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IIUM Journal of Orofacial and Health Sciences (IJOHS) is a peer reviewed biannual international journal dedicated to publish 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.

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EDITORIAL Open Access

Multidisciplinary management of obstructive sleep apnea: Challenges and current perspective

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Introduction

Obstructive sleep apnea (OSA) is characterized by recurrent episodes of partial or complete airway obstruction during sleep associated with a decrease in oxyhemoglobin saturation leading to sleep disruption. This chronic interrupted sleep condition will eventually produce a collection of physiologic derangements. If it is left untreated, OSA can negatively affect the neurocognition leading to impaired concentration and memory, excessive daytime somnolence, and ultimately, increase the risk of cardiovascular morbidity (Kenderska *et al*., 2014). The global prevalence of OSA in adults is estimated to be around 14% (Benjafield *et al.,* 2019). Similarly in Malaysia, about 15% to 20% adults presented with OSA features including obesity, snoring, hypersomnolence and interrupted breathing during sleep (Kamil *et al.,* 2007)

There is a wide variety of pathophysiology between children and adults affected by this chronic condition. The most common predisposing factor is obesity. However, in recent years, there is a growing interest among sleep clinicians looking at the structural and functional deformities in the maxillofacial and pharyngeal region that causes the collapsible airway during sleep (Senaratna *et al.,* 2017). Deformities in the function includes impaired pharyngeal dilator muscle and flaccid tongue (Eckert *et al.,* 2013). Whereas, anatomical deformities include retrognathic mandible, steep mandibular plane angle, narrow maxilla with a high arched palate, increased anterior facial height, and a short anterior cranial base (Kim *et al.,* 2015). If intervention is not initiated early in the growing patients, the likelihood to develop OSA in adult is intensified (Won *et al.,* 2019; Koca *et al.,* 2016).

Owing to its multifactorial pathophysiology and a heterogeneity in the presentation, early detection and screening is the responsibility of all clinicians including physicians and surgeons. Diagnosis of OSA should be made by highly trained and qualified respiratory physicians through polysomnography in a certified sleep facility (American Academy of Sleep Medicine, 2017). Nonetheless, dentists can play an important role in detecting OSA especially when it is associated with dentofacial deformities. Screening during routine dental consultation where features of lethargy, morning headaches, or dry mouth caused by mouth-breathing during sleep can be examined (Quan *et al.,* 2017). It is their

responsibility to arrange appropriate investigations and referrals to sleep clinicians for proper diagnosis, in addition to orthodontists and oral and maxillofacial surgeons for the correction of dentofacial deformity. Lateral cephalogram can also be used as a screening tool to assess the posterior airway space.

Treatment of OSA ideally involves clinicians with a multi-disciplinary background. Continuous positive airway pressure (CPAP) provided by respiratory physicians is conventionally the gold standard treatment. It has excellent treatment outcome in improving sleep quality. However, this mechanical device is not always tolerated by patients in long term. Advancement in minimally invasive sleep surgery has influenced the need and desire for the cure of OSA (MacKay *et al.,* 2020) where the role of surgery is aimed at restoring the anatomy and function of the hard and soft tissues of the upper airway.

The revised Stanford protocol on sleep surgery indicates that when there is evidence of severe OSA with failure of medical management and definite anatomic sites of obstruction, a stepwise approach to surgery should be implemented (Liu *et al.,* 2019). Patients with enlarged nasal turbinates and deviated nasal septum will benefit from nasal reconstructive surgery. Significant obstruction in the retropalatal region can be relieved by uvulopalatopharyngoplasty, or tonsillectomy. Whereas, the tongue base obstruction can be treated by tongue base reduction surgery or a genioglossus advancement surgery. A novel approach aiming at the tongue function is the hypoglossal nerve stimulation where electrical stimulation of the hypoglossal nerve will cause contraction of the genioglossus muscle and lead to opening of the airway (Olson *et al.,* 2021).

Despite all the surgical options, failure to surgery will eventually require a maxillomandibular advancement (MMA) surgery. In this surgery, the maxilla and the mandible is osteotomized from the cranial base, expanded and advanced by as much as 1cm in lateral and anterior direction, respectively. This movement leads to a marked opening of the posterior airway space and can successfully reduce the AHI to less than 5 (Giralt-Hernando *et al.,* 2019).

It is no doubt a challenge to manage obstructive sleep apnea owing to its heterogenous phenotypes. Understanding the different subgroups of OSA presentation is the primary role of all sleep clinicians in order to deliver a more personalized and tailored individual treatment. A multidisciplinary team approach plays a key role in the successful management of this chronic condition. Every specialty has the responsibility to bring their own expertise into integrating the holistic management. Without this, fragmentation of care will complicate the coordination of patient direction to other specialty clinic and leads to missed diagnosis and missed treatment. Therefore, it is prudent for the healthcare service provider to evolve into organizing a multidisciplinary sleep clinic in order to balance the bite, beauty, brain, and breathing for a sound mind and healthy body.

References

American Academy of Sleep Medicine; American Academy of Dental Sleep Medicine. (2012) Policy Statement on the Diagnosis and Treatment of OSA. *American Academy of Dental Sleep Medicine* website. Retrieved August 21, 2017 from http://aadsm.org/osapolicystatement.aspx.

Benjafield, A.V., Ayas, N.T., Eastwood, P.R., Heinzer, R., Ip, M.S.M., Morrell, M.J., *et al.* (2019) Estimation of the global prevalence and burden of obstructive sleep apnoea: a literature-based analysis. *The Lancet Respiratory Medicine*, 7(8), 687-698.

Eckert, D.J., White, D.P., Jordan, A.S., Malhotra, A., and Wellman, A. (2013) Defining phenotypic causes of obstructive sleep apnea. Identification of novel therapeutic targets. *American Journal of Respiratory and Critical Care Medicine*, 188(8), 996-1004.

Giralt-Hernando, M., Valls-Ontañón, A., Guijarro-Martínez, R., *et al.* (2019) Impact of surgical maxillomandibular advancement upon pharyngeal airway volume and the apnoea-hypopnoea index in the treatment of obstructive sleep apnoea: systematic review and meta-analysis. *BMJ Open Respiratory Research*, 6:e000402.

Kamil, M.A., Teng, C.L., Hassan, S.A. (2007) Snoring and breathing pauses during sleep in the Malaysian population. *Respirology*, 12(3), 375-380.

Kendzerska, T., Gershon, A.S., Hawker, G., *et al.* (2014) Obstructive sleep apnea and risk of cardiovascular

events and all-cause mortality: a decade-long historical cohort study. In: Patel A, editor. *PLoS Medicine*, 11(2), e1001599.

Kim, D.K., *et al*., (2015) Adenotonsillar hypertrophy as a risk factor of dentofacial abnormality in Korean children. *European Archives of Oto-Rhino-Laryngology*. 272(11), 3311-3316.

Koca, C.F., Erdem, T., and Bayındır, T. (2016) The effect of adenoid hypertrophy on maxillofacial development: an objective photographic analysis. *Journal of Otolaryngology - Head & Neck surgery*. 45(1), 48.

Liu, S.Y., Awad, M., Riley, R., Capasso, R. (2019) The Role of the Revised Stanford Protocol in Today's Precision Medicine. *Sleep Medicine Clinics*, 14(1), 99-107.

MacKay, S.G., Lewis, R., McEvoy, D., Joosten, S., Holt, N.R. (2020) Surgical management of obstructive sleep apnoea: A position statement of the Australasian Sleep Association. *Respirology*, 25(12), 1292-1308.

Olson, M.D., Junna, M.R. (2021) Hypoglossal Nerve Stimulation Therapy for the Treatment of Obstructive Sleep Apnea. *Neurotherapeutics*. 18(1), 91-99.

Quan, S.F., Schmidt-Nowara, W. (2017) The Role of Dentists in the Diagnosis and Treatment of Obstructive Sleep Apnea: Consensus and Controversy. *Journal of Clinical Sleep Medicine*. 15, 13(10), 1117-1119.

Senaratna, C.V., Perret, J.L., Lodge, C.J., Lowe, A.J., Campbell, B.E., Matheson, M.C., Hamilton, G.S., Dharmage, S.C. (2017) Prevalence of obstructive sleep apnea in the general population: A systematic review. *Sleep Medicine Reviews*, 34, 70-81.

Won, C.S., *et al*., (2019) Influence of adenotonsillar hypertrophy on dentofacial development of children. *Otorhinolaryngol Head Neck Surgery*. 4:pp.1-5.

ORIGINAL ARTICLE Open Access

Assessment of satisfaction in patients with existing complete dentures issued from International Islamic University Malaysia (IIUM) Kuantan Dental Polyclinic

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Abstract

Removable acrylic complete dentures are a popular choice of treatment for the edentulous patient in Malaysia because of their cost and affordability. However, dissatisfaction among denture wearers with their complete denture is still very common. The goal of this study is to determine the level of satisfaction among patients who receive complete dentures from the IIUM Kuantan Dental Polyclinic, as well as the factors that impact their satisfaction. 42 edentulous patients wearing complete dentures made in International Islamic University Malaysia (IIUM) Kuantan dental Polyclinic for at least 3 months were included. These patients were interviewed over the phone in Malay or English language regarding their satisfaction towards the complete denture that they received on different parameters like retention, aesthetics, mastication, and phonetic using Visual Analogue Scale (VAS) which uses a Likert scale of 0-4 (0= not satisfied at all; 1= not satisfied; 2=acceptable; 3=satisfied; 4=very satisfied) to express their satisfaction. The overall satisfaction comprises of 90.5% of the subjects are satisfied with their complete denture. The fitting of lower denture and mastication contributed to the highest percentage of dissatisfaction. The retention of lower denture contributed to most dissatisfaction of the patients and female patient are more concerned with aesthetic compared to male. As compared to patients who already have worn dentures previously, first-time denture wearers are more satisfied with the upper denture fitting. Three months of wearing duration influenced the successful or treatment. Majority of patients are satisfied with the dentures provided by student of Kulliyyah of Dentistry. However, the dissatisfaction of wearing the complete dentures is mainly because of lower denture is not fit and poor mastication.

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Introduction

Teeth loss can have an impact on function, aesthetics, and phonation, so it's usually replaced with a removable or fixed prosthesis. Even in developed countries, demand for prosthodontic treatment is expected to rise because to an ageing population, despite the fact that preventative dentistry helps to protect teeth. Many countries are struggling with an ageing population, with the proportion of persons over 65 expected to rise by 50% in the next few decades. As a result, the need for removable denture treatment, particularly

full dentures, would increase among elderly patients. However, in order to assess the level of satisfaction of elderly patients who wear complete dentures, it is vital to consider the denture's primary function of eating as well as its adaptability for speech.
Removable prostheses have been used widely as treatment for replacement of missing teeth. One of it is complete dentures. Although there are many treatment options that are available for completely edentulous patients especially in today's era of implant-supported complete dentures, conventional complete dentures are usually their first choice because of its simplicity and affordable price according to Bilhan *et al*. (2012) and *Deeksheetha et al*. (2019) in their study conclude that complete denture are important to enhance the mastication, phonetics, and aesthetic appearance of the completely edentulous patients.

However, the dissatisfaction among denture wearers with their complete dentures is still very common even though there have been a lot of improvement that have been created in the construction of complete denture over the years. Satisfaction of complete denture wearer toward their complete denture are influenced by various factors. This includes the patient's personality, patient's expectation, and duration of wearing complete denture, patients' salivary flow, patients' confidence in dentist and clinician experience and prosthetic complications as stated by Fenlon *et al.* (2007), Subramaniam *et al.* (2019) and Wolff *et al*. (2003). These factors are essential for adaptation, acceptance and discomfort of the patients while wearing their complete denture. In addition, on the report of Kovacić *et al.* (2010) and Celebić *et al.,* (2003), the success of these complete denture treatments really depends on the patient's satisfaction towards the denture that they received, and it is does not depend on the clinician's satisfaction as well as the quality of the complete dentures.

Thus, this research aims to assess the level of satisfaction among patients receiving complete dentures from IIUM Kuantan Dental Polyclinic and also the associated factors that affect the level of their satisfaction.

Materials and Methods

All patients come from a variety of backgrounds, including gender, race and age who received complete denture treatment at IIUM Kuantan Polyclinic were randomly selected from the outpatient section database. Our inclusion criteria for the subjects are being edentulous, having worn the complete dentures made in IIUM Kuantan Dental Polyclinic for at least 3 months and being able to listen, understand and provide their consent verbally. As for the exclusion criteria, subjects that are having speech disorders, and those that having implant-supported complete denture prostheses are not included in this research. A total of 380 denture patients were registered in the database between 2014 and 2019. Besides, 120 patients out of 380 patients have full detail of registration records. However, only 42 edentulous patients that mark all the criteria needed were enrolled. This study was approved by IIUM Research Ethic Committee (IREC 2020-103).

These patients were called one by one over the phone, informed about the research and their consent was taken verbally. The patients' data like age, race, gender, history of wearing denture previously, period of edentulism and age of existing dentures were recorded. The visual analogue scale used in this research was adapted from a validated study by Bilhan *et al.* (2012) and explained to each patient in Bahasa Melayu or English. The questionnaires divided into two parts, which is first part is social demographic data of patients and second part is the patient's satisfaction of the dentures. The second part of questionnaires comprise of the question regarding the fit of upper and lower denture, the color of the denture, the appearance of the denture, the appearance of the face, speech, mastication, smoothness of the denture and the overall satisfaction.

The respondents were asked on their satisfaction of the complete denture based on different parameters and indicated the degree of satisfaction or dissatisfaction of each item based on a Likert scale: 'strongly dissatisfied' =0, 'dissatisfied" =1, 'acceptable' =2, 'satisfied' =3, and 'strongly satisfied'=4. We simplified the results of 5 scales into 3 scales which are not satisfy, acceptable and satisfy by combining the scale not very satisfy at all and not satisfy as one and also the scale satisfy and very satisfy as one.

The patient's satisfaction with these various parameters was assessed and evaluated using IBM SPSS Statistics version 25, Chicago, America. Descriptive statistics were used like mean and percentage for demographic parameters. Besides descriptive statistic, the qualitative data were tested with Mann Whitney U test to relate between gender and the history of current dentures.

There are forty-two patients receiving complete denture treatments from polyclinic of Kulliyyah of Dentistry were included in this study, 26 were females and 16 we males. These patients aged from 49 years old to 77 years old and the majority of our subjects' ethnicity are Malay which are 95.2% and only 4.8% Chinese were included in this study. For history of denture wearer, 11% of the patients are first time complete denture wearer while the other 74% had previously experience wearing complete dentures.

The results of this study pointed out that the ratings of patients' assessments were surprisingly high as shown in Table 2. More than half of the patients rated all the parameters related to complete denture as satisfied. However, two variables were determined to be less than 50% satisfied, namely the fit of the lower denture and mastication, which together scored 42.95%

Results

Table 1. Characteristics of the respondents (n=42)

Variable	Frequency (%)
Sex	
Male	16 (38%)
Female	26 (62%)
Ethnicity	
Malay	40 (95.2%)
Chinese	2 (4.8%)
History of previous denture wearer	
Yes	31 (74%)
No	11 (26%)

Table 2. Distributions of different variables and level of satisfactions.

