonzia*, 28(1), 23–28. https://doi.org/10.1016/j.gien.2014.05.004

Marya, N., Yadav, S., Datta, A., Gupta, K., Budhiraja, S. (2014). Diagnosis and management of three rooted permanent mandibular molar: An endodontic challenge. *International Journal of Scientific and Research Publications,* 4(9), 1–4.

Mashyakhy, M., Hadi, F.A., Alhazmi, H.A., Alfaifi, R.A., Alabsi, F.S., Bajawi, H., et al. (2021). Prevalence of missed canals and their association with apical periodontitis in posterior endodontically treated teeth: a CBCT study. *International Journal of Dentistry*, 2021, 9962429. https://doi.org/10.1155/2021/9962429

Meidyawati, R., Suprastiwi, E. (2016). Root canal treatment of mandibular first molar with radix entomolaris. *Open Journal of Stomatology*, 6(9), 193–200. https://doi.org/10.4236/ojst.2016.69025

Mirikar, P., Shenoy, A., Mallikarjun, G.K. (2009). Nonsurgical management of endodontic mishaps in a case of radix entomolaris. *Journal of Conservative Dentistry*, 12(4), 169–174. https://doi.org/10.4103/0972-0707.58345

Mirza, A.J., Javaid, A., Bakr, S.A. (2018). Furcation-bone defect: management with non-surgical endodontics. *EC Dental Science*, 17,11.

Mittal, N., Narang, I. (2012). 3-D diagnosis-assisted management of anomalous mandibular molar. *Contemporary Clinical Dentistry*, 3(5), S51–S54. https://doi.org/10.4103/0976-237X.95105

Mohamed Khazin, S., Mustaffa, M. (2022). Management of radix entomolaris on permanent mandibular first molar complicated with ledge: a case report. *IIUM Journal of Orofacial and Health Sciences*, 3(1), 147–152. https://doi.org/10.31436/ijohs.v3i1.117

Nagaveni, N.B., Chandani, G.R., Kothari, S., Poornima, P. (2015). Radix entomolaris in children – A challenge to pedodontist: A report of case series with literature review. *International Journal of Contemporary Dental and Medical Reviews*, 2015, 1–5. https://doi.org/10.15713/ins.ijcdmr.53

Nahar, A.B. (2019). Radix entomolaris: Case reports. *IP Indian Journal of Conservative and Endodontics*, 4(2), 58–61. https://doi.org/10.18231/j.ijce.2019.013

Naidu, G.M., Kandregula, C.R., Koya, S. (2013). Bilateral radix entomolaris (third root): A rare endoexperience. *Journal of Advanced Oral Research*, 4(3), 1–4. https://doi.org/10.1177/2229411220130304

Ng, Y.-L., Mann, V., Gulabivala, K. (2011). A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: Part 1: Periapical health. *International Endodontic Journal*, 44(7), 583–609. https://doi.org/10.1111/j.1365-2591.2011.01872.x

Oberländer, S. (2012). Endodontic retreatment of two mandibular molars with radix entomolaris. *Endo: Endodontic Practice Today*, 6(3), 213–219.

Pandey, S., Garg, A.K., Hans, M., Paul, R. (2018). Endodontic treatment of radix entomolaris diagnosed with cone beam computed tomography: A case report. *University Journal of Dental Sciences*, 4(1), 130–133. https://www.researchgate.net/publication/329182440

Parsa, A., Rapala, H. (2016). Endodontic treatment of a mandibular 6 years molar with three roots: A pedodontist perspective. *International Journal of Pedodontic Rehabilitation*, 1(2), 64–67. https://doi.org/10.4103/2468-8932.196485

Patel, S., Brown, J., Semper, M., Abella, F., Mannocci, F. (2019). European Society of Endodontology position statement: Use of cone beam computed tomography in Endodontics. *International Endodontic Journal*, 52(12), 1675–1678. https://doi.org/10.1111/iej.13187

Patel, S., Durack, C., Abella, F., Roig, M., Shemesh, H., Lambrechts, P., et al. (2014). European Society of Endodontology position statement: The use of CBCT in Endodontics. *International Endodontic Journal*, 47(6), 502–504. https://doi.org/10.1111/iej.12267

Patil, A.A., Patil, S.A., Dodwad, P.K. (2013). Endodontic management of the mandibular first molar having independent middle mesial canal and radix entomolaris within the same tooth. *SRM Journal of Research in Dental Sciences*, 4(2), 69. https://doi.org/10.4103/0976-433X.120181

Patiño, P.V, Biedma, B.M., Liébana, C.R., Cantatore, G., Bahillo, J.G. (2005). The influence of a manual glide path on the separation rate of NiTi rotary instruments. *Journal of Endodontics*, 31(2), 114–116. https://doi.org/10.1097/01.don.0000136209.28647.13

Petrova, V., Vassileva, R., Yantcheva, S. (2020). Radix entomolaris: A case report. *Journal of Medical and Dental Practice*, 7(2), 1264–1268. https://doi.org/10.18044/Medinform.202072.1264

Pires, M.D., Martins, J.N.R. (2019). Endodontic treatment of the mandibular first molar with three distal root canals - Case series. *Revista Portuguesa de Estomatologia, Medicina Dentária e Cirurgia Maxilofacial*, 60(3), 137–144. https://doi.org/10.24873/j.rpemd.2019.09.453

Pivoto-João, M.M.B., Tanomaru-Filho, M., Pinto, J.C., Espir, C.G., Guerreiro-Tanomaru, J.M. (2020). Root canal preparation and enlargement using thermally treated nickel-titanium rotary systems in curved canals. *Journal of Endodontics*, 46(11), 1758–1765. https://doi.org/10.1016/j.joen.2020.08.007

Plotino, G., Nagendrababu, V., Bukiet, F., Grande, N. M., Veettil, S. K., De-Deus, G., et al. (2020). Influence of negotiation, glide path, and preflaring procedures on root canal shaping — Terminology, basic concepts, and a systematic review. *Journal of Endodontics*, 46(6), 707–729. https://doi.org/10.1016/j.joen.2020.01.023

Poly, A., AlMalki, F., Marques, F., Karabucak, B. (2019). Canal transportation and centering ratio after preparation in severely curved canals: Analysis by micro-computed tomography and double-digital radiography. *Clinical Oral Investigations*, 23(12), 4255–4262. https://doi.org/10.1007/s00784-019-02870-8

Qureshi, R., Agrawal, M., Singh, M.P., Singh, S.K., Sharma, K. (2017). Endodontic management of a rare anatomic variation of radix entomolaris in mandibular first and second molar using cone-beam computed tomography as a diagnostic aid. *International Journal of Prosthodontics and Restorative Dentistry*, 7(1), 30–33. https://doi.org/10.5005/jp-journals-10019-1172

Ricucci, D., Rôças, I.N., Alves, F.R.F., Loghin, S., Siqueira, J.F. (2016). Apically extruded sealers: Fate and influence on treatment outcome. *Journal of Endodontics*, 42(2), 243–249. https://doi.org/10.1016/j.joen.2015.11.020

Rodríguez-Niklitschek, C.A., Oporto, G.H., Garay, I., Salazar, L.A. (2015). Clinical, imaging and genetic analysis of double bilateral radix entomolaris. *Folia Morphologica*, 74(1), 127–132. https://doi.org/10.5603/fm.2015.0018

Schilder, H. (1974). Cleaning and shaping the root canal. *Dental Clinics of North America*, 18, 269–296.

Schumacher, C. (2008). Endodontic treatment of a mandibular first molar with radix entomolaris: A case report. *Endo: Endodontic Practice Today*, 2(4), 301–304.

Segura-Egea, J.J., Jiménez-Pinzón, A., Ríos-Santos, J.V. (2002). Endodontic therapy in a 3-rooted mandibular first molar: importance of a thorough radiographic examination. *Journal of the Canadian Dental Association*, 68(9), 541–543.

Shahbaz, S., Iftekhar, H., Alam, S., Shavez, Z. (2022). Endodontic management of mandibular first molar with four roots – A rare case report with clinical management guidelines. *Journal of Dentistry Indonesia*, 29(1), 67–72. https://doi.org/10.14693/jdi.v29i1.1160

Sinha, D.J., Mahesh, S., Jaiswal, N., Vasudeva, A. (2016). Radix entomolaris: A report of two cases. *The Bulletin of Tokyo Dental College*, 57(4), 253–258. https://doi.org/10.2209/tdcpublication.2015-0027

Sinha, D.J., Sinha, A.A. (2014). Additional roots: Challenge to the endodontist. *Indian Journal of Contemporary Dentistry*, 2(1), 7–10. https://doi.org/10.5958/j.2320-5962.2.1.002

Song, J.S., Choi, H.J., Jung, I.Y., Jung, H.S., Kim, S.O. (2010). The prevalence and morphologic classification of distolingual roots in the mandibular molars in a Korean population. *Journal of Endodontics*, 36(4), 653–657. https://doi.org/10.1016/j.joen.2009.10.007

Spili, P., Parashos, P., Messer, H.H. (2005). The impact of instrument fracture on outcome of endodontic treatment. *Journal of Endodontics*, 31(12), 845–850. https://doi.org/10.1097/01.don.0000164127.62864.7c

Srinivasan, R., Bhagabati, N., Rajput, A., Akhtar, S. (2015). Non surgical repair of iatrogenic furcal perforation of radix entomolaris. *Medical Journal Armed Forces India*, 71(Supplement 2), S422–S424. https://doi.org/10.1016/j.mjafi.2013.10.012

Štamfelj, I. (2014). Endodontic management of the three-rooted mandibular first permanent molar: A case report. *Acta Stomatologica Croatica*, 48(3), 216–223. https://doi.org/10.15644/asc48/3/6

Štamfelj, I., Sušek, L., Strmšek, L. (2016). Endodontic treatment of the permanent mandibular first molar with a radix entomolaris: A case report and literature review. *Acta Stomatologica Naissi*, 32(74), 1650–1667.

Subramaniam Ramachandran, V., Shankari, V., Rathakrishnan, M., Chandrasegaran, V., Kumaraguru, K. (2019). Management of three rooted mandibular first molar with six canals: A case report. *Cureus*, 11(12), e6280. https://doi.org/10.7759/cureus.6280

Tian, J., Liang, G., Qi, W., Jiang, H. (2015). Odontogenic cutaneous sinus tract associated with a mandibular second molar having a rare distolingual root: A case report. *Head and Face Medicine*, 11, 1–6. https://doi.org/10.1186/s13005-015-0072-y

Tricco, A., Lillie, E., Zarin, W., O'Brien, K., Colquhoun, H., Levac, D., et al. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): Checklist and explanation. *Annals of Internal Medicine,* 169(7), 467–473. https://doi.org/10.7326/m18-0850

Tsujimoto, Y. (2021). Root canal treatment of a mandibular first molar with radix entomolaris using a microscope and cone-beam computed tomography. *The International Journal of Microdentistry*, 12(1), 8–14. https://doi.org/10.50900/jamdmicro.12.1_8

Turki, A.A. (2019). Mandibular first molar with multiple roots: A case report. *International Journal of Medicine in Developing Countries*, 3(11), 967–970. https://doi.org/10.24911/IJMDC.51-1565259046

Vanti, A., Pujar, M., Ghivari, S., Chandar.M, A., Bynagari, C.S., Gopeshetti, P. (2019). Management of teeth with bilateral radix entomolaris: A case report. *ARC Journal of Dental Science*, 4(3), 13–15. https://doi.org/10.20431/2456-0030.0403003

Verma, P. (2009). Radix entomolaris – A case report. *New Zealand Endodontic Journal*, 40, 23–24.

Vijay, R.V., Sridhar, M., Satish, S.V., Krishnarao, K. (2011). Unusual canal morphology in mandibular second molar – A case report. *Annals and Essences of Dentistry*, 3(4), 52–55.