Variables	Level of Satisfaction (%)				
	Not satisfy at all	Not satisfy	Acceptable	Satisfy	Very satisfy
Fit of upper denture	1 (2.4%)	1 (2.4%)	3 (7.1)	16 (38.1%)	21 (50%)
Fit of lower denture	0 (0%)	6 (14.3%)	7 (16.7%)	11 (26.2%)	18 (42.9%)
Colour of the denture	0 (0%)	1 (2.4%)	4 (9.5%)	9 (21.4%)	28 (66.7%)
Colour of the teeth	0 (0%)	1 (2.4%)	3 (7.1%)	5 (11.9%)	33 (78.6%)
Appearance of the denture	0 (0%)	1 (2.4%)	0 (0%)	8 (19%)	33 (78.6%)
Appearance of the face	0 (0%)	1 (2.4%)	2 (4.8%)	8 (19%)	31 (73.8%)
Speech	0 (0%)	1 (2.4%)	4 (9.5%)	13 (31%)	24 (57.1%)
Mastication	0 (0%)	4 (9.5%)	9 (21.4%)	11 (26.2%)	18 (42.9%)
Smoothness of the denture	1 (2.4%)	1 (2.4%)	2 (4.8%)	9 (21.4%)	29 (69%)
Overall satisfaction	0 (0%)	1 (2.4%)	3 (7.1%)	15 (35.7%)	23 (54.8%)

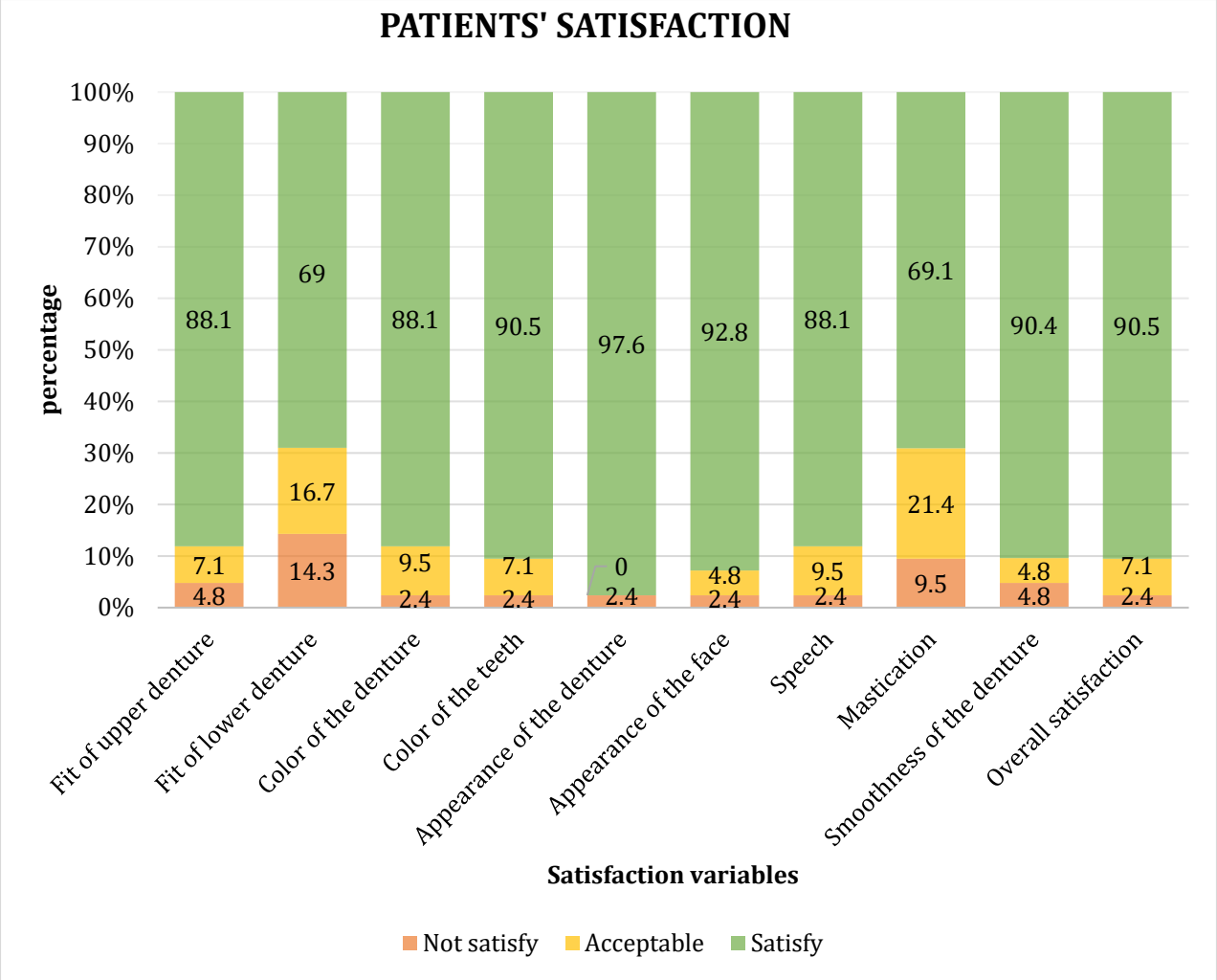

Figure 1. The percentage of patients' satisfaction of each variables.

The satisfaction level on each parameter is presented in Figure I with the best ratings were as follows: appearance of the denture (97.6%); appearance of the face (92.8%); color of the teeth (90.5%); and smoothness of the denture (90.4%). The parameters with the highest percentage of the lowest ratings were: Fit of the lower denture, 14.3% and mastication, 9.5%. The overall satisfaction comprises 90.5% are satisfied with their complete denture, 7.1% rated as acceptable and only 2.4% rated as not satisfied.

Significant difference was found between male and female in terms of the appearance of the denture (P<0.05). Furthermore, it was discovered that the appearance of the face and speech for both genders are nearly significant to P-values of 0.099 and 0.098, respectively. The others percentage of relationship between VAS score of each variable and gender are presented in Table 3.

Significant difference was found between patient who had previously experience of wearing denture and patient who had no experience in terms of fit of the upper denture (P<0.05). Additionally, because the P-value is greater than 0.05, other variables such as denture colors, appearance of denture, appearance of face, speech, mastication, smoothness of denture, and overall satisfaction are non-significant.

Table 4 shows the association between the VAS score of each variable and the previous history of wearing dentures.

Table 3. The relation between VAS of each variable and gender.

Variables	Level of Satisfaction (n=42)					P-value
	Not satisfy at all, n (%)	Not satisfy, n (%)	Acceptable, n (%)	Satisfy, n (%)	Very satisfy, n (%)	
Fit of upper denture						
Male	2.4	0	4.8	14.3	16.7	0.391
Female	0	2.4	2.4	23.8	33.3	
Fit of lower denture						
Male	0	4.8	4.8	9.5	19.0	0.460
Female	0	9.5	11.9	16.7	23.8	
Color of the denture						
Male	0	0	2.4	9.5	26.2	0.686
Female	0	2.4	7.1	11.9	40.5	
Color of the teeth						
Male	0	0	0	2.4	35.7	0.55
Female	0	2.4	7.1	9.5	42.9	
Appearance of the denture						
Male	0	0	0	0	38.1	0.009**
Female	0	2.4	0	19.0	40.5	
Appearance of the face						
Male	0	0	0	4.8	33.3	0.099
Female	0	2.4	4.8	14.3	40.5	
Speech						
Male	0	0	9.5	11.9	16.7	0.098
Female	0	2.4	0	19.0	40.5	
Mastication						
Male	0	2.4	9.5	7.1	19.0	0.593
Female	0	7.1	11.9	19.0	23.8	
Smoothness of the denture						
Male	2.4	0	0	7.1	28.6	0.524
Female	0	2.4	4.8	14.3	40.5	
Overall satisfaction						
Male	0	0	2.4	16.7	19.0	0.793
Female	0	2.4	4.8	19.0	35.7	

*Significant at P value < 0.05
A Mann Whitney U test

Table 4. The relation between VAS of each variable and previous history of wearing denture.

Variables	Level of Satisfaction (n=42)					P-value
	Not satisfy at all, n (%)	Not satisfy, n (%)	Acceptable, n (%)	Satisfy, n (%)	Very satisfy, n (%)	
Fit of upper denture						
Yes	2.4	2.4	0	23.8	45.2	0.022**
No	0	0	7.1	14.3	4.8	
Fit of lower denture						
Yes	0	11.9	9.5	16.7	35.7	0.463
No	0	4.8	7.1	9.5	7.1	
Color of the denture						
Yes	0	2.4	2.1	14.3	54.8	0.131
No	0	0	7.1	7.1	11.9	
Color of the teeth						
Yes	0	2.4	4.8	7.1	59.5	0.756
No	0	0	2.4	4.8	19.0	
Appearance of the denture						
Yes	0	2.4	0	11.9	59.5	0.735
No	0	0	0	7.1	19.0	
Appearance of the face						
Yes	0	2.4	2.4	8.9	59.5	0.233
No	0	0	2.4	8.9	14.3	
Speech						
Yes	0	2.4	4.8	23.8	42.9	0.778
No	0	0	4.8	7.1	14.3	
Mastication						
Yes	0	7.1	14.3	19.0	33.3	0.652
No	0	2.4	7.1	7.1	9.5	
Smoothness of the denture						
Yes	0	2.4	2.4	14.3	54.8	0.295
No	2.4	0	2.4	7.1	14.3	
Overall satisfaction						
Yes	0	2.4	4.8	21.4	45.2	0.295
No	0	0	2.4	14.3	9.5	

*Significant at P value < 0.05
A Mann Whitney U test

Discussion

The main objective of this study is to assess satisfaction level of complete denture wearer receiving treatment from IIUM Kuantan dental polyclinic. It is expected satisfaction level are high but would be influenced by different determinants.

Among the 10 parameters of satisfaction level, the parameters with the highest percentage of the lowest ratings which score in either category 'Not Satisfy at All' or 'Not Satisfy' are 'Fitting of the Lower Denture' which is 14.3%(n=6) followed by mastication 9.5% (n=4). This is expected due to the fact that residual edentulous ridge of mandible is rapidly undergoing continuous resorption in which according to Kovacic *et al.* (2010) the resorption rate in mandible was almost twice more pronounced than in maxilla and the fastest resorption rate is during the first few years after teeth extractions and gradually would slows down. In addition, the satisfaction of lower denture is described with low satisfaction may also be contributed by neuromuscular adaptation. Long period of neuromuscular adaptation is needed for the muscles of the lips, cheek, and tongue, which surround the lower denture, to adapt their function to the denture flanges. According to Celebic *et al.* (2003) the long period of neuromuscular adaptation will cause the mandibular dentures to move and damage oral mucosa, thus causing discomfort, unfavorable retention, and low levels of chewing ability and general satisfaction. Besides, it is interesting to note that the score of satisfaction for the mastication parameter, it is scored low rating by the same patients who had scored a low rating for 'Fit of Lower Denture'. It is predictable that any breach in retention would compromise stability during mastication.

In this study, female patients reported significantly less satisfaction compared to male in term of the appearance of dentures ($P < 0.05$). This is because female is more willing to report symptoms compare to male as reported by Pan *et al.* (2008) in which female patients score significantly lower overall satisfaction for both denture and implant supported overdenture for aesthetic component compared to male patients. By knowing this, having a proper satisfaction evaluation with female patient rather than male patient regarding the appearance of the denture during denture construction process would help to improve which parts that are lacking in the treatment and thus increasing the satisfaction level. Furthermore, a study done by Neumann *et al.* (1989) reported that male patients are to score less dissatisfaction with dental appearance although rated poor by dental professional for their aesthetic appearance. Thus, the perception of aesthetic is expected to be less critical for male compared to female and clinician should acknowledge that clinician perception of denture aesthetic alone may not be accurate with the patient's perception. There is systematic review article by Singh *et al*. (2019) concluded that patient-dentist communication in which how confidence the patient with the dentist is more important than the quality of the denture for the success of the denture.

There is significance elicited among first time denture wearers in our study showing that they were not satisfied with the retention of upper denture compared to patient who had experience with previous denture ($p < 0.05$). This is because first-time wearers probably still needed time for adaptation to the dentures. It might also be due to the fact that their perceptions regarding new complete dentures were not influenced by previous denture experience as investigated by Miranda *et al.* (2014). So, they probably have expectation that the experience of wearing denture is the same as with dentition. However, our result is in opposition to Celebic *et al.* (2003) which shows that patient who wears complete denture for the first time are more satisfied with the retention of maxillary complete denture.

It is found that some patients from our study were excluded from participating in this research because they did not continue to wear the complete denture for at least 3 months. This is mainly because of uncomfortable and pain. Other than that, it

was also noted that some patients who just got their complete denture refuse to wear the denture immediately because of mastication problem, unaesthetic, and ill fitting. We believe this is because of insufficient period of neuromuscular adaption which influence the satisfaction level. This finding is supported by Musavi *et al.* (2017) in which patients' satisfaction with the complete denture showed 67% satisfaction after 3 months delivery compared to only 38.4% during first month of delivery.

It is important for clinician to motivate patients and educate them to increase success of complete denture rehabilitation requires adaptation time which involve multiple reviews and commitment.

Conclusion

Overall, our study indicates that majority of patients receiving complete denture treatments from IIUM Kuantan Dental Polyclinic are satisfied in all 10 parameters ranging from 69% to 90.5% who scored at least satisfied or very satisfied. Only minimal number of patients who were not satisfied with their denture and mostly due to fitting of lower denture 14.3% and mastication 9.5%.

Within limitation of our study, we can conclude female patients are more concerned with aesthetic appearance of denture compared to male patient. We also find out that first-time denture wearer is significantly more satisfied with retention of upper denture. Furthermore, the study's findings revealed that patients who met the exclusion criteria did not continue to wear complete dentures due to discomfort and most of them did not return for follow-up visits.

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References

Bilhan, H., Erdogan, O., Ergin, S., Celik, M., Ates, G., Geckili, O. (2012). Complication rates and patient satisfaction with removable dentures. *The Journal of Advanced Prosthodontics,* 4(2), 109-115.

Celebić, A., Knezović-Zlatarić, D., Papić, M., Carek, V., Baucić, I., & Stipetić, J. (2003). Factors related to patient satisfaction with complete denture therapy. *The Journals of Gerontology. Series A, Biological Sciences and Medical Sciences*, *58*(10), 948–953.

Deeksheetha, P., Duraisamy, R., Ganapathy, D. (2019). Post insertion complications in patients' wearing conventional complete denture and bio functional prosthetic system dentures. *Drug Invention Today*, 11(9), 2061-2062.

Fenlon, M.R., Sherriff, M. & Newton, J.T. (2007). The influence of personality on patients' satisfaction with existing and new complete dentures. *Journal of Dentistry*, 35(2007), 744–748.

Kovacić, I., Celebić, A., Zlatarić, D. K., Petricević, N., Buković, D., Bitanga, P., *et al.* (2010). Decreasing of residual alveolar ridge height in complete denture wearers. A five year follow up study. *Collegium Antropologicum*, *34*(3), 1051–1056.

Miranda, B. B., Dos Santos, M. B., & Marchini, L. (2014). Patients' perceptions of benefits and risks of complete denture therapy. *Journal of Prosthodontics, 23*(7), 515–520.