Vinay Kumar, D., Shaktidar, P.R. (2014). Bilateral radix entomolaris. *Unique Journal of Medical and Dental Sciences*, 2(4), 45–52.

Vivekananda Pai, A.R., Jain, R., Colaco, A.S. (2014). Detection and endodontic management of radix entomolaris: Report of case series. *Saudi Endodontic Journal*, 4(2), 77–82. https://doi.org/10.4103/1658-5984.132723

Wang, Q., Yu, G., Zhou, X., Peters, O.A. (2011). Evaluation of x-ray projection angulation for successful radix entomolaris diagnosis in mandibular first molars *in vitro*. *Journal of Endodontics*, 37(8), 1063–1068. https://doi.org/10.1016/j.joen.2011.05.017

Wu, Y.C., Su, C.C., Tsai, Y.W.C., Cheng, W.C, Chung, M.P., Chiang, H.S., et al. (2017). Complicated root canal configuration of mandibular first premolars is correlated with the presence of the distolingual root in mandibular first molars: A cone-beam computed tomographic study in Taiwanese individuals. *Journal of Endodontics*, 43(7), 1064–1071. https://doi.org/10.1016/j.joen.2017.01.027

Yadav, K., De Ataide, I.D.N., Fernandes, M., Lambor, R., Alreja, D. (2016). Endodontic management of a mandibular first molar with radix entomolaris and conservative post-endodontic restoration with CAD/CAM onlay: A novel clinical technique. *Journal of Clinical and Diagnostic Research*, 10(11), ZD13–ZD15. https://doi.org/10.7860/JCDR/2016/22048.8828

Supplementary Table 1. Data collection sheet.

No	Author	Demographic data			Pre-operative factor			Diagnostic method to determine presence of RE	Treatment protocol				Mishap on RE	Outcome	
		Age, Gender	Race and Country	Medical history	Tooth no	Diagnosis	Clinical Findings		Canal Preparation method	Obturation method	Management of RE	Post-endodontic restoration		Follow-up (months)	Outcome
							RE type: Cavity: Pre-op pain: Pre-op TTP: Pre-op PPD: Pre-op swelling: Pre-op sinus tract: Mobility:	IOPA/ OPG/ CBCT/ SCT/ Inspection under DOM	Isolation: Coronal flare: Glide path: Canal prep: MAF: Irrigation: Needle size: No of Visit: Intracanal medication:	Final Irrigation: Activated irrigation: Obturation technique: Sealer type:	Access cavity: Canal preparation: MAF: Obturation technique:	Orifice seal: Definitive restoration:			Success/ Healing/ Asymptomatic/ Fail

CBCT; cone-beam computed tomography, DOM; dental operating microscope, IOPA; intraoral periapical radiograph, MAF; master apical file, OPG; panoramic radiograph, PPD; periodontal probing depth, RE; radix entomolaris, SCT; spiral computed tomography, TTP; tender to percussion.

Supplementary Table 2. Critical appraisal for case reports included in the review using JBI.

No	Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
		Were patient's demographic characteristics clearly described?	Was the patient's history clearly described and presented as a timeline?	Was the current clinical condition of the patient on presentation clearly described?	Were diagnostic tests or assessment methods and the results clearly described?	Was the intervention(s) or treatment procedure(s) clearly described?	Was the post-intervention clinical condition clearly described?	Were adverse events (harms) or unanticipated events identified and described?	Does the case report provide takeaway lessons?
1	Abella *et al.* 2011	Y	U	Y	Y	Y	N	NA	Y
2	Bhargav *et al.* 2017 (case 1)	Y	Y	Y	Y	Y	N	NA	Y
3	Bhargav *et al.* 2017 (case 2)	Y	Y	N	Y	Y	N	NA	Y
4	Bonaccorso & Tripi 2008	Y	N	Y	Y	Y	Y	NA	Y
5	Choi *et al.* 2018	Y	Y	Y	Y	Y	Y	Y	Y
6	Chowdhury & Hassan 2014	U	N	Y	U	Y	N	NA	Y
7	De Moor *et al.* 2004 (Case 1)	U	N	Y	Y	Y	Y	NA	Y
8	De Moor *et al.* 2004 (Case 2A)	Y	N	Y	N	Y	N	NA	Y
9	De Moor *et al.* 2004 (Case 2B)	Y	N	Y	N	Y	N	NA	Y
10	De Moor *et al.* 2004 (Case 3)	U	Y	U	Y	Y	N	NA	Y
11	De Moor *et al.* 2004 (Case 4)	U	Y	Y	Y	Y	N	NA	Y
12	De souza *et al.* 2017	Y	Y	Y	Y	Y	Y	NA	Y
13	Garg *et al.* 2011	Y	U	Y	Y	Y	Y	NA	Y
14	Gonapa *et al.* 2022	U	Y	Y	Y	Y	Y	NA	Y
15	Gupta *et al.* 2014	Y	U	Y	Y	U	N	NA	Y
16	Lopez-rosaes *et al.* 2015	U	Y	Y	Y	Y	Y	NA	Y
17	Mirza *et al.* 2018	U	Y	Y	Y	Y	Y	NA	Y
18	Mohamed Khazin and Mustaffa 2022	Y	Y	U	Y	Y	Y	Y	Y
19	Pai *et al.* 2014 (case 2)	U	U	Y	Y	Y	N	NA	Y
20	Pai *et al.* 2014 (case 3)	U	U	Y	Y	Y	N	NA	Y
21	Pai *et al.* 2014 (Case 4)	U	U	Y	Y	Y	N	Y	Y
22	Parsa & Rapala 2016	U	U	Y	Y	Y	Y	NA	Y
23	Patil *et al.* 2013	U	U	Y	U	Y	N	NA	Y
24	Petrova *et al.* 2020	Y	Y	Y	Y	Y	N	Y	Y
25	Pires & Martins 2019 (case 1)	Y	U	Y	Y	Y	Y	NA	Y
26	Segura-Egea *et al.* 2002	U	Y	Y	Y	Y	Y	Y	Y

No	Author	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
		Were patient's demographic characteristics clearly described?	Was the patient's history clearly described and presented as a timeline?	Was the current clinical condition of the patient on presentation clearly described?	Were diagnostic tests or assessment methods and the results clearly described?	Was the intervention(s) or treatment procedure(s) clearly described?	Was the post-intervention clinical condition clearly described?	Were adverse events (harms) or unanticipated events identified and described?	Does the case report provide takeaway lessons?
27	Shahbaz 2022	U	U	Y	Y	Y	N	NA	Y
28	Štamfelj 2014	Y	Y	Y	Y	Y	Y	Y	Y
29	Turki 2019	U	Y	Y	Y	Y	Y	NA	Y
30	Verma 2009	U	U	N	U	Y	Y	NA	Y
31	Yadav *et al.* 2016	U	U	Y	Y	Y	Y	NA	Y
32	Agarwal *et al.* 2019 (Case 1)	U	Y	Y	Y	Y	Y	NA	Y
33	Arora *et al.* 2018 (Case 1)	U	Y	U	U	Y	Y	NA	Y
34	Attam *et al.* 2012 (Case 2)	U	Y	Y	Y	Y	U	NA	Y
35	Bains *et al.* 2009	U	Y	Y	Y	Y	U	NA	Y
36	Banode *et al.* 2016	U	U	Y	Y	Y	Y	NA	Y
37	Bansal *et al.* 2015 (Case 2)	U	U	Y	Y	U	U	NA	Y
38	Khirtika & Ramesh 2017 (Case 1)	U	U	N	N	Y	Y	NA	Y
39	Kimura & Matsumoto 2000	U	U	Y	Y	Y	U	NA	Y
40	Kohli *et al.* 2020	U	U	Y	Y	Y	Y	NA	Y
41	Kumar & Shaktidar 2014 (Case A)	Y	Y	Y	N	Y	Y	N	Y
42	Kumar & Shaktidar 2014 (Case B)	Y	Y	Y	N	Y	Y	Y	Y
43	Kusumo *et al.* 2019	U	Y	Y	Y	Y	Y	Y	Y
44	Law & Beaumont 2004 (Case 1)	Y	Y	Y	Y	N	N	NA	Y
45	Law & Beaumont 2004 (Case 2)	Y	Y	Y	Y	N	N	NA	Y
46	Mangal *et al.* 2016	U	Y	Y	Y	Y	Y	Y	Y
47	Martins *et al.* 2014	Y	Y	Y	Y	Y	U	NA	Y
48	Marya *et al.* 2014 Case 1)	U	Y	Y	Y	Y	N	NA	Y
49	Marya *et al.* 2014 Case 1)	U	U	Y	Y	Y	N	NA	Y
50	Meidyawati & Suprastiwi 2016	U	U	Y	N	Y	Y	NA	Y
51	Mirikar *et al.* 2009	U	U	U	U	U	Y	Y	Y
52	Mittal & Narang 2012	U	Y	Y	Y	Y	Y	NA	Y
53	Nahar *et al.*2019 (Case 1)	U	U	U	N	Y	Y	NA	Y
54	Nahar *et al.* 2019 (Case 2)	U	U	U	N	Y	Y	NA	Y
55	Naidu *et al.* 2013	U	U	U	N	U	Y	NA	Y
56	Oberlander 2012 (Case A)	U	Y	Y	Y	Y	Y	Y	Y
57	Oberlander 2012 (Case B)	U	Y	Y	Y	Y	Y	NA	Y
58	Pandey *et al.* 2018	U	Y	Y	Y	Y	Y	NA	Y
59	Qureshi *et al.* 2017 (Case A)	Y	Y	Y	Y	Y	Y	NA	Y
60	Qureshi *et al.* 2017 (Case B)	Y	Y	Y	Y	Y	Y	NA	Y
61	Ramachandran *et al.* 2019	Y	Y	Y	Y	Y	Y	NA	Y
62	Vijay e *et al.* 2011	U	Y	Y	Y	Y	Y	NA	Y
63	Schumacher 2008	Y	Y	Y	Y	Y	Y	NA	Y
64	Sinha & Sinha 2014 (Case 1)	N	U	U	U	Y	Y	NA	Y
65	Sinha *et al.* 2016 (Case 2)	N	Y	Y	Y	Y	Y	NA	Y
66	Srinivasan *et al.* 2015	N	N	N	Y	Y	Y	NA	Y
67	Stamfelj *et al.* 2016	Y	Y	Y	Y	Y	Y	NA	Y
68	Tian *et al.* 2015	Y	Y	Y	Y	Y	N	NA	Y
69	Tsujimoto 2021	Y	U	Y	U	Y	Y	NA	Y
70	Vanti *et al.* 2019 (case A)	U	U	U	U	Y	Y	NA	Y
71	Vanti *et al.* 2019 (case B)	U	U	U	U	Y	Y	NA	Y
72	Nagaveni *et al.* 2015 (Case 1A)	Y	U	Y	Y	U	Y	NA	Y
73	Nagaveni *et al.* 2015 (Case 1B)	Y	U	Y	Y	U	Y	NA	Y
74	Nagaveni *et al.* 2015 (Case 2)	Y	U	Y	U	Y	Y	NA	Y
75	Nagaveni *et al.* 2015 (Case 3)	Y	U	Y	U	N	Y	NA	Y

Y; yes, N; no, U; unclear, NA; not applicable

CASE REPORT Open Access

Stereolithography (STL) model in dental autotransplant: A case report

Wan Nur Zahidah Wan Zullkefli[1], Khairul Bariah Chi Adam[2]*, Nabilah Rashida Jamali[2]

[1]*Dental and Maxillofacial Surgery Unit, Sultan Ahmad Shah Medical Centre (SASMEC @IIUM), International Islamic University Malaysia.*
[2]*Department of Oral and Maxillofacial Surgery and Diagnosis, Kulliyyah of Dentistry, International Islamic University Malaysia.*

Abstract

The goal of this case report was to describe the use of the stereolithography (STL) model in dental autotransplantation. This report described autotransplantation of the lower wisdom tooth (48) to replace a missing lower first molar (46) due to caries. This approach used an STL model of 48 fabricated in the laboratory from cone-beam computed tomography (CBCT) images to assist in recipient site preparation before autotransplant. In conclusion, the use of the STL model could potentially increase the success rate of autotransplantation as it can help to preserve the periodontal ligament (PDL) cells on the root surface of the donor tooth, shorten the extraoral time of the donor tooth, and provide optimum contact between the recipient bone and the root surface of the transplanted tooth.