Musavi, S. A., Eslami, H., Fakhrzadeh, V., Dabaghi-Tabriz, F., Rahbar, M., Khadem-Neghad, S., Salami, S. (2017). Evaluation of patients' satisfaction with the complete denture made in Prosthodontics Department of Dentistry Faculty, Tabriz, Iran 2017. *Advances in Bioscience and Clinical Medicine,* 6(2), 9-13.

Nandhin, T., Rakshagan, V., Jain, A. R. (2018). A survey to assess the patient's satisfaction on denture base color, customization, and esthetics made by undergraduates. *Drug Invention Today*, 10(11), 2222-2227.

Neumann, L. M., Christensen, C., & Cavanaugh, C. (1989). Dental esthetic satisfaction in adults. *Journal of the American Dental Association (1939)*, *118*(5), 565–570.

Panchevska, S., Elenchevski, S., Janeva, N., Mijoska, A. (2018). Satisfaction of complete denture wearers. *Medicinski Pregled*. 71(7-8). 247-249.

Pan, S., Awad, M., Thomason, J. M., Dufresne, E., Kobayashi, T., Kimoto, S., *et al.* (2008). Sex differences in denture satisfaction. *Journal of Dentistry*, *36*(5), 301–308.

Singh, S., Mishra, S.K., & Chowdhary, R. (2019). Patient expectations and satisfaction with conventional complete dentures: A systematic review. *Tanta Dental Journal*, 16(2), 55–6.

Subramanian, D., Govindarajulu,R.T, Narayanan, V., & Kalimuthu, N. D. (2019). Comparison of

expectation and satisfaction among new and existing denture wearers and correlation of duration of previous denture wearing experience to satisfaction in completely edentulous patients: A pilot study. *The Journal of Indian Prosthodontic Society*, 19(4), 324- 330.

Wolff, A., Gadre., A., Begleiter, A., Moskona, D. & Cardash, H. (2003). Correlation between patient satisfaction with complete dentures and denture quality, oral condition, and flow rate of submandibular/sublingual salivary glands. *The International Journal of Prosthodontics*, 16 (1), 45-48.

ORIGINAL ARTICLE Open Access

Assessing the feasibility of micro-computed tomography in comparing mineral densities and volume values of enamel and dentine in permanent premolars which were extracted teeth for orthodontic and periodontal treatment

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Abstract

The objective of our study was to show that the volumes of enamel-dentin tissues and mineral tissue densities of the teeth of young and adult individuals extracted for orthodontic and periodontal purposes could be measured using micro-computerized tomography. Non-decayed teeth extracted due to orthodontic and periodontal reasons were used. The teeth were scanned using a micro-CT (Skyscan 1172, Bruker, Belgium) device. The image data of the samples scanned with micro-CT were used in computer settings through the CTAn program for the calculation of the volumes of enamel and dentin tissues and their mineral densities. Comparisons between groups showed that there is no statistically significant difference between occlusal, middle, or apical zone mineral density values of the enamel and dentin tissues of the teeth in group 1 and group 2 ($p>0,05$). In addition, no statistically significant difference was detected between the mineral density values of average enamel and dentin tissues. Comparison between groups themselves showed a statistically significant difference between percentage ratios of enamel, dentin, and pulp volume compared to crown volume ($p<0.05$). We believe that the micro-CT technique is an imaging method that can perform accurate and sensitive measurements meant of volume changes observed in tooth tissues with time. In addition, we concluded that with micro-CT, the densities in enamel and dentin tissues in study groups could be measured reliably.

Keywords: *dentin, enamel, micro-computerized tomography, mineral density, volume*

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Introduction

Recent developments in digital technologies ensured that micro-computerized tomography (micro-CT) in the experimental studies of dentistry could be used in vitro studies in a variety of areas such as root canal morphological analysis, evaluation of root canal structuring, examination of the remaining filling materials in root canal after retreatment, examination of the development of head and face skeleton, evaluation of the microstructure of the bone around implant and root, measurement of enamel thickness and determination of the mineral concentration of teeth (Sahin &

Topuz, 2014; Kurt & Orhan,2016; Keles & Alcin, 2015).

The crown of the tooth consists of enamel, dentin, and pulp. Matured enamel is the hardest structure of the body, and its organic matrix is negligible. Enamel tissue does not include any veins and neural packages, which means that it lacks renovation features. In addition, it is a tissue that cannot remain stable. The enamel is exposed to change in a lifetime due to certain reasons (Bath-Balogh & Fehrenbach, 2006; Nanci, 2003). With aging, abrasion, erosion, attrition, and abfraction can be witnessed on the surface of the enamel with the impact of chewing (Nanci, 2003; Karaaslan *et al., 2008*).

Dentin is the most volumetric mineralized tissue of the tooth, which can be accepted as connective tissue. After the formation of primary dentin, in the later stages of life, physiological secondary dentin is formed as a relatively slow apposition without an apparent external stimulant (Bath-Balogh & Fehrenbach, 2006).

Mineral density distribution in the structure of bones and teeth affects the mechanical features of these structures (Farah *et al.*, 2010). Thus, the distribution of mineral density in tooth tissue is essential for clinicians and researchers (Zou *et al*., 2011). Researchers accept two methods as a golden standard for measuring the mineral density of hard tissues such as teeth and bones. These are histological / histo-morphometric analysis and the micro-CT method (Kim & Henkin, 2015; Dogan *et al.,* 2018).

Materials and Methods

The tooth samples used in this study were classified into the following groups: Group 1: young permanent upper first premolar teeth extracted due to orthodontic reasons (between 13-15 years old), and Group 2: permanent upper first premolar teeth extracted for periodontal treatment (over 40 years old). For this effect, a total of 30 teeth were collected. Permanent, non-decayed teeth which were not subjected to root canal treatment, restoration, and crown were used in this research.

The soft tissue scraps on the roots of extracted teeth were removed using a scaler and cleaned using pumice and bleaching; they were then left in distilled water at chamber temperature.

Micro-CT (Skyscan 1172, Bruker, Belgium) device was used for examining the samples. The teeth were placed in their holder. Samples were fixed on the sample bedding with the sample holder. The cover was closed. Camera values were 9 µm for pixel size, 0.9983 for camera angle, 85 kV for voltage, 118 milliampere, 360 degrees for re-constructor rotating angle, and 2 degrees for rotating angle, and each sample was scanned for 1 hour, and 1000-1200 image section data on average were obtained. Then, the image data collected from the samples were reconstructed. While the samples in the groups were rotating with half-angle, projection images are received until 180 degrees were completed. The images were recorded using 16-bit TİFF (Tagged İmage File Format) format (N.V., 2005).

After the scanning was completed, a series of x-ray images were formed. The number of the included images showed differences according to the chosen rotating speed of the device and the total number of rotations. Reconstruction was started after all these procedures. A raw data section was created during reconstruction. CT- volumetric images of sample models for which micro-CT scanning was made were created by CTAn (computer tomography Analyzer). Using this program, three-dimensional volumetric images were formed on the scanning image data obtained from the samples.

The sections obtained from the materials scanned with a micro-CT device were examined using the Data Viewer Software program (Version 1.6.6.0; Bruker micro-CT, Belgium). Dispersions were identified and corrected in scanned areas due to deficiency, error, or scanning.

Based on the sectional view data of the samples which were reconstructed and

analyzed using the Data Viewer Software program, crown volumes were calculated to the Cementoenamel junction using the CTAn software program (Version 1.16.4.1; Bruker micro-CT, Belgium). CTAn Software program was used to segregate the crown parts of the samples belonging to all study groups, and three-dimensional volumetric image data were obtained using the CTvol program similarly, the pulp, enamel, and dentin tissues of the samples used in our study were segregated using the CTvol program with the help of density differences and three-dimensional volumetric data the volumes of pulp, enamel, and enamel dentin tissues were measured and obtained for comparisons.

The densities of enamel and dentin tissues of the teeth in the groups were obtained by measuring with the CTAn program from different zones such as occlusal, median, and apical. In order to get the densities of the materials, calibration was made by scanning two phantom sticks with different densities using a micro-CT.

When the material is exposed to X-ray, an attenuation coefficient is determined related to the density of the material. Calibration phantoms are used in determining the material density in micro-CT. The concentrations of these calibration phantoms vary between 0.25 and 0.75 g.cm^3. For 0.25 calibration phantom, the attenuation coefficient was 0,00905. Then, for the 0.75 calibration phantom, the attenuation coefficient was found as 0,01948. These values were recorded in the program system. After choosing with the program the zone for which we wanted to see the density value, the density of the relevant zone was identified using attenuation coefficients. Finally, the observed values were loaded onto the system.

In the marked occlusal triple-zone, the target points in the enamel and dentin sections were marked, and densities were identified. In the occlusal triple, the zones were marked so that the entire coronal zone for which enamel volume was calculated was marked. The white areas in the figure were taken as reference points for measurement. Densities were examined by descending from occlusal to apical. These processes were applied separately for an occlusal, apical, and medium triple.

Results

Among the samples used in our study, 15 were young first premolar teeth and 15 were mature maxillary first premolar teeth, making up 30 samples in total.

During the evaluation of the findings obtained in the study, the convenience of parameters to normal distribution was tested using the Shapiro-Wilk test. According to these results, as the data showed normal distribution, the comparison between groups was carried out using the Student t-test, a parametric test that tested the mean values of two independent groups. Paired comparisons between study groups did not reveal any statistically significant difference between the occlusal, medium, and apical mineral density values of enamel and dentin tissues of group 1 teeth and the occlusal, middle and apical mineral density values of enamel and dentin tissues of group 2 teeth ($p>0,05$). At the same time, no statistically significant difference was revealed by comparing mineral density values of mean enamel and dentin tissues between groups (Table 1). Although a statistically significant difference was not found, the density values of occlusal, apical third, and dentine occlusal third of the enamel were higher in group 1 teeth. Meanwhile, the middle third density of enamel tissue and, the middle and apical third density of dentin tissue were higher in group 2 teeth. In all samples, the mineral density of enamel and dentin tissue was higher in the occlusal section compared to the apical section.

A comparison of the mineral density values of the enamel and dentin tissues of all teeth included in our study (Table 2) showed that there was a statistically significant difference ($p<0,05$) between the mean dentin density (1,309 ±0,200 g.cm^{-3}) and

mean enamel density (2,164± 0,195 g.cm^{-3}) of all teeth in the groups.

In the paired comparisons between groups, statistically significant differences ($p<0.05$) were found in the percentage of enamel, dentin, and pulp volume as per crown volume. For example, the percentage ratio of enamel and pulp volume of group 1 teeth was higher than Group 2 teeth; however, the dentin volume percentage per crown volume was lower (Table 3).

Table 1. Density and standard deviation values obtained from teeth.

	Groups	N	Mean (g.cm^{-3})	Std. Deviation
Enamel occlusal third density	1	15	2,2619	,19246
	2	15	2,1950	,25167
Enamel median third density	1	15	2,0690	,24933
	2	15	2,1716	,23602
Enamel apical third density	1	15	2,1711	,09025
	2	15	2,1177	,14463
Dentin occlusal third density	1	15	1,3594	,06980
	2	15	1,3251	,15194
Dentin medium third density	1	15	1,2861	,11187
	2	15	1,4064	,41150
Dentin apical third density	1	15	1,2358	,03896
	2	15	1,2468	,14524
Entire crown enamel density	1	15	2,1740	,10747
	2	15	2,1614	,10101
Entire crown dentin density	1	15	1,2938	,05461
	2	15	1,3423	,20614

**There was no statistically significant difference between the groups in terms of all variables, $p>0.05$.*

Table 2. Mean dentin and enamel density and standard deviation values of all teeth in the groups.

	N	Mean (g.cm^{-3})	Std. Deviation
Mean dentin density of all teeth in groups	90	1,309	,200
Mean enamel density of all teeth in groups	90	2,164	,195

**There was a difference between the mean dentin and enamel density and standard deviation values of all teeth in the groups, $p<0.05$.*

Table 3. The percentage volume and standard deviation values of the mean pulp, enamel and dentin volume compared to the crown volume.

	Groups	N	Mean	Std. Deviation
Percentage of pulp volume	1	15	% 1,690 mm^3	,423
compared to crown volume	2	15	%1,322 mm^3	,573
Percentage of enamel volume	1	15	%48,81 mm^3	3,068
compared to crown volume	2	15	%45,25 mm^3	3,760
Percentage of dentin volume	1	15	% 49,49 mm^3	2,888
compared to crown volume	2	15	% 53,42 mm^3	3,919
Crown volume	1	15	284,2 mm^3	40,65
	2	15	253,8 mm3	42,18

**There was a difference between all groups between the percentage volume and standard deviation values of the mean pulp, enamel and dentin volume compared to the crown volume, p<0.05.*

Discussion

Philippas (1961) conducted the first radiological studies to provide quantifiable data on the size of pulp chambers. The response of pulp and dentin to the abrasion and attrition occurs as a result of occlusal forces in forming secondary dentin. Although more primitive compared to the three-dimensional techniques of the present day, it is essential for being the first study that is parallel to our research.

One of the most essential advantages of micro-CT is that the structures of tissues can be viewed as three-dimensional without making any change in the makeup of the examined sample. Therefore, the sample can be used for other studies as no invasive processes are performed for scanning (Sahin & Topuz, 2014; Kurt & Orhan, 2016; Keles & Alcin, 2011; Marciano *et al.,* 2012; Davis & Wong, 1996). In addition, micro-CT is less time-consuming and less costly compared to other analyses (Uchiyama *et al.,* 1997).

In this study, we used micro-CT to calculate volumetric measures of the tissues that form the teeth due to such superior features.

Gant D. *et al*., (2006), P. Hofmann *et al.,* (2009), and Anthony J. O. *et al.,* (2008) examined the teeth of fossils with micro-CT. They calculated both the thickness and volumes of enamel dentin tissues. For this purpose, they stated that measuring the area covered by enamel and dentin tissue and its amount with micro-CT, which is a non-destructive method, is an accurate choice.

Similar to the studies indicated above, our study separates the young and adult maxillary 1. premolar teeth from cementoenamel junction using micro-CT and compares the volume measurement values obtained from the tissues.

The literature indicates that pulp chamber volume decreases due to increased secondary dentin formation with aging. Agematsu *et al.,* (2010) examined the change in secondary dentin accumulation and pulp chamber volume based on age and sex using micro-computerized tomographic images. Iwaka (2006) examined lower permanent first molar tooth on micro-computerized tomography and reported that the pulp volume decreased with age.

Similarly, the study conducted by Oi *et al.* (2004) using micro-computerized tomography analyzed the pulp chamber of the upper permanent first premolar tooth three-dimensional and reported that the size of the pulp chamber and canal openings

decreased with age. They argued for the reliability of micro-CT for volumetric measurements.

Aboshi *et al.* (2010) calculated using micro-CT the ratio of pulp volume of lower permanent premolar teeth to the entire tooth volume for age determination. Someda *et al.,* (2009) examined the enamel, dentin, and pulp volume of mandibular teeth for age determination and compared age with sex. They concluded that due to the abrasions in enamel with age, enamel should not be taken as a reference in age determination, and the volume of the pulp canal was affected by secondary dentin, which is formed with age. Colour settings were made at different tissues using micro-CT and pulp room, and hard tooth tissues were observed relatively well (Ma *et al*., 2013).