Keywords: *3D model, autotransplant, CBCT, stereolithography, STL*

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***Corresponding author**
Address:
Department of Oral and Maxillofacial Surgery and Diagnosis, Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Kuantan 25200, Pahang, Malaysia.

Telephone: +609 570 5466
Email address:
bariah@iium.edu.my

Introduction

Removable prostheses, fixed prostheses, autotransplantation, and implants are among the treatment options to replace missing teeth and restore masticatory functions and aesthetics. The selection of treatment depends on the patient's medical history, time constraints, financial status, the span of missing teeth, and bone quality.

Autotransplantation is defined as the transplantation of embedded, impacted, or erupted teeth from one site into extraction sites or surgically prepared sockets in the same person (Nimčenko *et al.*, 2013). A successful autotransplant can be presented as the absence of progressive root resorption, the presence of normal hard and soft periodontal tissues adjacent to the transplanted tooth, and a crown-to-root ratio <1(Czochrowska *et al.*, 2002; Intra *et al.*, 2014). To achieve a successful result, it is crucial to preserve the periodontal ligament cells on the root surface of the donor tooth, minimize the donor tooth's extraoral period, and ensure excellent adaptation between the recipient bone and the implanted tooth's root surface (Euiseong 2005). Hence, the use

of the stereolithography (STL) model of the autotransplanted tooth can assist surgeons in reducing the number of unnecessary trials for fitting the donor tooth into the bone socket, resulting in less injury to the periodontal ligament cells on the root surface. It can also aid minimize donor tooth extraoral time and improve the interface between the donor tooth and the recipient bone.

Case Description

A 22-year-old Malay female was referred to us for management of pericoronitis of the lower right wisdom tooth (48). She had no underlying medical illness and no drug allergies. She complained of pain on both sides of her wisdom teeth. The intermittent, throbbing pain started four years ago and was alleviated by analgesics. The patient had a history of surgical removal of the lower right first molar (46) under local anaesthesia due to extensive caries.

Upon clinical examination, the patient had no significant abnormalities extraorally. Intraorally, the patient had fair oral hygiene with a missing tooth (46). Bilateral third molar teeth (38 and 48) were partially erupted, with only the mesial portion visible clinically.

An orthopantomogram (OPG) revealed vertically impacted 38 and 48. Tooth 48 had a slightly curved distal root at the apical end, while tooth 38 had a curved mesial root. Both teeth were not closely approximated to the inferior alveolar canal.

CBCT was used to assess the thickness, height, and quality of the bone at site 46, as well as the height, width, and length of the tooth 48. At site of 46, the bone thickness measured 0.79 cm, the width was 0.90 cm, and the height was 1.79 cm from the ridge to the inferior alveolar nerve canal. Conversely, the height of tooth 48 measured 1.63 cm from the mesial cusp to the mesial root, while the crown width of tooth 48 was 0.88 cm.

Figure 1. Orthopantomogram(OPG) of the patient taken during the first visit.

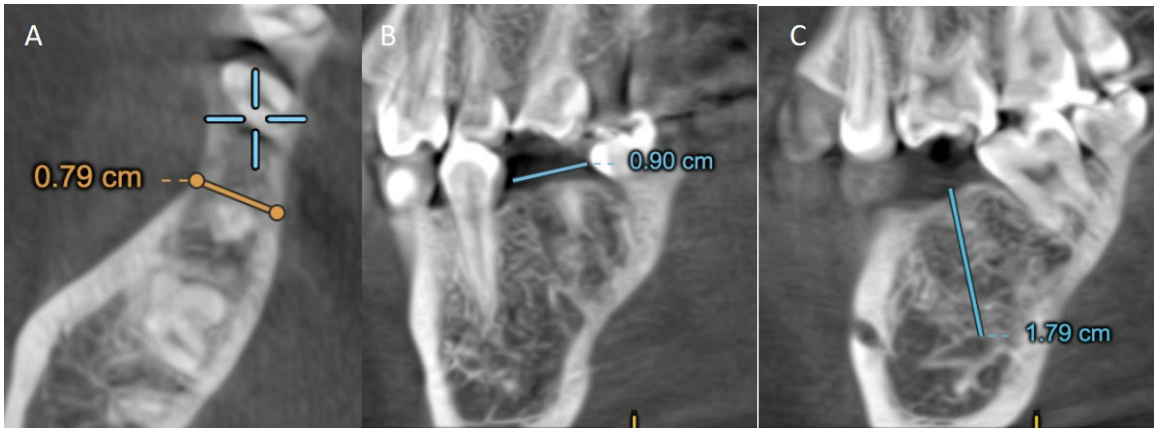

Figure 2. Cone Beam Computed Tomography (CBCT) at 46 region (preoperative). (A)Bone thickness (B)Width (C)Height from the ridge to the inferior alveolar nerve canal.

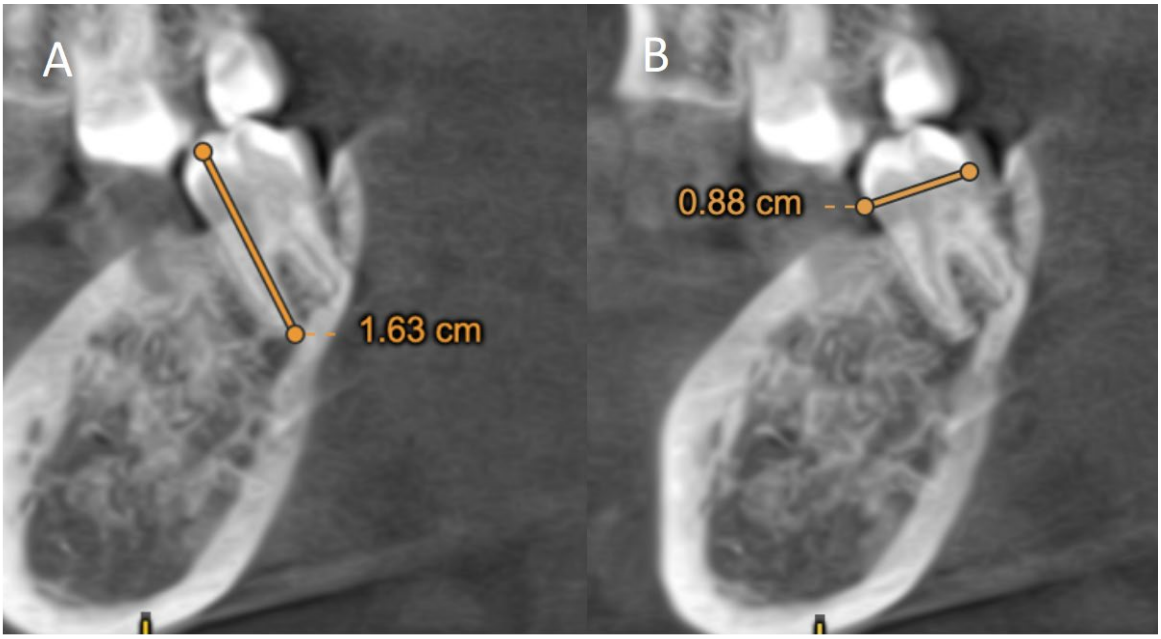

Figure 3. Cone Beam Computed Tomography (CBCT) of 48 tooth (preoperative). (A)Height of tooth 48 from mesial cusp to mesial root (B)Crown width.

The patient was presented with replacement options for tooth 46, including (1) a bridge, (2) an implant, or (3) autotransplantation of tooth 48 to site 46. The patient opted for autotransplantation of tooth 48 to site 46. CBCT images were then sent to 3D Gens laboratory for the fabrication of a stereolithography (STL) model of tooth 48. The material that was used for the fabrication of the STL model was stereolithography (SLA) material due to its high accuracy. The polymer resin was cured using ultraviolet lasers in the resin 3D printer to create the 48-tooth STL model.

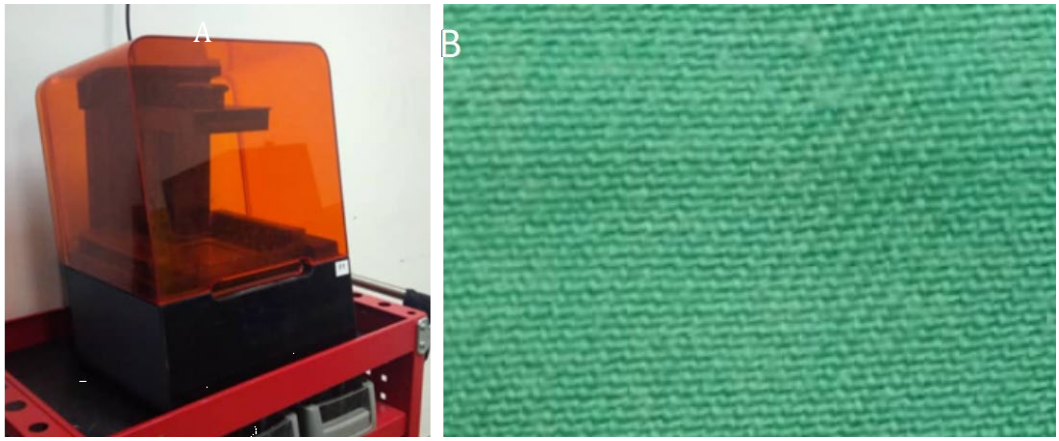

Figure 4. (A) SLA 3D printer (B) STL model of tooth 48.

The patient then underwent autotransplantation of tooth 48 to the site of tooth 46. During the surgery, the recipient site was first prepared using an implant surgical bur, and horizontal and buccal bone splits were also performed to create more space for the donor tooth. An STL model of the donor tooth was used to check for fit at the recipient site. Overall, it only took around 20–30 minutes to prepare the socket at the 36 region. When the fit of the STL model was satisfactory, the donor tooth was elevated out atraumatically and immediately placed at the prepared recipient site. Hence, the extraoral time is less than 15 seconds.

Bone removed during the socket preparation was placed on the buccal surface as an autograft due to buccal bone deficiency to support the tooth.

The donor tooth was then splinted to adjacent teeth with two twisted 0.5mm stainless steel wires bonded with composite and glass ionomer cement (GIC). Due to a thin lingual plate, the donor tooth was positioned buccally and slightly below the occlusal level (infraocclusion) to reduce the force transmitted to the tooth. The patient was discharged with analgesics and mouthwash.

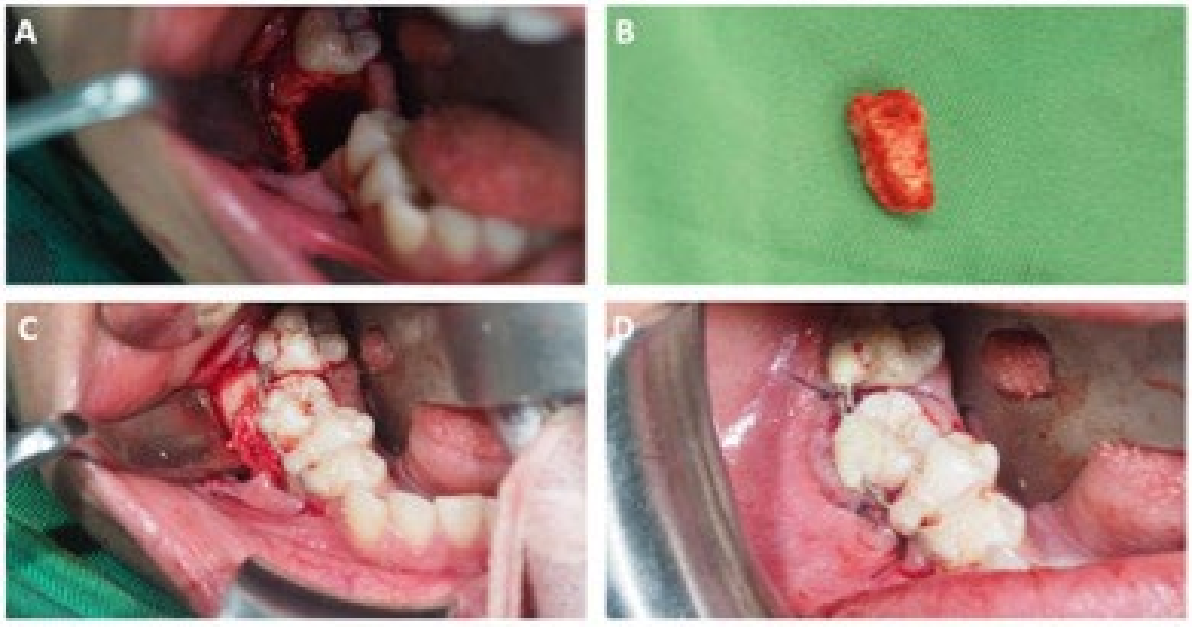

Figure 5. (A) Prepared socket at 46 region. (B) Extracted donor tooth - 48. (C) A splint was placed from 47 to 45 and autograft bone was placed buccally. (D) The flap was reapproximated.

The patient was closely reviewed post-operatively. The splint was removed after two weeks. Following splint removal, the donor tooth was mobile grade I and tender to palpation. The surrounding gingiva appeared healthy and pink in colour. Root canal treatment (RCT) had to be delayed due to COVID-19 issues.

Figure 6. Clinical picture post splint removal.

Figure 7. OPG taken post splint removal.

A single-visit RCT was performed three months later by an endodontist. All three canals were obturated with gutta percha (GP), but there was over-extrusion of GP at the distal and mesial roots. The occurrence was explained to the patient, and an apicectomy was planned should any infection develop in the future.

Figure 8. Post obturation OPG.

During the six-month post-obturation review, the donor tooth was already firm at the recipient site and non-tender to percussion. The surrounding gingiva appeared healthy and pink in colour. An OPG showed increased bone deposition surrounding the roots of the donor tooth with no sign of root resorption.

Figure 9. Clinical picture six months post obturation.

Figure 10. OPG taken 6 months post obturation.

Discussion

One of the advantages of an autotransplanted tooth is bone healing via bone induction. A transplanted tooth with a viable periodontal ligament (PDL) has the capacity to induce and maintain alveolar bone height and width. This is because PDL-resident stem cells are capable of differentiating into fibroblasts, cementoblasts, and osteoblasts. Therefore, these differentiated osteoblasts are more reliable in forming bone around the transplant (Tsukiboshi *et al.*, 2019).

Most clinicians consider autotransplants and implants to be similar procedures since they accomplish comparable goals. While autotransplants are more technique-sensitive and restricted to individuals with adequate donor teeth compared to most implant operations, implants have a wide range of functions and applications without the need for a donor (Mitsuhiro *et al.,* 2019, Mitsuhiro 2002).

However, the applications of implants may require a few considerations and setbacks, especially involving paediatric patients. For example, osseointegrated implants do not have the capability to move or erupt in tandem with adjacent teeth in young patients, resulting in infra occlusion with functional and aesthetic issues (Cross *et al.*, 2013; Tsukiboshi, 2002). Nonetheless, teeth that have been autotransplanted have the ability to erupt, move in unison with neighboring teeth, and seal any remaining gaps between opposing and adjacent teeth (Tatjana *et al.,* 2013, David *et al.*, 2013, Maryam *et al.*, 2012). According to Konstantinia *et al.* (2015), auto-transplanted teeth can also withstand orthodontic movement and permit healthy alveolar bone formation. In an autotransplanted tooth, the PDL regulates alveolar bone development, which contributes to these movements (Mitsuhiro *et al.,* 2019).

In situations where a patient's tooth has a poor prognosis or is congenitally absent, autotransplanted teeth continue to be a preferable option over implants in terms of function, appearance, cost, and time. This is because, even in the presence of a sizable bony defect in the recipient site, the viable PDL promotes quick healing and does not necessitate significant ridge augmentation, bone graft materials, or membranes (Mitsuhiro *et al.,* 2019). According to Tatjana *et al.* (2013), autotransplanted teeth exhibit a natural emergence profile and retain the natural colour and form of the crown and enamel, resulting in superior aesthetic results at a relatively lower cost compared to implants.

In a retrospective study of 614 autotransplanted teeth, it was reported that

the cumulative success rate of transplanted teeth with mature roots was 90.1% at 5 years, 70.5% at 10 years, and 55.6% at 15 years. However, the authors also reported that the success rate of implants and fixed partial dentures in 10 years is higher than that of autotransplanted teeth (Yoshino *et al.*, 2012). Hence, multiple factors must be improved to increase the success rate of autotransplant.

The success rate of dental autotransplants is highly dependent on the preservation of the PDL cells on the root surface of the donor tooth, the short extraoral time of donor tooth, and the optimum contact between the recipient bone and the root surface of the transplanted tooth (Kim *et al.*, 2005). In our case, in terms of the preservation of PDL cells, tooth 48 was selected as a donor tooth because it is minimally curved at the apical third compared to tooth 38. Teeth with sharp root curvatures are not ideal candidates for transplantation because there is an increased risk of PDL damage and cemental tear during extraction (Ravi Kumar *et al.*, 2012; Teixeira *et al.*, 2006).

The most crucial factor for the success of autotransplantation is the presence of viable PDL on the root surface, as damaged PDL may cause root resorption or ankylosis regardless of whether the tooth is immature or mature (Chung *et al.*, 2014; Strbac *et al.*, 2016; Tsukiboshi *et al.*, 2019). Based on a systematic review done by Machado *et al.*, (2016) they found that 4% of the autotransplanted teeth became ankylosed and another 4% had root resorption, at which point the PDL was compromised during the procedure. The use of the STL model could prevent unnecessary trial fits of the donor tooth, thereby reducing the risk of damaging the PDL (Shahbazian *et al.*, 2010; Shahbazian *et al.*, 2013).

Extraoral dry time should be minimal as the periodontal ligament cells are very sensitive to osmotic changes (Cross *et al.*, 2013; Jang *et al.*, 2016; Ravi Kumar *et al.*, 2012; Strbac *et al.*, 2016). A study done by Andreasen (1981) showed that the survival ability of PDL was significantly reduced if the extraoral time exceeded 18 minutes. On the other hand, a review done by Cross *et al.* (2013) found that 7% of the autotransplanted teeth developed pulp necrosis at which the extra-alveolar time was less than 1 minute and 20% of the autotransplanted teeth developed pulp necrosis at which the extra-alveolar time was more than 1 minute. In order to reduce extra-alveolar time, the STL model can act as a template instead of the donor tooth itself to prepare the socket (Shahbazian *et al.*, 2012).

A retrospective study done by Kim *et al.*, 2005 showed a better healing rate (87.7%) in cases with good initial stability at the time of the first follow-up as compared to those patients with poor initial stability (72.8%)(Kim *et al.*, 2005). According to Euiseong *et al.* (2005), the initial stability was determined by how well the donor tooth fit into the recipient location without experiencing significant motion. Adaptability between the recipient bone and the root surface of the transplanted tooth is very important as optimal contact with the recipient site can improve the blood supply and the level of nutrition to the periodontal ligament cells (Cross *et al.*, 2013; Jang *et al.*, 2016; Kim *et al.*, 2005). The STL model can help the surgeon prepare the socket as close as possible to the anatomy of the autotransplanted tooth and will provide good initial stability.

With all the benefits of the STL model that have been discussed, it is crucial to decide which materials to use since this affects the precision of the socket size that needs to be prepared. The SLA printer significantly produced the highest precision and trueness of the tooth STL model (Etemad-Shahidi *et al.*, 2020; Németh *et al.*, 2023; Rey-Joly Maura *et al.*, 2021) as it utilizes a laser beam to cure photopolymer material layer by layer.

Even though our patient had RCT treatment late with GP extrusion, the healing progress is still promising, as we believed that we had optimized the preservation of the PDL cells during the surgery. However, longer follow-up is still crucial to monitor the autotransplant tooth.

Conclusion

With the STL model, we were able to minimize injury to the PDL cells of the donor tooth by reducing extraoral time and reducing the number of try-ins of the donor tooth into the recipient socket. We were also able to prepare the recipient socket to have good adaptability with the donor tooth with the use of the STL model. However, longer follow-up is still crucial to monitor the autotransplant tooth.

Acknowledgement

We would like to acknowledge 3D Gens Laboratory for helping us with the STL model fabrication for this case.

Conflict Of Interest

We declare no conflicting interest in this study.

References

Andreasen, J. O. (1981). Periodontal healing after replantation and autotransplantation of incisors in monkeys. *International Journal of Oral Surgery*, 10(1), 54–61. https://doi.org/10.1016/S0300-9785(81)80008-7

Chung, W. C., Tu, Y. K., Lin, Y. H., & Lu, H. K. (2014). Outcomes of autotransplanted teeth with complete root formation: A systematic review and meta-analysis. *Journal of Clinical Periodontology*, 41(4), 412–423. https://doi.org/10.1111/jcpe.12228

Cross, D., El-Angbawi, A., McLaughlin, P., Keightley, A., Brocklebank, L., Whitters, J., *et al.* (2013). Developments in autotransplantation of teeth. *Surgeon*, 11(1), 49–55. https://doi.org/10.1016/j.surge.2012.10.003

Czochrowska, E. M., Stenvik, A., Bjercke, B., & Zachrisson, B. U. (2002). Outcome of tooth transplantation: Survival and success rates 17-41 years posttreatment. *American Journal of Orthodontics and Dentofacial Orthopedics*, 121(2), 110–119. https://doi.org/10.1067/mod.2002.119979

Etemad-Shahidi, Y., Qallandar, O. B., Evenden, J., Alifui-Segbaya, F., & Ahmed, K. E. (2020). Accuracy of 3-dimensionally printed full-arch dental models: A systematic review. *Journal of Clinical Medicine*, 9(10),1–18. https://doi.org/10.3390/jcm9103357

Intra, J. B. G., Roldi, A., Brandão, R. C. B., De Araújo Estrela, C. R., & Estrela, C. (2014). Autogenous premolar transplantation into artificial socket in maxillary lateral incisor site. *Journal of Endodontics*, 40(11), 1885–1890. https://doi.org/10.1016/j.joen.2014.07.008

Jang, Y., Choi, Y. J., Lee, S. J., Roh, B. D., Park, S. H., & Kim, E. (2016). Prognostic factors for clinical outcomes in autotransplantation of teeth with complete root formation: survival analysis for up to 12 years. *Journal of Endodontics*, 42(2), 198–205. https://doi.org/10.1016/j.joen.2015.10.021

Kim, E., Jung, J. Y., Cha, I. H., Kum, K. Y., & Lee, S. J. (2005). Evaluation of the prognosis and causes of failure in 182 cases of autogenous tooth transplantation. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology*, 100(1), 112–119. https://doi.org/10.1016/j.tripleo.2004.09.007