In their study, Kim I. *et al.* (2007) found that micro-CT was a more reliable method in the *in vitro* measurement of structures and volumes of teeth. This result is a study that supports our study in terms of reliability.

Ketterl (1983) compared the pulp volumes of permanent mandibular first molar extracted from individuals between the ages of 20 and 40 and found out that the volume of pulp chamber decreased in 40 years period.

Ma *et al.,* (2013) calculated the crown volume of mandibular central incisors of 5- and 6-years old children using micro-CT. Changes in enamel, dentin and pulp volumes were examined concerning age and sex. The ratio of pulp volume to the volume of the entire tooth crown is higher in 5 years old children (6.035%±1.568) compared to 6 years old children (5.106%±1.323).

In our study, the percentage ratio of pulp volume to crown volume is calculated as (1,690% mm^3 ± 0,423) in group 1 and (1,322% mm^3 ± 0,573) in Group 2. The difference between these groups was statistically significant, for which reason it was found that significant changes were made in pulp volume with age.

In our study, the volumetric calculations we made with micro-CT showed that the volume of enamel tissue decreased with age due to the abrasions in the enamel. In addition, secondary dentin formation increased the volume of dentin tissue, and the volume of pulp tissue decreased. This showed that the volume of enamel, dentin, and pulp tissues could be measured reliably using micro-CT. The conclusion we reached in the study was parallel to the volumetric measurements of Agemetsu *et al.* (2010), Oi *et al.,* Orhan *et al.* (2004), Someda *et al.* (2009), Ketterl *et al.* (1983), and Ma *et al.,* (2013) in the literature. Kinney *et al.* (1994) examined the mineral distribution in decayed canine teeth using the 3-D technique for the first time. Mineral concentration was found as 1,29 $g.cm^{-3}$ in healthy dentin and demineralized dentin was found as 0,55 $g.cm^{-3}$.

Djomehri *et al.* (2015) compared mineral densities of normal and diseased teeth hard teeth using micro-CT. They showed that mineral density distribution could be sectioned three-dimensional.

Dowker *et al.* (2006) reported that mineral density distribution was important in developing and identifying decays. For this purpose, they 3-D visualized the fissures of premolar teeth using micro-CT, examined the distribution of mineral density of the enamel, and showed the method's usefulness.

Microtomography and CTAn computer software used in our study helped determine that enamel tissue was more mineralized compared to dentin tissue in quantitative terms. These data were parallel to the information in the literature. Thus, it was concluded that enamel and dentin tissue could be measured reliably using micro -CT. Farah *et al.* (2010) compared the mineral density distribution in the teeth of MIH individuals (molar incisor hypo-mineralization) to individuals with healthy teeth using micro-CT. They reported that at the enamel-cement level, mineral density increased towards occlusal and reached its high at cusp/incisor tops. Also, they reported that as teeth could be dehydrated due to the solution, which was used for sterilization,

mineral density values could show higher figures. In addition, they stated that the thickness of the section taken from the samples could affect the measurement of mineral density distribution. Clementino – Luedemann & Kunzelman (2006) found mean enamel density value as 2,47 – 2,7 $g.cm^{-3}$.

Weidmann *et al.* (1967) took a section at the micron level from the samples and examined the entire mineral content of a mature enamel using a chemical method for the first time.

Hayashi-Sakai, S *et al.* (2018) concluded that the distribution of mineral density in sound enamel and dentin and attempted to determine the standard mineral density for each tooth type using micro-CT. The mineral density distributions found in this study contribute to our understanding of the mechanical properties of enamel and dentin. A positive correlation suggests that the systemic bone mineral density could be predicted based on the analysis of exfoliated teeth, such as in patients with hypophosphatasia. The present results may be useful in establishing a numerical standard for the mechanism involved in root fracture and for early detection of root fracture risk.

Schmitz *et al*. (2014) analyzed the mineral change during enamel formation using micro-CT and compared its reliability with the chemical method. However, measuring the mineral content and enamel volume is extremely difficult as dentin is connected to the enamel and the dental crown to create a two-layered bio-mineral. For this purpose, invasive and non-invasive methods were developed.

Nakata *et al*. (2012) observed that mineral content could be measured reliably using micro-CT. Similar values were found with the chemical method the density changes in minerals at the four layers (surface layer, lesion layer, medium layer, deep layer) of the enamel affected from decay longitudinally during remineralization of the enamel process. This approach reported that micro-CT was a reliable method to create a mineral density profile.

Wong *et al.* (2004) examined the mineral density of baby teeth enamels and found that mineral density at the occlusal zone was higher than in the cervical area.

Our study showed similar features to the studies conducted by Clementino – Luedemann & Kunzelman (2006), Farah *et al.* (2010), and Wong *et al.* (2004). We found out that the mineral density of enamel tissue increased from cervical to occlusal and from the enamel-dentin border to the outer enamel. In addition, it has been determined that the mineral densities of dentin tissue increased from the collum dentis layer to the occlusal layer of dentin tissue.

It is well-known that the mineral density of dentin tissue increases with age (Bath-Balogh & Fehrenbach, 2006; Nanci, 2003; Wong *et al.*, 2004). Our study's values are parallel to the information in the literature. Thus, the reliability and usefulness of our research conducted using micro-CT have been supported.

In addition, in our study, the mineral density of enamel tissue slightly decreased with age, but this finding is not statistically significant.

Conclusion

As a result, it was thought that the volumetric changes observed in teeth tissues in time could be accurately and delicately measured using the micro-CT technique as an imaging method. Parallel to the findings of previous studies, our research found that the mineral density of dentin tissue increased with age. Furthermore, it was seen that the density distribution of enamel tissue increased from cervical to occlusal. In addition, in our study, the mineral density of enamel tissue slightly decreased with age, but this finding is not statistically significant. It was concluded that mineral density distribution in enamel and dentin tissue could be accurately measured with micro-CT.

As the samples were not subjected to any procedure before being scanned, it was believed that it was a more favorable method for measuring the mineral density of hard tissues of teeth compared to other densities. The scanning speed and features of micro-CT are still in development. As a result, the researchers believed that micro-CT could develop more and provide images from samples with higher resolution and quality, thus serving as an essential *in vitro* research method in dentistry. Furthermore, it was also believed that the progress in this technology could reduce the radiation dose and increase its usefulness for *in vivo* studies in the future, as a result of which breakthroughs could be witnessed in scientific studies.

Researchers will enjoy broader perspectives in dentistry studies with micro-CT technologies.

This study will guide future studies on broader and different sample groups such as other racial and gender groups.

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References

Aboshi H., Takahashi T., Komuro T., (2010). Age estimation using microfocus X-ray computed tomography of lower premolars. *Forensic Science International*, 200, 35–40.

Agematsu H., Someda H., Hashimoto M., Matsunaga S, Abe S., Kim H-J., *et al.* (2010). Three-dimensional observation of a decrease in pulp cavity volume using micro-CT: age-related change. *The Bulletin of Tokyo Dental College*, 51(1), 1–6.

Bath-Balogh M, Fehrenbach (2006) M. *Illustrated Dental Embryology, Histology, and Anatomy* 2nd Ed. St. Louis: Elsevier Inc, pp. 61-91, 179-200.

Clementino-Luedemann T.N.R., Kunzelmann K-H. (2006). Mineral concentration of natural human teeth by a commercial micro-CT. *Dental Materials Journal,* 25(1), 113–119.

Davis G.R., Wong F.S.L.. (1996) X-ray microtomography of bones and teeth. *Physiological Measurement*, 17(3), 121–146.

Djomehri S.I., Candell S., Case T., Browning A., Marshall G.W., Yun W., *et al.* (2015). Mineral density volume gradients in normal and diseased human tissues. Aikawa E, editor. PLoS One, 10(4).

Dogan M., Callea M., Kusdhany L., Aras A., Maharani D., Mandasari M., *et al., (*2018*).* The evaluation of root fracture with Cone Beam Computed Tomography (CBCT): an epidemiological study. *Journal of Clinical and Experimental Dentistry*, 10(1).

Dowker S.E.P., Elliott J.C., Davis G.R., Wilson R.M., Cloetens P., **(**2006). Three-dimensional study of human dental fissure enamel by synchrotron X-ray microtomography. *European Journal of Oral Sciences,* 114 Suppl, 1, 353-359.

Farah R.A., Swain M.V., Drummond B.K., Cook R., Atieh M., (2010). Mineral density of hypomineralised enamel. *Journal of Dentistry*, 38(1), 50–58.

Gantt D.G., Kappleman J., Ketcham R.A., Alder M.E., Deahl T.H., (2006). Three-dimensional reconstruction of enamel thickness and volume in humans and hominoids. *European Journal of Oral Sciences*, 114, 360–4.

Hayashi-Sakai, S., Sakamoto, M., Hayashi, T., Kondo, T., Sugita, K., Sakai, J., *et al.* (2018). Evaluation of permanent and primary enamel and dentin mineral density using micro-computed tomography. *Oral Radiology*, *35*(1), 29-34.

Hofmann P., Marschallinger R., Daxner-Höck G., (2009). 3D volume modelling of fossil small mammal teeth using micro CT and object based image analysis. *In: Computational Vision and Medical Image Processing.* Tavares J. and Jorge N.,(Eds.)(CRC Press/Taylor & Francis) pp. 395–399.

Iwaka Y., (2006) Three-dimensional observation of the pulp cavity of mandibular first molars by micro-CT. *Journal of Oral Biosciences*, 48(2), 94–102.

Karaaslan E.S., Ertas E., Koprulu H., (2008). Dental hard tissue abrasions and treatments. *Journal of Ondokuz Mayıs Univ Fac Dent*, 9, 28–34.

Keles A., Alcin H., (2015). Micro Computed tomography and its aplications in endodontics. *Türkiye Klin J Endod*, 1(3), 32–39.

Ketterl W., (1983). Age-induced changes in the teeth and their attachment apparatus. *International Dental Journal,* 33(3), 262–271.

Kim I., Paik K-S., Lee S-P., (2007). Quantitative evaluation of the accuracy of micro-computed tomography in tooth measurement. *Clinical Anatomy*, 20(1), 27–34.

Kim Y.J., Henkin J., (2015). Micro-computed tomography assessment of human alveolar bone: bone density and three-dimensional micro-architecture. *Clinical Implant Dentistry and Related Research,* 17(2), 307–313.

Kinney J.H., Marshall G.W., Marshall S.J., (1994). Three-dimensional mapping of mineral densities in carious dentin: theory and method. *Scanning Microscopy*, 8(2), 197–204.

Kurt M.H., Orhan K., (2016). Micro-Computed Tomography in Dentistry. *Turkiye Klin Oral Maxillofacial Radiology - Spec Top*, 2, 14–21.

Ma J-L., Shi S-Z., Ide Y., Saka H., Matsunaga S., Agematsu H., (2013). Volume measurement of crowns in mandibular primary central incisors by micro-

computed tomography. *Acta Odontologica Scandinavica,* 71(5), 1032–1037.

Marciano M., Duarte M., Ordinola-Zapata R., Del Carpio-Perochena A., Cavenago B., Villas Bôas M., *et al.* (2012). *Applications of Micro-Computed Tomography in Endodontic Research*. In: A. Mendez, pp. 782–788.

Nakata K., Nikaido T., Nakashima S., Nango N., Tagami J., (2012). An approach to normalizing micro-CT depth profiles of mineral density for monitoring enamel remineralization progress. *Dental Materials Journal*, 31(4), 533–540.

Nanci A.., (2003). *Ten Cate's Oral Histology: Development, Structure, and Function*. 6. Ed. St. Louis: Mosby Elsevier, 79-110,145-195.

N.V. (2005). SksScan 1172 *X-Ray Microtomography User Manual*. V lunchtenburgstraat: Aartselaar.

Oi T., Saka H., Ide Y., (2004). Three-dimensional observation of pulp cavities in the maxillary first premolar tooth using micro-CT. *International Endodontic Journal*, 37(1), 46–51.

Olejniczak A.J., Tafforeau P., Feeney R.N.M., Martin L.B., (2008). Three-dimensional primate molar enamel thickness. *Journal of Human Evolution*, 54(2), 187–195.

Philippas G.G., (1961) Influence of Occlusal Wear and Age on Formation of Dentin and Size of Pulp Chamber. *Journal of Dental Research*, 40(6), 1186–1198.

Sahin F.U., Topuz O., (2014). Micro computerized tomography applications in dental research. *Acta Odontologica Turcica*, 31(2), 114–120.

Schmitz J.E., Teepe J.D., Hu Y., Smith C.E., Fajardo R.J., Chun Y-H.P., (2014). Estimating mineral changes in enamel formation by ashing/BSE and microCT. *Journal of Dental Research*, 93(3), 256–262.

Someda H., Saka H., Matsunaga S., Ide Y., Nakahara K., Hirata S., *et al.* (2009). Age estimation based on three-dimensional measurement of mandibular central incisors in Japanese. *Forensic Science International*, 185(1-3), 110–114.

Uchiyama T., Tanizawa T., Muramatsu H., Endo N., Takahashi H.E., Hara T. A., (1997). *Morphometric Comparison of Trabecular Structure of Human Ilium Between Microcomputed Tomography and Conventional Histomorphometry*. *Calcified Tissue International*, 61(6), 493–498.

Weidmann S.M., Weatherell J.A., Hamm S.M., (1967). Variations of enamel density in sections of human teeth. *Archives of Oral Biology*, 12(1), 85–97.

Wong F.S.L., Anderson P., Fan H., Davis G.R., (2004). X-ray microtomographic study of mineral concentration distribution in deciduous enamel. *Archives of Oral Biology*, 49(11), 937–944.

Zou W., Hunter N., Swain M.V., (2011). Application of Polychromatic μCT for Mineral Density Determination. *Journal of Dental Research*, 90(1), 18–30.

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Retention of periodontally hopeless tooth and the clinical effect on the adjacent tooth at maintenance phase: A retrospective study

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Abstract

Previous research has shown that periodontal maintenance therapy can keep teeth healthy for a long time. However, only a few studies have been conducted on the periodontal hopeless tooth that is retained during the maintenance phase. The purpose of this study was to evaluate if retaining a periodontal hopeless tooth had an effect on the periodontal conditions in the adjacent tooth at maintenance. A retrospective analysis was conducted on the periodontal status of periodontitis patients who presented with retained hopeless tooth. Hopeless prognosis is based on the mean percentage of the mesial and distal radiographic bone loss ≧ 65%. The periodontal status consists of periodontal pocket depth (PPD), clinical attachment loss (CAL), and bleeding on probing (BoP), which were evaluated at baseline (T0), after active therapy (T1) and at the last examination (T2) for both the hopeless tooth and the tooth/teeth adjacent to it. Compliance toward maintenance and reason for hopeless tooth extraction were also evaluated at maintenance (T1-T2). A total of 65 patients with 121 hopeless teeth and 187 adjacent teeth were included. Significant improvement of all periodontal parameters for both hopeless and adjacent teeth at T1 and T2 from T0 were observed within 5.05±2.58 years of observation, except for the CAL during maintenance. In conclusion, a low risk of disease progression on the tooth adjacent to the retained periodontal hopeless tooth can be achieved following active treatment with strict maintenance care.