Machado, L. A., do Nascimento, R. R., Ferreira, D. M. T. P., Mattos, C. T., & Vilella, O. V. (2016). Long-term prognosis of tooth autotransplantation: a systematic review and meta-analysis. *International Journal of Oral and Maxillofacial Surgery*, 45(5), 610–617. https://doi.org/10.1016/j.ijom.2015.11.010

Németh, A., Vitai, V., Czumbel, M. L., Szabó, B., Varga, G., Kerémi, B., *et al.* (2023). Clear guidance to select the most accurate technologies for 3D printing dental models – A network meta-analysis☆. Journal of Dentistry,134. https://doi.org/10.1016/j.jdent.2023.104532

Nimčenko, T., Omerca, G., Varinauskas, V., Bramanti, E., Signorino, F., & Cicciù, M. (2013). Tooth auto transplantation as an alternative treatment option: A literature review. *Dental Research Journal*, 10(1), 1–6. https://doi.org/10.4103/1735-3327.111756

Ravi kumar, P., Jyothi, M., Sirisha, K., Racca, K., & Uma, C. (2012). Autotransplantation of mandibular third molar: a case report. *Case Reports in Dentistry*, 2012, 1–5. https://doi.org/10.1155/2012/629180

Rey-Joly Maura, C., Godinho, J., Amorim, M., Pinto, R., Marques, D., & Jardim, L. (2021). Precision and trueness of maxillary crowded models produced by 2 vat photopolymerization 3-dimensional printing techniques. *American Journal of Orthodontics and Dentofacial Orthopedics*, 160(1), 124–131. https://doi.org/10.1016/j.ajodo.2020.06.033

Shahbazian, M., Jacobs, R., Wyatt, J., Denys, D., Lambrichts, I., Vinckier, F., et al. (2013). Validation of the cone beam computed tomography-based stereolithographic surgical guide aiding autotransplantation of teeth: Clinical case-control study. *Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology*, 115(5), 667–675. https://doi.org/10.1016/j.oooo.2013.01.025

Shahbazian, M., Jacobs, R., Wyatt, J., Willems, G., Pattijn, V., Dhoore, E., *et al.* (2010). Accuracy and surgical feasibility of a CBCT-based stereolithographic surgical guide aiding autotransplantation of teeth: *In vitro* validation. *Journal of Oral Rehabilitation*, 37(11), 854–859. https://doi.org/10.1111/j.1365-2842.2010.02107.x

Shahbazian, M., Wyatt, J., Willems, G., & Jacobs, R. (2012). Clinical application of a stereolithographic tooth replica and surgical guide in tooth

autotransplantation: A case study is presented of the use of a stereolithography-fabricated model donor tooth and several guides to facilitate pre-operative planning as well as surgery in the case of tooth auto transplantation in a 10-year-old child. *Virtual and Physical Prototyping*, 7(3), 211–218. https://doi.org/10.1080/17452759.2012.711681

Strbac, G. D., Schnappauf, A., Giannis, K., Bertl, M. H., Moritz, A., & Ulm, C. (2016). Guided autotransplantation of teeth: a novel method using virtually planned 3-dimensional templates. *Journal of Endodontics*, 42(12), 1844–1850. https://doi.org/10.1016/j.joen.2016.08.021

Teixeira, C. S., Pasternak, B., Vansan, L. P., & Sousa-Neto, M. D. (2006). Autogenous transplantation of teeth with complete root formation: Two case reports. *International Endodontic Journal*, 39(12), 977–985. https://doi.org/10.1111/j.1365-2591.2006.01170.x

Tsukiboshi, M. (2002). Autotransplant Success. *Journal Dental Traumatology*, 18(29), 157–180.

Tsukiboshi, M., Yamauchi, N., & Tsukiboshi, Y. (2019). Long-term outcomes of autotransplantation of teeth: A case series. *Dental Traumatology*, 35(6), 358–367. https://doi.org/10.1111/edt.12495

Yoshino, K., Kariya, N., Namura, D., Noji, I., Mitsuhashi, K., Kimura, H., *et al.* (2012). A retrospective survey of autotransplantation of teeth in dental clinics. *Journal of Oral Rehabilitation*, 39(1), 37–43. https://doi.org/10.1111/j.1365-2842.2011.02234.x

CASE REPORT Open Access

A prosthetic-surgical approach for aesthetic treatment of peri-implant soft tissue defects: A case report

Mohamad Adib Jaafar[1,2]*, Sharul Nisha Ali[2], Esther Voo Vui Ching[2], Siti Nurqissa Mustafa[2]

[1]*Periodontal Specialist Clinic of Jalan Perak, Ministry of Health Malaysia, 11600, Jelutong, Penang, Malaysia.*
[2]*Periodontal Specialist Clinic of Mak Mandin, Ministry of Health Malaysia, 13400, Butterworth, Penang, Malaysia.*

Abstract

Peri-implant soft tissue defects (PSTD) in the esthetic zone affect approximately 54% cases of post-implant insertion, leading to aesthetic concerns and increasing the risk of peri-implantitis. Various surgical techniques are aimed at addressing these issues, but the outcomes can be unpredictable, especially for severely mispositioned implants. This report details a combined prosthetic and surgical approach to treat a severely angulated single central maxillary implant with mid-labial mucosal recession. A 38-year-old female expressed dissatisfaction with the implant at 21 area, which appeared elongated due to peri-implant mucosal recession of almost 4 mm. Treatment involved two phases: 1) prosthetic phase involves replacing the original crown of implant at 21 area with a temporary crown to promote mucosal growth and 2) surgical phase that involves soft tissue surgery three months later using an envelope flap technique at the recipient site and a connective tissue graft harvested from the palate. Upon three months after the surgery, full coverage with thick mucosal tissue was achieved, and a new zirconia crown was placed. The outcome remained stable throughout the nine-month follow-up. This case demonstrates that PSTD in angulated implants in the esthetic zone can be effectively treated through a combination of prosthetic and surgical modalities.

Keywords: *augmentation, complication, connective tissue, dental implant, recession*

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***Corresponding author**
Address:
Periodontal Specialist Clinic of Jalan Perak, Ministry of Health Malaysia, 11600, Jelutong, Penang, Malaysia.

Telephone: +66043316243
Email address:
madibjaafar@gmail.com

Introduction

Peri-implant soft tissue defects (PSTD) is a common complication following dental implant placement, often leading to aesthetic concerns and functional issues (Bengazi *et al*., 1996; Small *et al*., 2001). Various surgical techniques, including gingival grafts and growth factor applications have been employed to address such deformities (Al-Diasty *et al*., 2022; Sculean *et al*., 2017). However, the success of these interventions depends on factors such as the implant angulation and underlying bone and mucosal morphology (Stefanini *et al*., 2023). The surgical procedure is also unpredictable and frequently necessitates multiple surgeries to achieve aestheticity (Burkhardt *et al*., 2008). This will increase the cost and length of the procedure and expose the patients to unwanted complications, such as infection or prolonged healing period. There is a suggestion to employ combine both prosthetic and surgical strategies in this scenario, as it has the potential to decrease the frequency of surgical interventions. Zucchelli *et al*., (2019) deemed PSTD with severe implant malposition suitable for this approach. Here, we present a case of PSTD management in a patient with a severe angulation dental implant utilising the

combined prosthetic and surgical techniques.

Case Report

A 38-year-old Chinese female expressed dissatisfaction with the appearance of her dental implant, which was placed 10 years ago following tooth loss due to a cracked root after an unsuccessful endodontic treatment. The implant was inserted two months after tooth extraction (Type 2 placement) using a Straumann Bone Level (RC) implant with a diameter of 4.1 mm and a length of 10 mm. It was positioned with a slight apical tilt towards the palatal side to prevent labial bone dehiscence. At the same time, bone augmentation was performed using a xenograft (Bio-Oss Spongious Granules) to correct labial bone deficiency. Due to the labial angulation of the implant, a cement-retained porcelain-fused-to-metal (PFM) crown was chosen to avoid the need for labial screw access.

Almost five months after the implant placement, the patient noticed peri-implant mucosal recession and greyish discoloration. Two surgeries were attempted to correct the defect: the first used a platelet-rich fibrin (PRF) membrane with a coronally advanced flap approach, and the second, performed around a year later, used a Vista approach with an allograft (Mucoderm). Both procedures resulted in temporary coverage, with the mucosa receding and scar forming within a month. PRF injections were then proposed to increase tissue thickness and prevent greyish shadowing. Although this procedure has successfully thickened the mucosa, it is not able to improve the mucosal height. To maintain the thickness, repeated applications are required every 5-6 months. During the assessment in 2023, the patient raised similar concerns about the appearance of the implant area, expressing ongoing dissatisfaction from the aesthetic aspect. She experienced a lack of confidence to smile, which significantly affected her daily activities. Further examination revealed a 4 mm peri-implant mucosal defect on the mid-labial aspect, with no pockets of ≥6 mm or bleeding on probing. The labial aspect exhibited a thin mucosal phenotype and <2 mm keratinised tissue width (Figure 1a). The labial mucosal depression suggested soft tissue deficiencies and a possible hard tissue deficiency. The implant crown was slightly positioned labially without mucosal shadowing (Figure 1c).

The treatment plan was thoroughly discussed, addressing potential risks and procedural limitations. Concerns were highlighted regarding the crown width, which was slightly wider than that of tooth 11, and the possibility of spacing or black triangles between crowns. The patient's history of fluorosis affecting natural dentition was also considered, as it could potentially impact the aesthetic outcome of the crown blend with adjacent teeth. Initially, the existing crown was removed. An implant transfer piece was placed to evaluate the implant's orientation, revealing a significant angulation of approximately 25° (Figure 1d), indicative of Class IV PSTD as described by Zucchelli *et al*. (2019).

A temporary crown was fabricated using direct composite build-up, modified to reduce labial thickness to facilitate mucosal tissue growth or creeping. In addition, composite build-up on the mesial aspect of tooth 22 aimed at minimising the space between teeth 21 and 22, promoting better papilla formation. The patient underwent monthly reviews to assess the growth of the labial mucosa until stabilisation at 3 months (Figure 2a-c).

Following the prosthetic stage, a surgical procedure that involves harvesting a palatal connective tissue graft (CTG) (Figure 3a) was conducted. An envelope flap was created on the labial aspect using a split-full-split technique, as described by Zucchelli *et al*. (2013).

Figure 1. Pre-treatment clinical characteristics: (a) Mid-labial mucosal recession of implant-supported crown 21 with thin mucosal phenotype, and intact interdental papilla. (b) Periapical radiograph of Straumann bone level implant (D:4 mm x L:10 mm). (c) Emerge profile of the crown with labial depression. (d) Lateral view showing implant angulation post- crown removal.

Figure 2. Prosthetic phase: (a) Composite build-up of the temporary crown with elevated mucosal margin. (b) Three months post-modification of the temporary crown with reduced labial-mucosal thickness. (c) Coronal mucosal growth achieved, but incomplete coverage.

This flap extended from the mid-distal point of tooth 11 to the mid-distal point of tooth 22, without raising the distal papilla of either tooth. The apical flap was moderately split to enable passive coronal movement, facilitating complete coverage of the CTG placed on the implant abutment surface at the cementoenamel junction level of the adjacent teeth (Figure 3b). The CTG was secured with two resorbable simple interrupted sutures on each side, and the flap was stabilised with sling and simple interrupted sutures using 6/0 non-resorbable monofilament (Figure 3c).

The patient was instructed to refrain from brushing the surgical site for one week, while maintaining regular brushing of the remaining dentition using a gentle technique. Chlorhexidine 0.12% mouthwash was prescribed for daily use, with specific instructions to rinse gently to minimise the potential for flap displacement. In addition, caution was advised against lifting the upper

lip to reduce the risk of inadvertent traction. The patient was also prescribed Ibuprofen 400 mg for three times daily and Amoxicillin 500 mg for three times daily for a week. The palatal sutures were removed after one week. Plaque removal was performed with gentle saline irrigation at the recipient site, and the remaining sutures were removed two weeks post-surgery. The patient underwent weekly reviews during the first month and the months after for up to three months to monitor healing progress.

Figure 3. Surgical phase: (a) Palatal flap sutured post-harvesting a subcutaneous connective tissue graft (CTG) with optimal closure. (b) Obtained a thick CTG of sufficient size. (c) Flap stabilized by coronal advancement using a sling and interrupted sutures, placing CTG underneath. Distal papillae of teeth 11 and 22 remained undisturbed and intact.

Three months post-surgery, there was a significant increase in mucosal tissue thickness, achieving 100% coverage on the labial surface of the temporary crowns on implant 21 (Figures 4a–c). Subsequently, a new Zirconia implant crown with an angulated screw channel was fabricated to support the screw-retained prosthesis (Figure 4d), which was successfully placed. The patient expressed satisfaction with the outcome (Figure 4e), and a periapical radiograph confirmed the abutment seating, showing satisfactory outcome (Figure 4f)

Upon follow-up within six months after the permanent crown placement (nine months post-surgery), mucosal tissue thickness and complete coverage of the implant crown were maintained without signs of inflammation (Figures 5a–d).

Discussion

Peri-implant soft tissue defects (PSTD) in the esthetic zone is common, with a reported prevalence of approximately 54% following implant placement (Tavelli *et al*., 2022). The development of PSTD is multifactorial, often attributed to factors such as thin mucosal phenotype and malposition of the implant, particularly in relation to the labial aspect (Stefanini *et al*., 2023; Tavelli *et al*., 2022). Some authors have proposed clinical decision pathways and provided examples to guide treatment protocols for several clinical situations related to PSTD (Alrmali *et al*., 2023; Zucchelli *et al*., 2019).

In this case, we addressed a class IV defect using a suggested approach, which involves employing a temporary crown with a thinned labial surface. This approach has resulted in visible improvement of mucosal growth after three months. Although no further changes were observed thereafter, the moderately enhanced appearance prepared the mucosa for subsequent mucosal augmentation surgery utilising CTG, which remains the gold standard in such procedures (Surdiacourt *et al*., 2024). CTG can be harvested from either the palatal or tuberosity areas.

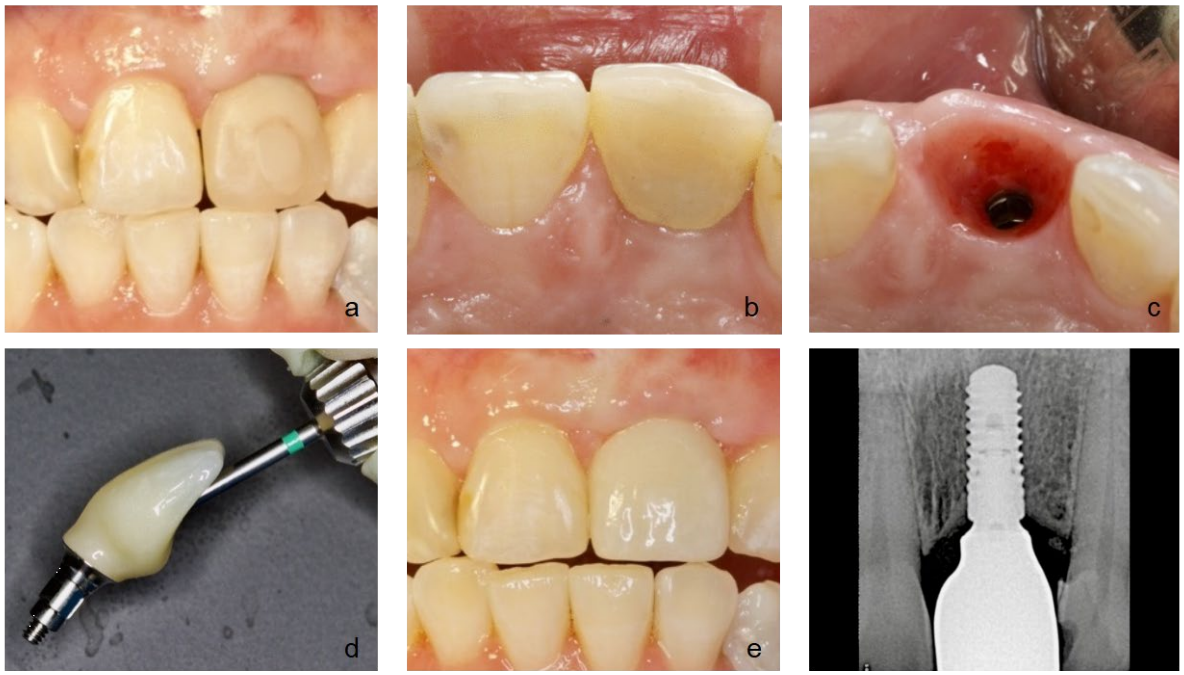

Figure 4. Three months post-surgery and permanent crown placement: (a) Recipient site demonstrates stable healing. (b) Intact palatal tissue observed. (c) Occlusal view reveals increased labial mucosal thickness. (d) Screw-retained zirconia crown with angulated crown with angulated screw channel. (e) Mucosal level over the crown aligns well with adjacent gingiva. (f) Periapical radiograph confirms proper abutment seating and interproximal bone attachment.

Figure 5. Nine months after surgery follow-up: (a-c) Mucosal position and level maintained at the implant site. (d) Absence of inflammation, with healthy mucosal tissue. (e) Patient-completed questionnaire during recent assessment.

Some studies suggest that CTG from tuberosity areas offer advantages due to its denser lamina propria content, thereby reducing the risk of shrinkage (Dellavia *et al*., 2014; Sanz-Martín *et al*., 2019). However, conflicting evidence indicates comparable outcomes between subepithelial and tuberosity CTG (Rojo *et al*., 2018). In terms of aesthetics, tuberosity CTG may prompt a more fibrotic response, potentially affecting the final aesthetic outcome. Nonetheless, patient evaluations indicate similar satisfaction levels for both types of CTG (Kotsailidi *et al*., 2022; Rojo *et al*., 2018). In this specific case, palatal CTG is preferred due to its accessibility and the larger quantity available for harvest.

It is essential to evaluate the patient's aesthetic expectations to ensure they are realistic and understand the treatment limitations. Given the patient's high smile line, assessing the quality of peri-implant mucosa is crucial. To create an identical contour for the crown presents challenges, particularly due to the wider space. To address this, a composite build-up is applied on the mesial proximal surface of tooth 22 to slightly reduce crown 21 dimensions and adjust the contact point downward towards the apex for better papilla filling. Recent studies indicate that maintaining a papilla height between 3.4 mm and 4.2 mm effectively fills interproximal spaces between implants (Kourkouta *et al*., 2009; Tarnow *et al*., 2003). However, recent research suggests that the periodontal bone attachment status of the adjacent teeth may be more critical than papilla dimensions (Roccuzzo *et al*., 2018), which was observed in this patient, demonstrating a good level of bone crest between teeth 11 and 22 on radiographs.

In addition, the patient demonstrates excellent compliance with oral hygiene care, with no inflammation observed around the implant mucosal, contributing to the stability of peri-implant tissues and potentially preventing peri-implant disease. Moreover, the patient maintains excellent compliance with the scheduled maintenance appointments, which is crucial for the long-term oral health and implant stability (Roccuzzo *et al*., 2012).

An alternative treatment option is a veneer to reshape tooth 11, matching the shape and colour of crown 21. However, this may increase treatment costs and pose a risk of damaging healthy tooth structure. Nevertheless, the patient's primary concern is mucosa recession rather than tooth width. The patient expressed satisfaction with the outcome (Figure 5e), and the mucosa remained stable during the recent nine-month follow-up.

Conclusion

Effective management of labially angulated dental implants with peri-implant soft tissue defects (PSTD) demands a multidisciplinary approach. Precise treatment planning, meticulous surgical techniques, and thoughtful prosthetic interventions play pivotal roles in the success of tissue augmentation and optimal aesthetic outcomes. Regular follow-up evaluations are essential to ensure the long-term health and stability of the implant.

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Disclosure

All authors declare no conflict of interest.

Human right statement

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1964 and later versions. Informed consent was obtained from patient for being included in the study.

Ethical approval

The study was exempted from the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia review, and this case report is registered with the number NMRR ID-24-01312-GUW.

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References

Al-Diasty, Z., El-Meadawy, S., Salem, A. S., & Mowafey, B. (2022). Onlay platelet-rich fibrin membrane versus free gingival graft in increasing the width of keratinized mucosa around dental implants: A split-mouth randomized clinical study. *Journal of Advanced Periodontology & Implant Dentistry*, 14(2), 53-61.

Alrmali, A., Stuhr, S., Saleh, M. H. A., Latimer, J., Kan, J., Tarnow, D. P., *et al.* (2023). A decision-making tree for evaluating an esthetically compromised single dental implant. *Journal of Esthetic and Restorative Dentistry*, 35(8), 1239-1248.

Bengazi, F., Wennström, J. L., & Lekholm, U. (1996). Recession of the soft tissue margin at oral implants. A 2-year longitudinal prospective study. *Clinical Oral Implants Research*, 7(4), 303-310.

Burkhardt, R., Joss, A., & Lang, N. P. (2008). Soft tissue dehiscence coverage around endosseous implants: a prospective cohort study. *Clinical Oral Implants Research*, 19(5), 451-457.

Dellavia, C., Ricci, G., Pettinari, L., Allievi, C., Grizzi, F., & Gagliano, N. (2014). Human palatal and tuberosity mucosa as donor sites for ridge augmentation. *International Journal of Periodontics & Restorative Dentistry*, 34(2), 179-186.

Kotsailidi, E. A., Tatakis, D. N., Chen, Y. W., Caton, J. G., Ercoli, C., Barmak, A. B., *et al.* (2022). Comparison of maxillary tuberosity and palatal donor sites for soft tissue augmentation at implant placement: A pilot controlled clinical study. *International Journal of Oral Implantology*, 15(4), 353-365.

Kourkouta, S., Dedi, K. D., Paquette, D. W., & Mol, A. (2009). Interproximal tissue dimensions in relation to adjacent implants in the anterior maxilla: clinical observations and patient aesthetic evaluation. *Clinical Oral Implants Research*, 20(12), 1375-1385.

Roccuzzo, M., Bonino, F., Aglietta, M., Dalmasso, P. (2012). Ten-year results of a three arms prospective cohort study on implants in periodontally compromised patients. Part 2: Clinical results. *Clinical Oral Implants Research*, 23(4), 389-395.

Roccuzzo, M., Roccuzzo, A., & Ramanuskaite, A. (2018). Papilla height in relation to the distance between bone crest and interproximal contact point at single-tooth implants: A systematic review. *Clinical Oral Implants Research*, 29 (Suppl 15), 50-61.

Rojo, E., Stroppa, G., Sanz-Martin, I., Gonzalez-Martín, O., Alemany, A. S., & Nart, J. (2018). Soft tissue volume gain around dental implants using autogenous subepithelial connective tissue grafts harvested from the lateral palate or tuberosity area. A randomized controlled clinical study. *Journal of Clinical Periodontology*, 45(4), 495-503.

Sanz-Martín, I., Rojo, E., Maldonado, E., Stroppa, G., Nart, J., & Sanz, M. (2019). Structural and histological differences between connective tissue grafts harvested from the lateral palatal mucosa or from the tuberosity area. *Clinical Oral Investigations*, 23(2), 957-964.

Sculean, A., Chappuis, V., & Cosgarea, R. (2017). Coverage of mucosal recessions at dental implants. *Periodontology 2000*, 73(1), 134-140.