Keywords: *hopeless tooth, periodontitis, periodontal maintenance, retention, tooth loss*

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Introduction

The main goal of periodontal therapy is to preserve natural teeth by arresting the progression of attachment loss (Nicholls, 2000). Several studies have reported the effectiveness of periodontal treatment in preventing tooth loss (Cortellini & Tonetti, 2004; Graetz *et al.*, 2011; Graetz *et al.*, 2017). Following a good maintenance care programme, the prolonged survival of periodontally compromised teeth can be Achieved (Hirschfeld & Wasserman, 1978; Matuliene *et al.*, 2008). However, in some situations, the extraction of periodontally compromised tooth is recommended. The extraction usually involves teeth that are indicated as 'hopeless', mainly due to advanced periodontal destruction. The majority of these teeth were extracted during active therapy (APT), while some of the remaining are likely to be extracted

during the supportive phase (Carnevale *et al.*, 2007; Matuliene *et al.*, 2008).

The decision of assigning the tooth as a hopeless is mainly based on local-tooth related and systemic factors (Checchi *et al.*, 2002; Machtei &Hirsch, 2007; Mcguire &Nunn, 1996; Nguyen *et al.*, 2020; Wojcik *et al.*, 1992). Although the majority of teeth lost due to periodontal disease had been initially assigned as questionable or hopeless prognosis, cases of improvement of state have been encountered (Graetz *et al.*, 2011). This indicates that it is not always possible to definitively identify teeth at risk of being lost with prognosis alone. Therefore, extractions conducted during APT should be performed with caution.

In clinical practice, the decision to treat or extract a tooth is often based on the assumption that the retention of a hopeless tooth may accelerate periodontal tissue destruction of the adjacent tooth. Therefore, as a preventive measure, "strategic extractions" have been advocated (Kao, 2008; Lin *et al.*, 2019; Lundgren *et al.*, 2008). As patients may refuse to have their periodontally hopeless tooth extracted due to milder symptoms, it is important to base the intervention on whether the patient will benefit from the extraction.

The impact of retaining hopeless teeth on the adjacent periodontium has been studied previously, and was found that it had no negative effect on the proximal alveolar bone and PPD of the adjacent teeth following periodontal therapy (Devore *et al.*, 1988; Machtei &Hirsch, 2007; Wojcik *et al.*, 1992). However, no evaluation was made on other periodontal parameters, such as clinical attachment loss (CAL) and bleeding on probing (BoP). Nonetheless, the outcomes on PPD, CAL and BoP are clinical signs widely used as indicators of periodontal disease progression (Lang *et al.*, 2009; Matuliene *et al.*, 2008; Mdala *et al.*, 2014). Therefore, it is relevant to observe the impact of the retention of the hopeless tooth on the clinical parameters of the adjacent tooth.

Materials and Methods

Data Collection

This retrospective study consisted of patients with periodontal disease who were treated at the Mak Mandin Periodontal Specialist Clinic in Penang. To identify patients with periodontal hopeless teeth, a comprehensive review of all clinical records and radiographs from 2010 to 2019 was performed. The patients were then screened to include only those with hopeless teeth remained in the maintenance phase. All other clinical information was also extracted from the case note and radiography records.

For the purpose of this study, prognosis for a hopeless tooth was solely based on radiographic assessment at baseline. The percentage of alveolar bone loss was measured based on the formula [distance from cemento-enamel junction (CEJ) to the most apical extension of the alveolar bone crest (BL) / root length from the apex (AP) to the CEJ] X 100. If a restoration was presented over the CEJ, the margin of the restoration was used as the reference point. Measurement was done on each proximal (mesial and distal) surfaces. The mean percentage of alveolar bone loss (% mesial + % distal / 2) at ≧ 65% was considered as hopeless (Figure 1). Measurements were performed by a single examiner (M.A.J). Manual measurements for conventional radiographs, such as periapical and panoramic were performed under standardized viewing conditions using a negatoscope, and a transparent plastic ruler to the nearest millimetre. For the digital radiographs, measurements were done using a computerized software.

Intra-examiner reliability was calculated based on a repeated radiographic assessment of 30 teeth (a combination of 15 conventional and 15 digital radiographs) at 1-week intervals, using Intraclass Correlation Coefficient (ICC). The average ICC was 0.998 with a 95% confidence interval from 0.995 to 0.999 (P<0.001). These outcomes demonstrated that the performed measurements were standardized.

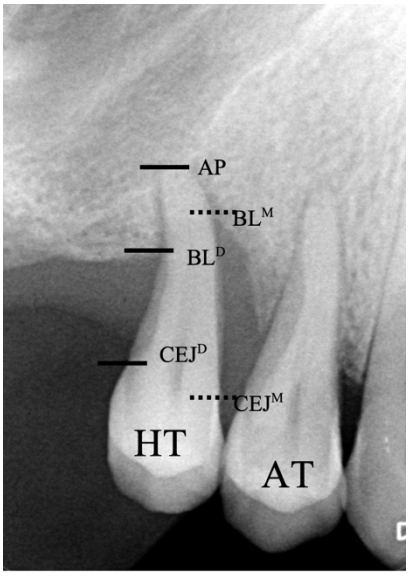

Figure 1. References for alveolar bone loss measurement. Hopeless tooth determination, based on mean percentage between mesial and distal bone loss (≥ 65%). Inclusion was based on the presence of adjacent tooth/teeth with less than 65% bone loss, and survival of hopeless tooth at maintenance (T1-T2) for a minimum of one year.

$$\frac{CEJ^{M} - BL^{M}}{CEJ^{M} - AP} \times 100 = M\%$$

$$\frac{CEJ^{D} - BL^{D}}{CEJ^{D} - AP} \times 100 = D\%$$

Mean percentage of alveolar bone loss:

$$\frac{\mathbf{M + D}}{\mathbf{2}} = \mathbf{BL\%}$$

Hopeless tooth when the BL% ≥ 65%.

Inclusion and exclusion criteria

Patients were included in the study when three sets of periodontal examinations are available: at baseline (T0), after APT (T1) and at last examination (T2). Hopeless tooth needs to survive after the APT, with at least one adjacent tooth (mean BL <65%) and both retained for a minimum of one year from T1. Patients were excluded if they received regenerative therapy of either the hopeless and adjacent teeth.

Periodontal evaluation

At baseline (T0), three clinical parameters; PPD, CAL, and BoP measurements were extracted from the clinical note for both hopeless and adjacent teeth. Similar clinical parameters were evaluated at T1 and T2.

Tooth loss and reasons for it at time points T1 to T2 were also assessed. Any unidentified reason for missing of initially prognosed as 'hopeless' will be assumed as 'extracted due to periodontal reason'.

Periodontal therapy

All patients received initial non-surgical periodontal therapy (scaling and root debridement, under local anaesthesia if necessary), together with oral hygiene instructions. Systemic antibiotics were prescribed as an adjunct to scaling and debridement for generalized aggressive periodontitis, according to Griffiths *et al.* (2011). Periodontal surgery (resective, or open flap debridement) was performed if indicated. Those who received periodontal regenerative therapy were excluded from the study.

Maintenance visits

Maintenance visits per year were determined for each patient by dividing the number of visits by the number of years between T1 to T2 (Checchi *et al.*, 2002). The level of compliance towards maintenance was defined as good or poor. Level of compliance was considered as 'good' if patients reliably and consistently presented for the maintenance and completely complied with the proposed intervals during the entire duration of T1 to T2. Patients who did not consistently follow the prescribed maintenance visits, but still continued to irregularly appear were identified as 'poor' compliers. Patients who were missed or did not comply with the suggested maintenance visits (non-compliers) were not included in the study. Non-compliers were excluded due to breaching of the inclusion criteria. Majority of these patients were not available for a re-evaluation at T2 of more than 1 year.

Statistical analysis

Statistical analyses were performed using the IBM SPSS for Windows, version 26 (IBM Corp., Armonk, N.Y., USA). Changes for mean PPD, CAL, and percentage of BoP from T0 to T1 and from T0 to T2 were independently calculated using the Wilcoxon signed-rank test. The same test was used for changes between levels of compliance toward periodontal maintenance at T1 to T2. Logistic regression was used to determine periodontitis progression variables. Several independent factors were looked at, such as the smoking, and diabetes. Statistical significance was declared for *p*-values of <0.05.

This study was approved by the Medical Research and Ethics Committee (MREC), Ministry of Health Malaysia (NMRR-21-581-59184 IIR). The ethics committee waived the need to obtained consent for the data collection, analysis and publication of the retrospectively obtained secondary data for this non-interventional study.

Results

Demographic data

The 65 patients diagnosed with periodontitis were evaluated between 2010 and 2019. Table 1 presents the characteristics of the sample, including gender, mean age at first visit, general health, mean frequency of maintenance, mean follow-up length, number of hopeless and adjacent teeth, and percentage of bone loss. It is important to note that most of the patient (93.80%) were none smoker. In addition to the findings presented in Table 1, nearly all patients (97%) were assessed for alveolar bone loss using conventional radiographs. Further data are shown in Table 1, 2, and 3.

Changes in clinical parameters of retained hopeless tooth and the adjacent tooth.

The clinical changes (PPD, CAL and BoP) of retained hopeless tooth and the adjacent tooth are demonstrated in Table 4. The mean PPD for hopeless tooth at baseline (T0) was significantly reduced ($P < 0.0001$) from 5.32 mm, SD $\pm$ 1.49 to 4.03 mm, SD $\pm$ 1.55 after APT (T1). A further significant improvement ($P < 0.0001$) was observed following maintenance therapy, with a mean PPD of 3.85 mm, SD $\pm$ 1.55 at the latest assessment (T2). Similar results were also observed for the adjacent tooth with significant PPD reduction ($P < 0.0001$) from T0 (4.52 mm, SD $\pm$ 1.44) to T1 (3.43 mm, SD $\pm$ 1.34), and to T2 (3.11 mm, SD $\pm$ 1.12).

Changes in mean CAL of the hopeless tooth were evidenced from T0 (7.50 mm, SD $\pm$4.19) to T1 (6.50 mm, SD $\pm$ 1.97) with a statistically significant reduction ($P < 0.0001$). However, CAL was increased at T2 (7.13 mm, SD $\pm$ 2.38), with no statistical significance difference from the T0 ($P = 0.439$). Similarly, a slight increase in CAL at T2 (5.01 mm, SD $\pm$ 2.06) from the T1 (4.95 mm, SD $\pm$ 1.82) was observed for the adjacent tooth as well. Nevertheless, the CAL value was below baseline (T0) (5.60 mm, SD $\pm$ 1.80), and the reductions were statistically significant ($P < 0.0001$) at T0-T1, and T0-T2.

Table 1. Demographic data, maintenance period, follow-up period.

Patient	**n = 65**	
Age (mean ± SD)	45.15 ± 9.12	
Gender		
Male	25	(38.50%)
Female	40	(61.50%)
Medical status		
Healthy	41	(63.00%)
Diabetes	8	(12.40%)
Hypertension	16	(24.60%)
Smoking		
No	61	(93.80%)
Yes	4	(6.20%)
Radiograph		
Panoramic/conventional	59	(90.80%)
Periapical/conventional	4	(6.20%)
Periapical/digital	2	(3.00%)
Maintenance		
Mean ± SD frequency per year	2.94 ± 1.16	
Follow-up period (mean ± SD)		
T0-T1 (month)	1- 21 m	(4.03 ± 3.87)
T0-T2 (year)	2 - 10 y	(5.05 ± 2.58)
T1-T2 (year)	2 - 10 y	(4.48 ± 2.63)

Table 2. Number of teeth, percentage of alveolar bone loss, and type of teeth that retained after active periodontal therapy (T1).

Tooth:	
Hopeless	121
Adjacent	187
Total	308
% BL at T0 (mean ± SD):	
Hopeless	76.13% ± 8.28
Adjacent	45.33% ± 12.50

Table 3. Hopeless tooth that loss during the maintenance (T1-T2).

Loss:	**29**	**(23.97%)**
Reason for TL		
Pain	5	(17.25%)
Mobility	16	(55.17%)
Prosthetic reasons	6	(20.69%)
Caries or endodontic reasons	2	(6.89%)
Type of tooth extracted		
Maxillary molar	3	(10.34%)
Maxillary premolar	6	(20.69%)
Maxillary anterior	7	(24.14%)
Mandibular molar	5	(17.24%)
Mandibular premolar	4	(13.79%)
Mandibular anterior	4	(13.79%)

The mean percentage of BoP for the hopeless tooth at T0 was 66.30%, SD ± 31.64, which reduced to 37.74%, SD ± 34.14 at T1. The mean percentage continued to improve significantly to 33.33%, SD ± 28.30 at T2. A statistically significant (P < 0.0001) reduction in BoP percentage of the adjacent tooth were noted from T0 (50.83%, SD ± 35.06) to T1 (28.48%, SD ± 32.31), and to T2 (20.96%, SD ± 27.14).

Table 4. Means (+SD) of clinical parameters at baseline (T0), after active periodontal therapy (T1) and last examination (T2) for hopeless and adjacent teeth.

Clinical measurements	**Baseline (T0)**	**After APT (T1)**	**Last examination (T2)**	***P* value**	
				T0-T1	**T0-T2**
Hopeless tooth					
PPD (mm)	5.32 ± 1.49	4.03 ± 1.55	3.85 ± 1.55	< 0.0001	< 0.0001
CAL (mm)	7.50 ± 4.19	6.50 ± 1.97	7.13 ± 2.38	< 0.0001	0.439
BoP (%)	66.30 ± 31.64	37.74 ± 34.14	33.33 ± 28.30	< 0.0001	< 0.0001
Adjacent tooth					
PPD (mm)	4.52 ± 1.44	3.43 ± 1.34	3.11 ± 1.12	< 0.0001	< 0.0001
CAL (mm)	5.60 ± 1.80	4.95 ± 1.82	5.01 ± 2.06	< 0.0001	< 0.0001
BoP (%)	50.83 ± 35.06	28.48 ± 32.31	20.96 ± 27.14	< 0.0001	< 0.0001

PPD, periodontal pocket depth; CAL, clinical attachment loss; BoP, bleeding on probing.

Influence of maintenance status on the periodontal stability

Maintenance status was evaluated as T1-T2. The mean frequency of maintenance visits per year was (2.94 years, SD ± 1.16) (Table 1). Forty-two patients (64.62%) were deemed as good compliers, whereas 23 patients (35.38%) were deemed as poor-compliers. Patients who were good and poor compliers retained 77 and 44 hopeless teeth, respectively. Additionally, 119 adjacent teeth were evaluated from the good compliers and 68 AT from the poor compliers (Table 5).

Table 5. Means (+SD) of clinical parameters at (T1-T2) for hopeless and adjacent teeth according to the level of compliance to maintenance.