Small, P. N., Tarnow, D. P., & Cho, S. C. (2001). Gingival recession around wide-diameter versus standard-diameter implants: a 3- to 5-year longitudinal prospective study. *Practical Procedures in Aesthetic Dentistry*, 13(2), 143-146.

Stefanini, M., Marzadori, M., Sangiorgi, M., Rendon, A., Testori, T., & Zucchelli, G. (2023). Complications and treatment errors in peri-implant soft tissue management. *Periodontology 2000*, 92(1), 263-277.

Surdiacourt, L., Christiaens, V., De Bruyckere, T., De Buyser, S., Eghbali, A., Vervaeke, S.,. *et al.* (2024). A multi-centre randomized controlled trial comparing connective tissue graft with collagen matrix to increase soft tissue thickness at the buccal aspect of single implants: 3-Year results. *Journal of Clinical Periodontology*.

Tarnow, D., Elian, N., Fletcher, P., Froum, S., Magner, A., Cho, S. C., *et al.*. (2003). Vertical distance from the crest of bone to the height of the interproximal papilla between adjacent implants. *Journal of Periodontology*, 74(12), 1785-1788.

Tavelli, L., Barootchi, S., Majzoub, J., Chan, H. L., Stefanini, M., Zucchelli, G., *et al.* (2022). Prevalence and risk indicators of midfacial peri-implant soft tissue dehiscence at single site in the esthetic zone: A cross-sectional clinical and ultrasonographic study. *Journal of Periodontology*, 93(6), 857-866.

Zucchelli, G., Mazzotti, C., Mounssif, I., Marzadori, M., Stefanini, M. (2013). Esthetic treatment of peri-implant soft tissue defects: a case report of a modified surgical-prosthetic approach. *International Journal of Periodontics & Restorative Dentistry*, 33(3), 327-35.

Zucchelli, G., Tavelli, L., Stefanini, M., Barootchi, S., Mazzotti, C., Gori, G., *et al.* (2019). Classification of facial peri-implant soft tissue dehiscence/deficiencies at single implant sites in the esthetic zone. *Journal of Periodontology*, 90(10), 1116-1124.

CASE REPORT Open Access

The resurrection of an immature upper anterior tooth: A case report

Hema Devi Sivan[1], Nurul Farah Azih[1], Musliana Mustaffa[2]*

[1]*Unit Pakar Pergigian Restoratif, Klinik Pakar Pergigian Jalan Gambut, 25200 Kuantan, Pahang, Malaysia.*
[2]*Department of Restorative Dentistry, Kulliyyah of Dentistry, International Islamic University Malaysia, 25200 Kuantan, Pahang, Malaysia.*

Abstract

Revascularization of necrotic dental pulp has regained interest as an alternative treatment for immature permanent teeth. An 18-year-old female patient was referred for management of an immature upper anterior tooth with symptomatic apical periodontitis. Patient presented with an unsightly tooth 21 with no symptoms. Patient experienced dental trauma approximately 10 years ago. Clinical examination revealed a light-yellow discoloration with Class IV composite restoration on tooth 21, no carious lesion, Grade 1 tooth mobility, tenderness to percussion, and probing depths within normal limit. Periapical radiograph of tooth 21 revealed a periapical lesion, root of normal length but thin root dentin, and an open apex. Revascularization of tooth 21 was carried out in two visits. The first visit focused on disinfection of the root canal, while the second visit focused on the induction of bleeding followed by placement of mineral trioxide aggregate (MTA). The 6-month and 24-month follow-up visits revealed an absence of periapical lesion, although a significant reduction in the size of root apex could not be observed. An immature permanent tooth presents clinical challenges that affects both the short-term and the long-term treatment outcomes, therefore, an appropriate case selection taking into consideration various factors, and the skills and experience of the clinician are of upmost importance to ensure the predictability of the treatment provided. This procedure could eliminate intraradicular infection, however, increased dentin thickness on the root canal wall could not be observed, suggesting an indeed challenging procedure despite meticulous technical steps to perform the procedure.

Keywords: *immature permanent tooth, open apex, regenerative endodontics, revascularization*

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***Corresponding author**
Address:
Kulliyyah of Dentistry, International Islamic University Malaysia, Jalan Sultan Ahmad Shah, Bandar Indera Mahkota, 25200 Kuantan, Pahang, Malaysia.

Telephone: +609 5705500
Email address:
muslianamustaffa@iium.edu.my , drmusliana@gmail.com

Introduction

Revascularization was first put forward by two authors in 2004 describing a new technique for the management of immature permanent teeth with apical periodontitis (Banchs & Trope, 2004). The principle of revascularization is to provide a sterile root canal that allows new cells to populate with the objective of restoring pulp vitality (Caruso *et al.*, 2014; Simon *et al.*, 2014).

Contrary to apexification, revascularization allows the continuation of root development to minimize the risk of tooth fracture. Necrotic dental pulp in immature permanent teeth causes disruption of root development which reduces dentin thickness particularly at the apical third of the root, making these teeth more prone to fractures (Albuquerque *et al.*, 2014; Raddall & Leung, 2019).

An alternative treatment was developed to overcome the aforementioned drawback (Alghamdi & Alqurashi, 2020; Lv *et al.*, 2018) which has been shown to induce root

extension and radicular reinforcement (Albuquerque *et al.*, 2014). A standardized protocol for this technique was formulated by the American Association of Endodontics (AAE) (AAE, 2016) and European Society of Endodontology (ESE) (Galler *et al.*, 2016). According to the AAE guidelines, the primary goal of regenerative endodontics is healing of the apical periodontitis, the secondary goal is increased root wall thickness and/or root length, and the tertiary goal is to regain positive response to pulp testing. Both the secondary and tertiary goals are desirable, but not essential in determining clinical success.

The application of mineral trioxide aggregate (MTA) over the blood clot without utilization of a matrix or scaffold was demonstrated in previous case reports (Machado *et al.*, 2016; Neelamurthy *et al.*, 2018) although a direct placement of a glass ionomer cement over the blood clot was also reported (Kanaparthy *et al.*, 2011). In current practice, the selection of bioactive material is more appropriate due to its properties and favorable outcomes (Machado *et al.*, 2016, Neelamurthy *et al.*, 2018, Yu *et al.*, 2022).

This case discusses the technique and outcomes of revascularization on an immature upper anterior tooth with symptomatic apical periodontitis.

Case Report

A healthy 18-year-old female patient was referred to the 'Unit Pakar Pergigian Restoratif, Klinik Pergigian Jalan Gambut, Kuantan, Pahang' for the management of an immature upper anterior tooth with symptomatic apical periodontitis. Patient had history of dental trauma about 10 years ago, with sustained tooth fracture involving the incisal edge of tooth 21. The tooth was restored following the incident. On presentation, patient could not recall the episodes of pain or swelling in the area. An extraoral examination revealed no abnormalities. Intraoral examination revealed a light-yellow discoloration with a Class IV composite restoration associated with tooth 21, no carious lesion, Grade 1 tooth mobility, tenderness to percussion, and probing depths within normal limit. The tooth did not show any response to pulp sensitivity tests (Digitest 2, Parkell Inc, USA). A panoramic radiograph revealed the overall dentition and good bone level (Figure 1). Periapical radiograph revealed a periapical lesion in relation to tooth 21 with root of normal length but thin root dentin, fragile walls and an open apex (Figure 2).

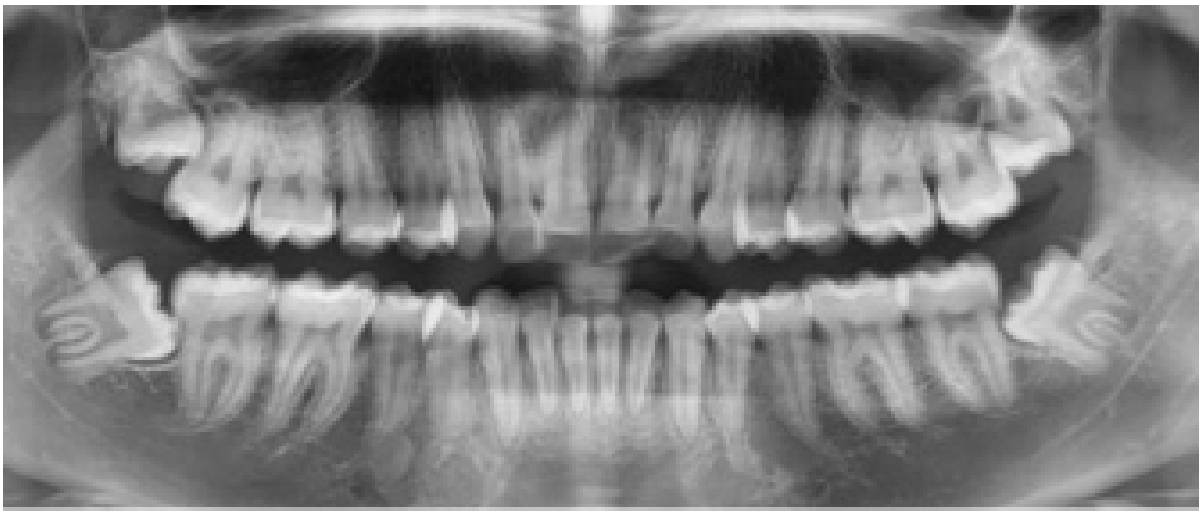

Figure 1. Panoramic radiograph.

Figure 2. Preoperative radiograph.

During the first visit, informed consent was given outlining the treatment options, risks and benefits of each option, and the likely prognosis. Following the discussion with patient, revascularization of tooth 21 was decided and the clinical procedure was carried out. Local anesthesia (2% lidocaine, 1:100000 epinephrine) was administered at the labial aspect of tooth 21. Effective tooth isolation with a rubber dam was achieved and an access cavity was prepared to gain access to the pulp chamber. Irrigation with 3% sodium hypochlorite (CanalPro, Coltene, USA) and 17% EDTA (CanalPro, Coltene, USA) was carried out and the root canal was dried with sterile paper points. The working length was determined with an electronic apex locator (Dentaport ZX, Morita MFG Corp, Japan) and confirmed with a working length radiograph (Hatela Instant Film, Hanshin Technical Lab LTD, Japan) at 22.5mm. The tip of an endodontic file was at the radiographic apex, suggesting at the appropriate position and length.

Triple antibiotic paste (TAP) containing ciprofloxacin, metronidazole and cefaclor in a 1:1:1 ratio was mixed with sterile distilled water to form a thick consistency paste. Then, the TAP was placed gently in the root canal by using a lentulo spiral until below the cementoenamel junction and the excess TAP at the root canal entrance was cleaned with cotton pellets. The access cavity was temporarily restored with glass ionomer cement (GC Fuji 7, GC Corporation, Japan).

During the second visit 3 weeks later, patient did not report of any pain or discomfort following the procedure and the clinical examination revealed no significant findings. Local anesthesia (2% mepivacaine without vasoconstrictor) was administered at the labial aspect of tooth 21, followed by tooth isolation with a rubber dam. The temporary restoration was removed, intracanal medicament in the root canal was irrigated with 3% sodium hypochlorite (CanalPro, Coltene, USA) and 17% EDTA (CanalPro, Coltene, USA), and the root canal was dried with paper points.

A #40 Hedstrom file (Dentsply Maillefer, Switzerland) was used to penetrate the periapical tissue, confirmed with the periapical radiograph (Figure 3). Bleeding from the periapical region gradually filled into the root canal and reached the cementoenamel junction in a semicoagulated form. A Rootdent MTA (TehnoDent, Belgorod region, Russia) approximately 3mm thick was placed over the blood clot and a moist cotton pellet was placed over the Rootdent MTA (TehnoDent, Belgorod region, Russia). Access cavity was temporarily restored with glass ionomer cement (GC Fuji 7, GC Corporation, Japan). A periapical radiograph was taken immediately after the procedure to assess the placement of Rootdent MTA (TehnoDent, Belgorod region, Russia) (Figure 4).