	Compliance level	T1	T2	*P* value
Hopeless tooth	**Good (n=77)**			
	PPD	4.10 ± 1.56	3.80 ± 1.59	0.180
	CAL	6.27 ± 2.01	6.94 ± 2.61	0.003
	BoP*	40.26 ± 35.08	30.95 ± 30.31	0.032
	Poor (n=44)			
	PPD	3.91 ± 1.55	3.93 ± 1.49	0.745
	CAL	6.91 ± 1.86	7.45 ± 1.90	0.023
	BoP*	33.33 ± 32.35	37.50 ± 24.15	0.501
Adjacent tooth	**Good (n=119)**			
	PPD	3.43 ± 1.35	3.08 ± 1.21	0.012
	CAL	4.69 ± 1.77	4.77 ± 2.07	0.484
	BoP	29.77 ± 31.01	18.49 ± 25.28	<0.0001
	Poor (n=68)			
	PPD	3.44 ± 1.34	3.17 ± 0.95	0.419
	CAL	5.39 ± 1.83	5.42 ± 1.98	0.896
	BoP	26.23 ± 34.59	25.28 ± 29.82	0.963

PPD, periodontal pocket depth; CAL, clinical attachment loss; BoP, bleeding on probing. The inter-group comparisons (good vs poor compliance) for the mean differences between T1-T2 showed no statistical differences except for *BoP of hopeless tooth (p =0.013); Wilcoxon test.

Changes in the clinical parameters were independently evaluated for hopeless and adjacent teeth at T1 to T2 according to patients' compliance status (Table 5). Hopeless tooth for patients with good compliance toward maintenance showed a reduction in PPD and BoP. From this data, statistically significant differences were only seen for BoP (*P*=0.032). CAL however, showed further statistically significant deterioration (*P*=0.003). For the poorly compliance patients, their hopeless tooth showed a further increase for all measured parameters, whereby only CAL showed a statistically significant difference (*P*=0.023). Meanwhile, for the adjacent tooth, improvements in the clinical parameters except for the CAL were observed for both good and poor compliers. However, only the good compliers group showed statistically significant improvement. A comparison was made between poor and good compliers, with only significant result observed for the BoP of the hopeless tooth (p =0.013). Others, failed to show any significant results.

Regression model

A univariate binary logistic regression was performed to predict the progression of periodontitis for adjacent and hopeless teeth from T1 to T2 based on smoking, and diabetes status. A case of periodontitis was considered to be progressive if there was ≥ 2mm CAL between two observation points (T1 and T2) during the maintenance phase. Both of these factors however, were not significantly related to the progression of periodontitis within this study (Table 6).

Table 6. Univariate binary logistic regression for the progression of periodontitis from T1 to T2.

	Factor	OR	95% CI	*P* value
Hopeless tooth	*Smoking*			
	No	1		
	Yes	0.216	(0.012 - 3.773)	0.216
	Diabetes Mellitus			
	No	1		
	Yes	0.985	(0.241 - 4.032)	0.983
Adjacent tooth	*Smoking*			
	No	1		
	Yes	1.089	(0.127 - 9.341)	0.938
	Diabetes Mellitus			
	No	1		
	Yes	0.966	(0.351 - 2.660)	0.946

Hopeless tooth loss and reasons for extraction

Hopeless tooth loss was analysed between the T1 and T2 period. From a total of 121 hopeless tooth present after APT (T1), 29 (23.97%) were lost at the maintenance phase; 16 (55.17%) due to mobility, followed by prosthetic reasons at 6 (20.69%), pain at 5 (17.25%), and caries/endodontic reasons at 2 (6.89%). The majority were the maxillary anterior teeth (24.14%) and the least were the maxillary molar teeth (10.34%) (Table 3).

Discussion

The decision to treat teeth diagnosed as periodontally "hopeless" is controversial. While most practices favors extraction, some patients may not have consented to the procedure. In such situations, the tooth is usually retained throughout the periodontal maintenance phase. The decision to retain should be accompanied by considerations on its benefit, and the possibilities of progression into deterioration and affects toward the adjacent tooth.

A previous study by Machtei & Hirsch (2007), found that providing surgical treatment on periodontally hopeless tooth can preserve the teeth for a mean of 4 years with significant bone gain. This was also observed on the adjacent tooth. The study also found no statistically significant difference to the bone level of the adjacent tooth with either retained or extracted hopeless tooth. Similarly, in another study, following periodontal therapy on retained periodontal hopeless tooth, no significant detrimental effects were observed on the periodontal pocket, alveolar bone loss, and periodontal ligament space width on the proximal periodontium of the adjacent tooth (Wojcik *et al.*, 1992). However, both studies had different definitions for hopeless prognosis. Wojcik defined hopeless tooth using a combination of multiple risk indicators, namely 78% alveolar bone loss,

residual PPD of 8 mm, Class III furcation, Class III mobility, poor crown-root ratio, root proximity and repeated periodontal abscess. A minimum of two criteria was required for a tooth to be deemed hopeless. While Machtei defined the hopeless prognosis simply based on radiographic residual alveolar bone loss of ≥ 70% at either of the tooth's proximal sites.

For current study, we used a definition by Machtei with minor modification. The mean percentage of alveolar bone loss was calculated, and tooth was defined as hopeless when alveolar bone loss was ≥ 65% (Figure 1). Because of severe bone destruction of the hopeless tooth, a surgical treatment was not possible due to extreme mobility. At the maintenance phase, all patients received standard periodic supragingival scaling. Subgingival debridement was also provided for an area with the pocket of > 4mm. It was observed that retention of the hopeless tooth did not result in deterioration of the periodontal status; in fact, there was a significant improvement in PPD, CAL, and BoP. The same was also observed for the adjacent tooth (Table 4), indicate that hopeless tooth and the tooth adjacent to them can be maintained without significant deteriorating effect on the periodontal health provided with good periodontal treatment and strict maintenance care.

In general, hopeless tooth for patient with poor compliance toward maintenance showed progression in periodontal destruction for all three parameters. However only CAL showed statistically significant result. Patient with good compliance on the other hand, showed further improvements for the periodontal parameters, except for CAL which deteriorate significantly from T1 to T2. For the adjacent tooth, stability of the periodontal parameters (except for CAL) can be observed for patients with either good or poor compliance toward the maintenance care. However, only patient with good compliance showed significant improvement for PPD and BoP. There was only BoP's parameter for the hopeless tooth that showed significant different statistically when compared between patients with good and poor compliance within this study. The findings of this study are supported by Costa *et al.* (2018). Their prospective study indicated that patients with regular periodontal maintenance had better plaque index, PPD, and BoP after 6 years compared to the irregular complier. An increase in the percentage of patients with CAL> 5mm could be seen at different study time points in those with irregular compliance.

Lack of significant difference between poor and good compliance levels from the studies may be influenced by intervals of the maintenance procedures. Matuliene *et al.* (2008) observed a three-fold increase in periodontitis progression for maintenance done less than twice a year (6 monthly), in comparison to patients with rigid and frequent maintenance. In the current study, the mean number of maintenance visits per year was 2.94 + 1.16. Therefore, even patient with poor maintenance category was monitored at every 4 months. This frequency is in line with the multi-factorial Periodontal Risk Assessment model proposed for high risk patients (Lang &Tonetti, 2003). This may explain why there were no significant differences between poor and good compliance for both hopeless and adjacent teeth except for BoP of hopeless tooth ($p = 0.013$) observed within this study (Table 5).

On the other hand, the result for CAL, showed a deteriorating trend in all categories, yet significant only seen in the hopeless tooth (Table 5). Nevertheless, progression of periodontitis was to be expected during maintenance. Matuliene *et al.* (2008) found that a significant increase in the number of periodontal pockets of PPD ≥ 5mm per patient (4.1 ± 5.3 to 5.4 ± 6.8) occurred during a mean maintenance of 11 years.

There were several definitions used to define recurrent or progression of periodontitis during long-term maintenance. The 5th European Workshop on Periodontology defines periodontitis recurrence as at least two teeth with a CAL≥ 3 mm between two observation periods

(Tonetti *et al.*, 2005). In contrast, Lorentz *et al.* (2009) defined it as a change in CAL at a single site more than 3 mm. While, the 2017 classification of periodontitis defines a rapid progression rate of periodontitis (Grade C) as CAL≥ 2mm over a 5-year period (Papapanou *et al.*, 2018). Despite differences, CAL is a key clinical determinant in predicting disease progression. This study therefore considered teeth with the periodontitis recurrent if the CAL ≥ 2mm between T1 and T2.

The progression of periodontitis might eventually result in the loss of teeth. From a total of 121 hopeless tooth at T1, 29 teeth (23.97%) were lost during maintenance (T1-T2). The main reasons for extraction were mobility, followed by prosthetic reasons, pain, and caries/endodontic factors. Anterior teeth were generally lost more frequently than molars (37.93% vs 27.58%). On the contrary, previous studies found that multi-rooted teeth were most frequently lost during maintenance (Checchi *et al.*, 2002;Hirschfeld &Wasserman, 1978). This may be related to the low number of retained hopeless molar teeth (34.71%) presented after T1, compared to a higher retention of the anterior teeth (44.63%). The lack of extraction of the anterior teeth may be also due to aesthetic reasons. Since there is no particular research on patient perception elements related to the decision of anterior teeth extraction in periodontitis, one can only speculate based on study of oral health-related quality of life (OHRQoL) on anterior tooth loss. Several studies demonstrate that anterior tooth loss has a greater impact on patients in terms of both function and aesthetics (Al-Omiri *et al.*, 2009;Tsakos *et al.*, 2004;Tsakos *et al.*, 2006;Walter *et al.*, 2007). According to Elias&Sheiham (1999), aesthetics and communication are the most important factors in determining the value of oral health satisfaction, as well as the primary motivators for receiving prosthesis therapy. However, financial factor was found to influence patients' decisions to seek prosthetic treatment (Teofilo &Leles, 2007). This is probably why anterior teeth are extracted less than posterior teeth. This assumption needs further study.

This study, however, is subject to several limitations. The use of retrospective data does not favour proper assessment of risks such as furcation and mobility; instead must rely on the accuracy of clinical records performed by several clinicians in the past. It is also possible that accuracy was compromised with the heavy use of the conventional panoramic type of radiographic assessment. However, study found that there were no significant differences between a periapical and panoramic radiograph in assessing severe alveolar bone destruction (≥ 10mm from CEJ to bone crest) (Pepelassi & Diamanti-Kipioti, 1997). Semenoff *et al.* (2011) also found no significant differences between conventional and digitized periapical and panoramic radiographs for assessing advanced alveolar bone loss (≥ 6mm) in periodontitis. It was thus concluded that radiographic selection may not significantly influence the results of the current study.

In this study, neither diabetics nor smokers were excluded. This may have an impact on the results of this study, as both of these variables may increase the likelihood of periodontitis progression throughout maintenance (Costa *et al.*, 2013;Matuliene *et al.*, 2008). To analyze both factors, a univariate binary logistic regression analysis was performed. The results of the analysis reveal that smokers and diabetics have an elevated risk of periodontitis progression in hopeless and adjacent teeth, but statistically were not significant (Table 6). The insignificant results of smoker and diabetes within this study could be attributed to the small sample size of those factors. Furthermore, regular maintenance treatment could be a contributing factor as well. Fisher *et al.* (2008) found that both current smokers and non-smokers with chronic periodontitis who got regular maintenance treatment seemed to be able to stop the progressive destruction of periodontal tissue. Similar to the current study, their patients received maintenance therapy every 3 to 4 months.

In addition, evaluation of dental plaque was not included due to inconsistency in the assessment, especially for the hopeless tooth. This can influence the outcome of the present study, as the dental biofilm is one of the etiological factors for periodontitis (Kornman & Loe, 1993). The reasons for the inconsistency of plaque assessment of the hopeless tooth cannot be identified. Assumption was related to the fact that once a tooth is diagnosed as hopeless, it may be considered irrational to treat and therefore a complete assessment was not done. However, due to intensive maintenance care at an average of three times per year, patients within this study are expected to have an overall lower plaque score. Unfortunately, this cannot be proven.

Moreover, certain hopeless tooth (mandibular incisors) suffered from occlusal trauma were stabilized with direct composite splints. Studies have found that under regular periodontal maintenance, splinting of the hopeless mandibular incisors can stabilize the periodontal health and prolong survival (Graetz *et al.*, 2019; Sonnenschein *et al.*, 2017). However, a recent systematic review failed to draw a definitive conclusion on the efficacy of splint. The review concludes that the procedure does not improve survival of the mobile hopeless tooth, especially in patients with advanced (Stage IV) periodontitis (Dommisch *et al.*, 2021). Lastly, the reasons for hopeless tooth extraction were not clear. The intention to retain or extract the tooth may have been influenced by the clinicians' treatment philosophies.

Conclusion

Within the limitations of this study, the results suggest that periodontal therapy with a regular maintenance at an average of 4-month intervals favours retention of the hopeless tooth in periodontitis patients with no significant impact on the clinical periodontal parameters of the adjacent tooth.

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Conflict of interest

The authors declare no conflict of interest.

References

Al-Omiri, M. K., Karasneh, J. A., Lynch, E., Lamey, P. J. , Clifford, T. J. (2009). Impacts of missing upper anterior teeth on daily living. *International Dental Journal,* 59(3), 127-132.

Carnevale, G., Cairo, F. , Tonetti, M. S. (2007). Long-term effects of supportive therapy in periodontal patients treated with fibre retention osseous resective surgery. Ii: Tooth extractions during active and supportive therapy. *Journal of Clinical Periodontology,* 34(4), 342-348.

Checchi, L., Montevecchi, M., Gatto, M. R. , Trombelli, L. (2002). Retrospective study of tooth loss in 92 treated periodontal patients. *Journal of Clinical Periodontology,* 29(7), 651-656.

Cortellini, P. , Tonetti, M. S. (2004). Long-term tooth survival following regenerative treatment of intrabony defects. *Journal of Periodontology,* 75(5), 672-678.

Costa, F. O., Miranda Cota, L. O., Pereira Lages, E. J., Soares Dutra Oliveira, A. M., Dutra Oliveira, P. A., Cyrino, R. M., *et al.* (2013). Progression of periodontitis and tooth loss associated with glycemic control in individuals undergoing periodontal maintenance therapy: A 5-year follow-up study. *Journal of Periodontology,* 84(5), 595-605.

Costa, F. O., Vieira, T. R., Cortelli, S. C., Cota, L. O. M., Costa, J. E., Aguiar, M. C. F., *et al.* (2018). Effect of compliance during periodontal maintenance therapy on levels of bacteria associated with periodontitis: A 6-year prospective study. *Journal of Periodontology,* 89(5), 519-530.

DeVore, C. H., Beck, F. M. , Horton, J. E. (1988). Retained "hopeless" teeth. Effects on the proximal periodontium of adjacent teeth. *Journal of Periodontology,* 59(10), 647-651.

Dommisch, H., Walter, C., Difloe-Geisert, J. C., Gintaute, A., Jepsen, S. , Zitzmann, N. U. (2021). Efficacy of tooth splinting and occlusal adjustment in patients with periodontitis exhibiting masticatory dysfunction: A systematic review. *Journal of Clinical Periodontology*.

Elias, A. C. , Sheiham, A. (1999). The relationship between satisfaction with mouth and number, position and condition of teeth: Studies in brazilian adults. *Journal of Oral Rehabilitation,* 26(1), 53-71.

Fisher, S., Kells, L., Picard, J. P., Gelskey, S. C., Singer, D. L., Lix, L., *et al.* (2008). Progression of periodontal disease in a maintenance population of smokers and non-smokers: A 3-year longitudinal study. *Journal of Periodontology,* 79(3), 461-468.

Graetz, C., Dorfer, C. E., Kahl, M., Kocher, T., Fawzy El-Sayed, K., Wiebe, J. F., *et al.* (2011). Retention of questionable and hopeless teeth in compliant patients treated for aggressive periodontitis. *Journal of Clinical Periodontology,* 38(8), 707-714.