Figure 3. #40 Hedstrom file was used to penetrate the periapical tissue.

Figure 4. MTA placement over the blood clot.

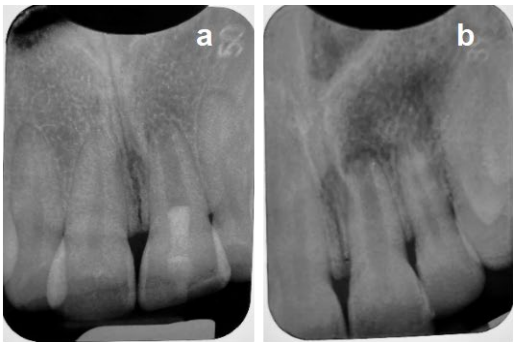

Figure 5. a) Periapical radiograph at 6-month follow-up in comparison with the b) Preoperative radiograph.

During the third visit 1 week later, patient did not report of any pain or discomfort following the procedure and clinical examination revealed no significant findings. The temporary restoration and cotton pellet were removed and the access cavity was restored with a light-curing composite resin (G-aenial Anterior, 3M ESPE, USA) as a definitive restoration.

At the 6-month follow-up visit, patient did not report of any pain or discomfort following the procedure and clinical examination revealed no significant findings. A periapical radiograph revealed decreased size of periapical lesion, however, thickening of the root canal walls could not be observed (Figure 5). At the 24-month follow-up visit, clinical aspect remained the same with no significant findings (Figure 6), however, the improvement on the root canal walls could not be observed (Figure 7). The tooth was not responsive to pulp sensitivity test at any of the follow-up visits.

Figure 6. Front clinical view at 24-month follow up.

Figure 7. a) Periapical radiograph at 24-month follow-up in comparison with the b) Preoperative radiograph.

Discussion

This case documented revascularization on an immature upper anterior tooth with symptomatic apical periodontitis using blood clot as a scaffold. The primary goal of eliminating the symptoms was achieved uneventfully. However, the secondary goal of increased dentin thickness and/or increased root length, including the tertiary goal of regaining positive response to pulp sensitivity test were not achieved. The biggest challenge encountered in revascularization is successful induction of bleeding into the root canal space for the sources of viable cells, which can be derived from non-pulpal origins, namely circulating cells, cementum, periodontal ligament and alveolar bone (Simon *et al.*, 2014). Revascularization could resolve the apical inflammation, but is unable to support dentin-pulp regeneration (Cao *et al.*, 2015). This might explain the reason of not achieving the thickening of root dentin and/or increased root length, and negative response to pulp sensitivity test during all follow-up visits in this case. Although revascularization may be successful in resolving apical periodontitis and revitalization in some cases, it is unknown whether the revascularized tissues truly represent dentin-pulp regeneration (Cao *et al.*, 2015).

Prerequisites for successful revascularization include disinfection of the root canal, placement of a suitable matrix or scaffold for tissue ingrowth, and achieving a bacteria-tight coronal seal (Law, 2013). The inability to achieve these aspects could lead to a treatment failure. Disinfection in the root canal is carried out using an antimicrobial root canal irrigant namely sodium hypochlorite and an intracanal medicament namely TAP. The disadvantage of TAP use is tooth discoloration due to its minocycline composition. In this light, double antibiotic paste can be opted which excludes the minocycline, or replaced with clindamycin, amoxicillin, or cefaclor (a member of the second-generation

cephalosporins) (Valverde *et al.*, 2017; Lee, 2019). The TAP was used in this case but surprisingly no apparent tooth discoloration afterwards. Perhaps, careful application of TAP by using the lentulo spiral until below the cementoenamel junction could contribute to this outcome.

The placement of a matrix or scaffold for tissue ingrowth was not possible in this case due to a delicate and time-consuming procedure, costly, requiring highly trained and skilled personnel to perform the procedure. Hence, a 3mm thickness of MTA was placed over the blood clot instead. Even though the blood clot in the root canal space was used as a matrix or scaffold, the treatment outcome observed in this case was favorable, suggesting its suitability as an alternative when access to another matrix or scaffold is restricted. The resolution of periapical lesion observed in this case report corroborated with other case report in which the MTA was placed over the blood clot without the utilization of a matrix or scaffold (Machado *et al.*, 2016; Neelamurthy *et al*., 2018). In a case report when the induction of bleeding into the root canal space was unsuccessful, a concentrated growth factor (CGF) was utilized as an alternative scaffold followed by MTA placement on the thrombus of the CGF (Yu *et al.*, 2022). Regarding a bacteria-tight coronal seal in this case, it was achieved using a composite resin, which was bonded effectively to the remaining coronal tooth structure.

Despite favorable treatment outcomes, challenges associated with the clinical procedures are still present. The matrix or scaffold with the highest success rate is platelet-rich plasma (PRP) (Bezgin *et al*., 2015; Alagl *et al.*, 2017; Shivashankar *et al.,* 2017), however, the process for obtaining PRP needs to be considered when deciding on use of this matrix or scaffold. The PRP and platelet-rich fibrin (PRF) require blood samples from the patients, which can be traumatic in young children (Rizk *et al.,* 2020). The procedure also requires other specialized equipment and materials, causing the technique to be less accessible to the dental clinic. Additionally, the process of stimulating bleeding at the periodontal tissue past the root apex to obtain the blood clot in the root canal space has the disadvantage of being more difficult to control (Shivashankar *et al.*, 2017) where sometimes it is impossible to generate the bleeding into the root canal space (Rizk *et al.*, 2020). In this case, bleeding into the root canal space can be achieved effectively, could be attributed to an appropriate case selection and the clinical procedure is performed by an experienced clinician under standard protocol.

The utilization of cone-beam computed tomography (CBCT) is beneficial because the true nature of the lesion and improvement on the root dentin following revascularization procedure can be observed effectively. However, in this case report, the use of CBCT was not possible due to unavailability of this method at the dental setting. Perhaps, for future consideration, CBCT can be used not only as one of diagnostic tools but for monitoring purposes related to the revascularization procedure.

Conclusion

The outcome of revascularization on an immature upper anterior tooth with symptomatic apical periodontitis is favorable after 24-month follow-up, with the evidence of insignificant clinical findings, and absence of periapical lesion. However, increased dentin thickness on the root canal wall could not be observed, including negative response to pulp sensitivity test. The outcome of this case fulfilled the essential requirement according to AAE guidelines, and is considered a successful treatment clinically, despite not observing the secondary and tertiary outcomes. An appropriate case selection taking into consideration various factors, combined with the skills and experience of the clinician are of upmost importance in ensuring the predictability of the treatment provided.

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Conflict of interest

None

References

Alagl, A., Bedi, S., Hassan, K. and AlHumaid, J. (2017). Use of platelet-rich plasma for regeneration in non-vital immature permanent teeth: Clinical and cone-beam computed tomography evaluation. *Journal of International Medical Research*, 45(2), 583-593.

Albuquerque, M.T.P., Valera, M.C., Nakashima, M., Nör, J.E. and Bottino, M.C. (2014). Tissue-engineering-based strategies for regenerative endodontics. *Journal of Dental Research*, 93(12), 1222-1231.

Alghamdi, F.T. and Alqurashi, A.E. (2020). Regenerative endodontic therapy in the management of immature necrotic permanent dentition: a systematic review. *The Scientific World Journal*, 2020.

American Association of Endodontics, 2016. Clinical considerations for a regenerative procedure. Retrieved from, https://www.aae.org/specialty/wp-content/uploads/sites/2/2017/06/currentregenerativeendodonticconsiderations.pdf

Banchs, F. and Trope, M. (2004). Revascularization of immature permanent teeth with apical periodontitis: new treatment protocol?. *Journal of Endodontics*, 30(4), 196-200.

Bezgin, T., Yilmaz, A.D., Celik, B.N., Kolsuz, M.E. and Sonmez, H. (2015). Efficacy of platelet-rich plasma as a scaffold in regenerative endodontic treatment. *Journal of Endodontics*, 41(1), 36-44.

Caruso, S., Sgolastra, F., and Gatto, R. (2014). Dental pulp regeneration in paediatric dentistry: the role of stem cells. *European Journal of Paediatric Dentistry*, 15(1), 90-94.

Cao, Y., Song, M., Kim, E., Shon, W., Chugal, N., Bogen, G. *et al.* (2015). Pulp-dentin regeneration: current state and future prospects. *Journal of Dental Research*, 94(11), 1544-1551.

Galler, K.M., Krastl, G., Simon, S., Van Gorp, G., Meschi, N., Vahedi, B. *et al.* (2016). European Society of Endodontology position statement: Revitalization procedures. *International Endodontic Journal*, 49(8), 717-723.

Kanaparthy, A., Kanaparthy, R., Muktishree, M., Agarwal, N. (2011). An old concept revisited-Revascularisation in endodontics - A case report. *Journal of International Oral Health*, 3(6), 49-54.

Lv, H., Chen, Y., Cai, Z., Lei, L., Zhang, M., Zhou, R. et al. (2018). The efficacy of platelet-rich fibrin as a scaffold in regenerative endodontic treatment: a retrospective controlled cohort study. *BMC Oral Health*, 18, 1-8.

Law, A.S. (2013). Considerations for regeneration procedures. *Pediatric Dentistry*, 35(2), 141-152.

Lee, S.M. (2019). Infection Control in Regenerative Endodontic Procedures. American Association of Endodontists. Retrieved from, https://www.aae.org/specialty/infection-control-in-regenerative-endodontic-procedures/

Machado, R., Almeida, G., Santos, T.S., Barbosa, B.P., Moreira, G.A., Junior, A.P. (2016). Pulp revascularisation in a traumatised and necrotic tooth. *Endodontic Practice*, 6-9.

Neelamurthy, P.S., Kumar, R.A., Balakrishnan, V., Venkatesan, S.M., Narayan, G.S., Karthikeyan, I. (2018). Revascularization in immature and mature teeth with necrotic pulp: a clinical study. *Journal of Contemporary Dental Practice*, 19(11), 1393-1399.

Raddall, G., Mello, I. and Leung, B.M. (2019). Biomaterials and scaffold design strategies for regenerative endodontic therapy. *Frontiers in Bioengineering and Biotechnology*, 7, 317.

Rizk, H.M., Al-Deen, M.S.S. and Emam, A.A. (2020). Pulp revascularization/revitalization of bilateral upper necrotic immature permanent central incisors with blood clot vs platelet-rich fibrin scaffolds - a split-mouth double-blind randomized controlled trial. *International Journal of Clinical Pediatric Dentistry,* 13(4), 337.

Shivashankar, V.Y., Johns, D.A., Maroli, R.K., Sekar, M., Chandrasekaran, R., Karthikeyan, S. *et al.* (2017). Comparison of the effect of PRP, PRF and induced bleeding in the revascularization of teeth with necrotic pulp and open apex: a triple blind randomized clinical trial. *Journal of Clinical and Diagnostic Research: JCDR*, 11(6), ZC34.

Simon, S. and Goldberg, M. (2014). Regenerative endodontics: regeneration or repair?. In: *The Dental Pulp: Biology, Pathology, and Regenerative Therapies* (267-276). Berlin, Heidelberg: Springer Berlin Heidelberg.

Yu, L., Zhou, Y., Li, J., Cheng, J., Song, G. (2022). Revascularization of an immature permanent tooth with periapical periodontitis using concentrated growth factor assisted by erbium laser (2940 nm) irrigation: a case report. *Applied Sciences*, 12(9), 4751.

Valverde, M.E., Baca, P., Ceballos, L., Fuentes, M.V., Ruiz-Linares, M. and Ferrer-Luque, C.M. (2017). Antibacterial efficacy of several intracanal medicaments for endodontic therapy. *Dental Materials Journal*, 36(3), 319-324.

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