Graetz, C., Ostermann, F., Woeste, S., Salzer, S., Dorfer, C. E. , Schwendicke, F. (2019). Long-term survival and maintenance efforts of splinted teeth in periodontitis patients. *Journal of Dentistry,* 80, 49-54.

Graetz, C., Plaumann, A., Schlattmann, P., Kahl, M., Springer, C., Salzer, S., *et al.* (2017). Long-term tooth retention in chronic periodontitis - results after 18 years of a conservative periodontal treatment regimen in a university setting. *Journal of Clinical Periodontology,* 44(2), 169-177.

Griffiths, G. S., Ayob, R., Guerrero, A., Nibali, L., Suvan, J., Moles, D. R., *et al.* (2011). Amoxicillin and metronidazole as an adjunctive treatment in generalized aggressive periodontitis at initial therapy or re-treatment: A randomized controlled clinical trial. *Journal of Clinical Periodontology,* 38(1), 43-49.

Hirschfeld, L. , Wasserman, B. (1978). A long-term survey of tooth loss in 600 treated periodontal patients. *Journal of Periodontology,* 49(5), 225-237.

Kao, R. T. (2008). Strategic extraction: A paradigm shift that is changing our profession. *Journal of Periodontology,* 79(6), 971-977.

Kornman, K. S. , Loe, H. (1993). The role of local factors in the etiology of periodontal diseases. *Periodontology 2000,* 2(83-97.

Lang, N. P., Schatzle, M. A. , Loe, H. (2009). Gingivitis as a risk factor in periodontal disease. *Journal of Clinical Periodontology,* 36 Suppl 10(3-8.

Lang, N. P. , Tonetti, M. S. (2003). Periodontal risk assessment (pra) for patients in supportive periodontal therapy (spt). *Oral Health and Preventive Dentistry,* 1(1), 7-16.

Lin, J. H., Tu, C. C., Chen, Y. W., Wang, C. Y., Liu, C. M., Kuo, M. Y., *et al.* (2019). Influence of adjacent teeth absence or extraction on the outcome of non-surgical periodontal therapy. *International Journal of Environmental Research and Public Health,* 16(22).

Lorentz, T. C., Cota, L. O., Cortelli, J. R., Vargas, A. M. , Costa, F. O. (2009). Prospective study of complier individuals under periodontal maintenance therapy: Analysis of clinical periodontal parameters, risk predictors and the progression of periodontitis. *Journal of Clinical Periodontoly,* 36(1), 58-67.

Lundgren, D., Rylander, H. , Laurell, L. (2008). To save or to extract, that is the question. Natural teeth or dental implants in periodontitis-susceptible patients: Clinical decision-making and treatment strategies exemplified with patient case presentations. *Periodontology 2000,* 47(27-50.

Machtei, E. E. , Hirsch, I. (2007). Retention of hopeless teeth: The effect on the adjacent proximal bone following periodontal surgery. *Journal of Periodontology,* 78(12), 2246-2252.

Matuliene, G., Pjetursson, B. E., Salvi, G. E., Schmidlin, K., Bragger, U., Zwahlen, M., *et al.* (2008). Influence of residual pockets on progression of periodontitis and tooth loss: Results after 11 years of maintenance. *Journal of Clinical Periodontology,* 35(8), 685-695.

McGuire, M. K. , Nunn, M. E. (1996). Prognosis versus actual outcome. Iii. The effectiveness of clinical parameters in accurately predicting tooth survival. *Journal of Periodontology,* 67(7), 666-674.

Mdala, I., Olsen, I., Haffajee, A. D., Socransky, S. S., Thoresen, M. , de Blasio, B. F. (2014). Comparing clinical attachment level and pocket depth for predicting periodontal disease progression in healthy sites of patients with chronic periodontitis using multi-state markov models. *Journal of Clinical Periodontology,* 41(9), 837-845.

Nguyen, L., Krish, G., Alsaleh, A., Mailoa, J., Kapila, Y., Kao, R. T., *et al.* (2020). Analyzing the predictability of the kwok and caton periodontal prognosis system: A retrospective study. *Journal of Periodontology,* 95(5), 662-669.

Nicholls, C. (2000). A 12-year retrospective audit study of tooth loss in a general dental practice. *British Dental Journal,* 189(2), 98-99.

Papapanou, P. N., Sanz, M., Buduneli, N., Dietrich, T., Feres, M., Fine, D. H., *et al.* (2018). Periodontitis: Consensus report of workgroup 2 of the 2017 world workshop on the classification of periodontal and peri-implant diseases and conditions. *Journal of Periodontology,* 89 Suppl 1(S173-S182.

Pepelassi, E. A. , Diamanti-Kipioti, A. (1997). Selection of the most accurate method of conventional radiography for the assessment of periodontal osseous destruction. *Journal of Clinical Periodontology,* 24(8), 557-567.

Semenoff, L., Semenoff, T. A., Pedro, F. L., Volpato, E. R., Machado, M. A., Borges, A. H., *et al.* (2011). Are panoramic radiographs reliable to diagnose mild alveolar bone resorption? *International Scholarly Research Notices,* 2011(363578.

Sonnenschein, S. K., Betzler, C., Rutters, M. A., Krisam, J., Saure, D. , Kim, T. S. (2017). Long-term stability of splinted anterior mandibular teeth during supportive periodontal therapy. *Acta Odontologica Scandinavica,* 75(7), 475-482.

Teofilo, L. T. , Leles, C. R. (2007). Patients' self-perceived impacts and prosthodontic needs at the time and after tooth loss. *Brazilian Dental Journal,* 18(2), 91-96.

Tonetti, M. S., Claffey, N. , European Workshop in Periodontology group, C. (2005). Advances in the progression of periodontitis and proposal of definitions of a periodontitis case and disease progression for use in risk factor research. Group c consensus report of the 5th european workshop in periodontology. *Journal of Clinical Periodontology,* 32 Suppl 6(210-213.

Tsakos, G., Marcenes, W. , Sheiham, A. (2004). The relationship between clinical dental status and oral impacts in an elderly population. *Oral Health and Preventive Dentistry,* 2(3), 211-220.

Tsakos, G., Steele, J. G., Marcenes, W., Walls, A. W. , Sheiham, A. (2006). Clinical correlates of oral health-related quality of life: Evidence from a national sample of british older people. *European Journal of Oral Sciences,* 114(5), 391-395.

Walter, M. H., Woronuk, J. I., Tan, H. K., Lenz, U., Koch, R., Boening, K. W.*, et al.* (2007). Oral health related quality of life and its association with sociodemographic and clinical findings in 3 northern outreach clinics. *Journal of the Canadian Dental Association,* 73(2), 153.

Wojcik, M. S., DeVore, C. H., Beck, F. M. , Horton, J. E. (1992). Retained "hopeless" teeth: Lack of effect periodontally-treated teeth have on the proximal periodontium of adjacent teeth 8-years later. *Journal of Periodontology,* 63(8), 663-666.

REVIEW ARTICLE Open Access

Medical emergencies response plan: Is your dental clinic ready?

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Abstract

Dentists should provide a safe environment for all patients and this also includes preparing for the occurrence of medical emergencies in dental setting. Managing medical emergencies must be considered in the initial set up of a dental clinic. Some emergencies are indeed unavoidable hence all dental clinic members must be prepared and well trained to manage medical emergencies. Among the steps that should be taken in preparing dental clinic for medical emergencies are development of emergency plan, evaluation of patients' risk, monitoring of vital signs, training of staff and availability of emergency drugs and equipment.

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Introduction

An emergency is often regarded as a serious, unexpected, and occasionally dangerous situation requiring immediate action. Medical emergencies can occur to patients in dental setting with or without any relation to the dental procedure. The silent epidemic of aging that is taking over our population has increased the likelihood of senior citizens with complex medical histories being treated in dental clinics (Ngeow *et al.,* 2015). With the advancement in medical fields, it is anticipated that there will be more complex medical conditions which later will result in new challenges to dental practitioners.

The frequency of medical emergency in dental setting varies between countries, but it would be enough to say that it is not uncommon (Alhamad *et al*., 2015). Recent studies on prevalence of emergencies events in dental clinic showed that many dentists will at least experience one medical emergency event annually (Obata *et al*, 2021). Therefore, dentists should be prepared to equip themselves with proficient knowledge and training on the management of medical emergencies which includes the administration of common drugs used in such situation.

Most of the medical emergencies that occur in dental settings are not preventable and can be managed accordingly such as vasovagal syncope, hypoglycaemia, angina, choking, allergic reaction, asthmatic attack and myocardial infarction (Vaughan *et al*., 2018: Mohamed Ramli *et al*., 2019). Dental practitioner's ability to cope with medical emergencies during dental visit is imperative as the first responder that will ensure the adverse events do not lead to tragic consequences and occasionally any legal action. An ill-prepared team may result in delay in response time which may increase the likelihood of serious morbidity or mortality of the affected patient (Lawson, 2015). However, during a high-pressure scenario, sometimes it is hard to navigate the flow on how to respond through the crisis especially when one is unable to identify the exact diagnosis of the patient's condition. Previous studies have proven that there were significant gaps in proficiency of handling medical emergency among dental practitioners and dental students which later reflects as lack of confidence (Vaughn *et al.,* 2018).

Initiating the immediate management with ABC (airway, breathing and circulation) approach of basic cardiopulmonary resuscitation should always be considered during emergency events as it is consistent with the key principle in managing most medical emergencies especially in the situation when the diagnosis is vague (Uyamadu & Odai, 2012). Providing a effective basic pulmonary resuscitation as the cornerstone management of medical emergency is the prime contribution of dental practitioner towards sustaining the chain of survival of their patients and failure to comply may lead to the loss of life (Elacheziyan *et al*., 2012).

Objectives

1. To introduce comprehensive steps in preparing dental clinic in dealing with unexpected medical emergencies.

Steps for Preparing Dental Care Managing Medical Emergency

1) Development of Medical Emergency Response Plan.

Appropriate preparation of the dental office is important for the rapid identification, and successful management of medical emergencies in dental setting. During the incident of medical emergency in dental setting, one can easily experience panic and may be in a confused state as how to respond to the condition. Being ill-prepared will only lead to more negative outcome. Patients' safety includes avoidance of preventable adverse events (accidents, errors, and complications) associated with health care and to limit the impact of inevitable adverse events. Medical emergencies account for 5% of patients' safety incidents recorded (Thusu *et al*., 2012). Assessment of the current available safety management in the dental clinic is the first step that should be taken by the dental practitioner. Any data or previous experience in handling medical emergency in dental practice should not be hidden and must be acknowledged to plan for improvement (Yamalik, & Pérez, 2012).

Subsequently, a dental clinic must establish a comprehensive and easy to follow written manual on how to handle medical emergency situation. The response plan will be different from one dental clinic to another, depending on the types of treatment offered (inhalation or intravenous sedation), trained staff available, accessibility to the nearest hospital, equipment and drugs available.

Studies have shown that prevalence of medical emergency in a hospital setting and general dental clinic differs as there are more medically compromised and elderly patients being referred to dental clinic in hospital setting for treatment (Anders *et al*, 2010). Clinic that offers dental treatment under sedation must be able to handle medical emergencies such as central nervous system depression and medical emergency related to respiratory complications (Becker *et al*., 2014). Thus,

specific medical emergency plan must be laid out based on the type of treatment provided and the capability of dental auxiliaries in handling medical emergency.

In the development of medical emergency plan, each dental staff should be able to respond and act according to the role assigned (Table 1). During emergency situation, it is easy to get panic and thus, unable to react appropriately. An assertive leader must be able to give instructions and keep the team calm and take command of the situation. This role must clearly be assigned in the medical emergency plan and each dental staff should be trained to perform specific task as outlined in the response plan. Ultimately, the goal of all team members must be focused on adequate oxygenation of the brain and heart of the patient. Roles can be interchangeable according to the situation and availability.

Table 1. Example of roles during medical emergency in dental clinic.

Team Members	Role
Team member 1 (T1)	• In charge and lead the management of the crisis. • Assign team member to call for outside assistance. • Assess ABCs and initiate cardiopulmonary resuscitation (CPR) if indicated until assistance arrives. • Give direct and clear instructions. • Remain with the patient throughout the emergency.
Team member 2 (T2)	• Preparation of emergency drugs and help with documentation (findings of the event which includes vital signs, random blood glucose, SPO2, timing, type and amount of drugs administered). • Assists with ABCs, CPR and vital signs monitoring.
Team member 3 (T3)	• Contact ambulance, wait for paramedics and lead them to the patient. • Locate and bring the emergency kit, portable oxygen and automated external defibrillator (AED). • Help in the further management of patient.

Effective communication during an emergency is pivotal in making sure the management goes smoothly. "Close-loop" approach is advocated to use during such situation (Haas *et al*., 2010). This means when the leader sends a message, the team member acknowledges receiving the instruction, thereby confirming that he or she heard and understood the message. This technique will ensure that the instructions given are not being missed by team members assuming that someone else is performing the task when in fact no one is acting on the command (Table 2).

In the manual, outline the flow of management for specific expected medical emergency. This can be simply taken from various established manual and guideline. Other factor should also be taken into consideration such as:

1. Location of the clinic
2. Usage of lift elevator (whether the size can fit a stretcher)
3. Nearest hospital direct number (prior arrangement and agreement must be made between the dental clinic and nearest hospital to refer any medical emergencies)
4. Maximum weight for dental chair (whether CPR can be performed on the

dental chair or need to transfer patient down on the floor)

2) Medical history and at-risk patients

Prevention is the main strategy in dealing with any diseases including in the case of emergency. Screening of at-risk patients can be done by a comprehensive medical, allergies and drug history. Advances in medicine have greatly increased the survival of patients with severe health problems and have significantly prolonged life in elderly individuals with systemic disorders. The updated past medical history is an essential component of risk assessment for the likelihood of a patient to experience a medical emergency.

Obtaining the medical history will prompt the dental practitioner to modify the treatment plan or make any necessary specialist referral. Knowledge of the dental practitioner on medical diseases such as cardiovascular, endocrine and respiratory systems must be sound in order to identify at risk patient

Table 2. Examples of close loop communication.

Team member 1	: *Ali, call for ambulance.*
Team member 2	: *I am going to call ambulance.*
Team member 1	: *Yes, hurry up.*
When Ali returns	
Team member 2	: *I have called the ambulance and they are on the way.*

Team member 1:	: *Ali, bring the AED.*
Team member 2	: *I am going to get the AED.*
When Ali returns	
Team member 2	: *AED is here.*
Team member 1	: *Thank you, help me assemble it.*

If there are any enquiries regarding a patient's medical condition, it is best to actually consult patient's own medical practitioner.

The ability to conduct an accurate patient risk evaluation becomes the foundation for informed practice, patient selection and risk assessment. Other than updated medical condition, risk assessment of dental patient prior to treatment can be done using American Society of Anaesthesiologists Physical Status (ASA PS) classification. This system may be useful, particularly when communicating with other teams involved in patient care. (Clough *et al*., 2016) The ASA status of patient should be recorded in patients notes as stated in Table 4. For patients in ASA PS 1, all dental treatment can be allowed. While for ASA PS II and III, dental treatment can be done with minimal risk and treatment modification. Extreme caution must be taken for ASA PS III. As for PS IV and V the risk for elective dental treatment is too high, and for emergency treatment, it is advisable to be done under hospital setting (Malamed, 2010).

3) Vital Signs

The National Early Warning Score (NEWS) can be used as a method in avoiding medical emergencies in dental setting (Omar, 2013). In this system, it uses simple scoring system in which a score is allocated to physiological measurements undertaken when a patient becomes or complains of feeling 'unwell'. The parameters include respiratory rate, oxygen saturation, temperature, systolic blood pressure, pulse rate and level of consciousness.

Patient with medical problems must have basic monitoring such as blood pressure and pulse rate before receiving dental treatment to ensure safety during the treatment (Table 4). Value for each sign must be recorded and make sure that vital signs are stable prior to dental treatment. The dental practitioner and staff involved in treating the patient can perform these basic monitoring without the need for costly monitoring equipment. During emergency, monitoring of these vital signs is important as it will reflect on patient's condition from time to time. From previous study, sadly it was found that majority of the dental practitioner did not take vital signs before performing dental treatment (Kumarswami S. *et al*., 2015). Vital signs are early signs showing that patient is not in a stable condition, for example, blood pressure readings will help the dental practitioner to identify patient with severe hypertension which carries risk of heart attack and stroke (Southerland *et al*., 2016)

Pain and stress experienced by the patient may alter the vital signs. The stress leads to changes of physiological parameters that can in return induces medical emergencies. Dental anxiety itself is able to cause hemodynamic changes by releasing catecholamines and increases workload of the heart. Therefore, close monitoring of patients with dental anxiety during the treatment is advised (Alghareeb Z. *et al*, 2022). This practice allows dental practitioners to treat patients in a safer environment as well as improving overall health outcomes.

Table 3. Indicator for increased risk of medical emergency.

Medical Condition	Criteria for increased risk for medical emergency
Angina	Recent chest pain. Consider risk factor in patient (stress). Raised blood pressure upon physical examination.
Asthma	The number of inhalers and the dose that patient is on. History of frequent asthma attacks (requiring nebulisation or visit to emergency department) Previously been hospitalized, previous intensive care unit (ICU) admission and those patients currently taking oral corticosteroids.
Epilepsy	Recent change of medication and poor seizure control. Information regarding trigger for previous seizures for precaution. Early recognition of aura.
Diabetes	Type 1 diabetes patients are more at risk of going into hypoglycaemic state. Patient on oral hypoglycaemic agents is at lower risk. Patient with poor control or poor awareness.
Allergies	Patient with known allergies including previous reactions to antibiotics, latex and rarely local anaesthetics. History of hospitalization due to allergic reaction.

4) Training of dental practitioners and dental auxiliaries

Dental practitioners and auxiliaries being prepared in dealing with emergency in dental setting is the best way to handle the situation. Studies have shown alarming statistics where many dental practitioners were not well prepared in handling emergency situations (Kumarswami, *et al*, 2015; Smereka *et al*.,2019). The lack of training and inability to manage patients with medical emergencies can lead to unfortunate consequences legal action. The aim of Basic Life Support (BLS) is to perform effective cardiopulmonary resuscitation (CPR) with attention towards circulation, airway, and breathing. BLS knowledge and practical competency deteriorates over time and it is necessary to update the training periodically (Kim SY *et al*., 2020). Simulation education in medical emergencies such as team training and system testing for dental practitioners and auxiliaries have been proven to improve knowledge and skills among them (Hadfield A. *et al.*, 2018).

Table 4. American Society of Anesthesiologists (ASA) Physical status classification system.

ASA PS Classification	Description	Adult Examples and blood pressure reading	Treatment recommendation
I	A normal healthy patient	Healthy, non-smoking, no or minimal alcohol use	All dental treatment can be done without special precaution.
II	A patient with mild systemic disease	Mild diseases only without substantive functional limitations. Current smoker, social alcohol drinker, pregnancy, obesity (30<BMI) Blood Pressure (BP) reading: 140-159/90-94mmHg	Elective dental treatment can be done, maybe need treatment modifications depending on the case.
III	A patient with severe systemic disease	Substantive functional limitations; one or more moderate to severe diseases. Poorly controlled DM or HTN, COPD, morbid obesity (BMI ≥40), active hepatitis, alcohol dependence or abuse, implanted pacemaker, moderate reduction of ejection fraction, ESRD undergoing regularly scheduled dialysis, history (>3 months) of MI, CVA, TIA, or CAD/stents. BP reading: 160-199/ 95-114 mm Hg	Dental treatment with precautions. Will need medical consultation prior to dental treatment.
IV	A patient with severe systemic disease that	Recent (valve dysfunction, severe reduction of ejection fraction, shock, sepsis, DIC, ARD or ESRD not undergoing regularly scheduled dialysis	Elective dental care is contraindicated. Emergency care: non-invasive or need to be done in hospital setting.

	is a constant threat to life	BP reading: > 200/> 115 mm Hg	
V	A moribund patient who is not expected to survive without the operation	Ruptured abdominal/thoracic aneurysm, massive trauma, intracranial bleed with mass effect, ischemic bowel in the face of significant cardiac pathology or multiple organ/system dysfunction	All dental care is done in hospital setting. Palliative only.

It is worthwhile to send all dental personnel to attend BLS training periodically. Routine simulated medical emergency drills is also advocated to connect between knowledge and real situation as realistic simulation training is an effective adjunct coupled with theory session (Lawson L., 2017). Simulation training must include all the common medical emergencies that can take place in dental setting such as syncope, epileptic episode, hypoglycaemia, and asthma attack (Vaughan M. *et al*., 2018)

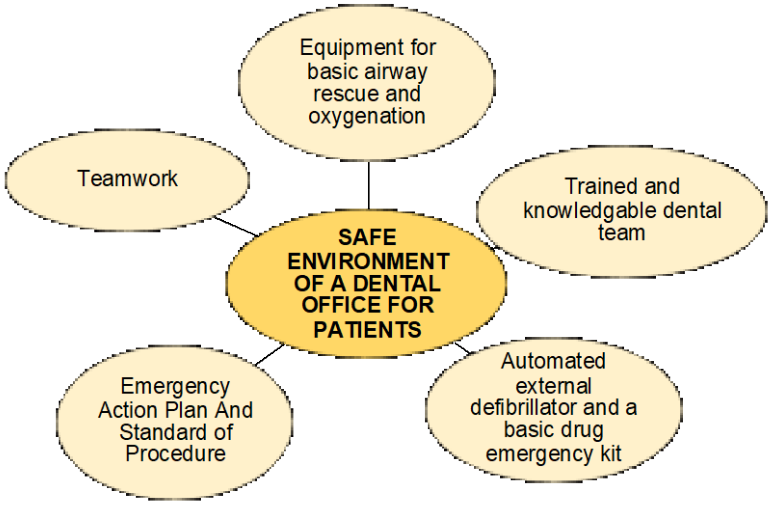

Figure 1. Factors contributing to safe environment of a dental clinic.

5) Equipment and Drugs and its maintenance

A dental clinic should have appropriate medical emergencies equipment and drugs available. A minimum list of equipment and drugs (Table 4) have been recommended by several authors and guideline (Jevon, 2012; Lawson, 2017; Greenwood and Meechan, 2014). The targeted list of drugs and equipment are based on the likely occurrence of medical emergency that can happen in the dental setting. Furthermore, consideration of capability of a dental practitioner administering those drugs is also important. The use of intravenous drugs for medical emergencies in general dental practice is to be discouraged. Intramuscular, inhalational, sublingual, buccal and intranasal routes are all much quicker method to administer drugs during emergency by taking into consideration the capability of a dental practitioners to obtain intravenous line.

All drugs should be stored together in a custom-designed 'Emergency Drug' storage container. Having the necessary emergency drugs and equipment readily accessible (and portable) in the dental clinic help to minimize response time. The equipment

should be available for use within the first minutes of cardiorespiratory arrest. It is crucial to highlight that the team members should be proficient and had been fully trained to administer the drugs contained in the emergency kit. The drugs should be properly labelled and periodically checked to ensure they have not expired. Resuscitation standards expected for clinics that offer "conscious sedation" are different from a primary dental practice setting (Resuscitation Council UK, 2013).

Table 5. List of recommended emergency drugs and equipment in primary dental care practice (Resuscitation Council UK, 2013).

Emergency Drugs	Emergency Equipment
• Adrenaline injection (1:1,000, 1 mg/ml) • Aspirin dispersible 300 mg • Glucagon injection 1 mg • Glyceryl trinitrate (GTN) spray (400 µg/dose) • Oral glucose solution/tablets/gel/powder • Midazolam 10 mg (buccal) • Salbutamol aerosol inhaler (100 µg/actuation)	• Protective equipment - gloves, aprons, eye protection • Pocket mask with oxygen port • Portable suction *e.g.* Yankauer • Oropharyngeal airways sizes 0,1,2,3,4 • Self-inflating bag with reservoir (adult and child) • Clear face masks for self-inflating bag (sizes 0,1,2,3,4) • Oxygen cylinder • Oxygen masks with reservoir • Oxygen tubing • Automated external defibrillator (AED) • Adhesive defibrillator pads • Razor • Scissors

Conclusion

Prevention of medical emergency in dental clinic must be one of the major aims in practicing safe dentistry. Even though it is not common, but all dental practitioners should be able to handle medical emergencies as they are mostly manageable and non-life threatening. Patents' risk assessment must be made thoroughly, and their medical status should be updated at each visit. In preparing for an emergency situation, the dental clinic must have a functional medical action plan, trained staff, good teamwork, adequate medical emergency equipment and drugs.

References

Alghareeb, Z., Alhaji, K., Alhaddad, B., & Gaffar, B. (2022). Assessment of Dental Anxiety and Hemodynamic Changes during Different Dental Procedures: A Report from Eastern Saudi Arabia. *European Journal of Dentistry*, 01:1-239

Alhamad, M., Alnahwi, T., Alshayeb, H., Alzayer, A., Aldawood, O., Almarzouq, A., & Nazir, M. A. (2015). Medical emergencies encountered in dental clinics: A study from the Eastern Province of Saudi Arabia. *Journal of Family & Community Medicine*, *22*(3), 175.

American Society of Anesthesiologists (2020). ASA physical status classification system. Retrieved 10 March 2022, from https://www.asahq.org/standards-and-guidelines/asa-physical-status-classification-system

Anders, P. L., Comeau, R. L., Hatton, M., & Neiders, M. E. (2010). The nature and frequency of medical emergencies among patients in a dental school

setting. *Journal of Dental Education*, *74*(4), 392-396.

Becker, D. E., Rosenberg, M. B., & Phero, J. C. (2014). Essentials of airway management, oxygenation, and ventilation: part 1: basic equipment and devices. *Anesthesia Progress*, *61*(2), 78-83.

Clough, S., Shehabi, Z., & Morgan, C. (2016). Medical risk assessment in dentistry: use of the American Society of Anesthesiologists Physical Status Classification. *British Dental Journal*, *220*(3), 103-108.

Corcuera-Flores, J. R., Delgado-Muñoz, J. M., Ruiz-Villandiego, J. C., Maura-Solivellas, I., & Machuca-Portillo, G. (2014). Dental treatment for handicapped patients; sedation vs general anesthesia and update of dental treatment in patients with different diseases. *Medicina Oral, Patologia Oral y Cirugia Bucal*, *19*(2), e170.

Greenwood M, Meechan JG. (2014) General medicine and surgery for dental practitioners: part 3, Management of specific medical emergencies in dental practice, *British Dental Journal,* 217(1):21-6.

Guidelines For Resuscitation Training In Ministry of Health, National Committee on Resuscitation (NCORT), Ministry of Health Malaysia (2012). Retrieved 9 February 2022, from https://www.moh.gov.my/moh/images/gallery/Garispanduan/NCORT_Book.pdf

Haas, D. A. (2010). Preparing dental office staff members for emergencies: developing a basic action plan. *The Journal of the American Dental Association*, *141*, S8-S13.

Hadfield, A., Thompson, S., Hall, J., & Diaz-Navarro, C. (2018). Perception of simulation training in emergencies for dental sedation practitioners. *The Clinical Teacher*, *15*(1), 52-56.

Jevon, P. (2012). Updated guidance on medical emergencies and resuscitation in the dental practice. *British Dental Journal*, *212*(1), 41-43.

Jevon, P. (2020). Medical emergencies in the dental practice poster: revised and updated. British Dental Journal, 229(2), pp.97-104.

Kim, S. Y., Shin, D., Kim, H. J., & Karm, M. H. (2020). Changes of knowledge and practical skills before and after retraining for basic life support: Focused on students of Dental School. *International journal of Medical Sciences*, *17*(18), 3082.

Kumarswami, S., Tiwari, A., Parmar, M., Shukla, M., Bhatt, A., & Patel, M. (2015). Evaluation of preparedness for medical emergencies at dental offices: A survey. *Journal of International Society of Preventive & Community Dentistry*, *5*(1), 47.

Lawson L. Medical emergency preparedness in dental practice. RDH. 2017;37(6):47-59.

Malamed, S. F. (2010). Knowing your patients. *The Journal of the American Dental Association*, *141*, S3-S7.

Ngeow, W. C., Lim, D., Ng, C. S., & Chai, W. L. (2015). The management of unexpected events in a general dental practice. *Malaysian Dental Journal*, *38*(2).

Obata, K., Naito, H., Yakushiji, H., Obara, T., Ono, K., Nojima, T*., et al*. (2021). Incidence and characteristics of medical emergencies related to dental treatment: a retrospective single-center study. *Acute Medicine & Surgery*, *8*(1), e651.

Omar, Y. (2013). Avoiding medical emergencies. *British Dental Journal*, *214*(5), 255.

Ramli, N. M., Tarmidzi, N. A. A., Samsuddin, A. D., Idaham, N. I., & Ibrahim, A. Z. (2019). A Pilot Study of Preparedness for Medical Emergencies in Urban Private Dental Practices in Malaysia. *Archives Of Orofacial Science*.

Resuscitation Council UK (2013). Medical Emergencies and Resuscitation: Quality Standards: Primary dental care equipment list. Retrieved 7 February 2020, from https://www.resus.org.uk/library/quality-standards-cpr/primary-dental-care-equipment-list

Royal College of Physicians (2017). NEWS. London: Royal College of Physicians. Retrieved 10 February 2022, from http://www.rcplondon.ac.uk/resources/national-early-warning-score-news

Smereka, J., Aluchna, M., Aluchna, A., & Szarpak, Ł. (2019). Preparedness and attitudes towards medical emergencies in the dental office among Polish dentists. *International Dental Journal*, *69*(4), 321-328.

Southerland, J. H., Gill, D. G., Gangula, P. R., Halpern, L. R., Cardona, C. Y., & Mouton, C. P. (2016). Dental management in patients with hypertension: challenges and solutions. *Clinical, Cosmetic and Investigational Dentistry*, *8*, 111.

Thusu, S., Panesar, S., & Bedi, R. (2012). Patient safety in dentistry–state of play as revealed by a national database of errors. *British Dental Journal*, *213*(3), E3-E3.

Uyamadu, J., & Odai, C. D. (2012). A review of medical emergencies in dental practice. *Orient Journal of Medicine*, *24*(3-4), 1-9.

Vaughan, M., Park, A., Sholapurkar, A., & Esterman, A. (2018). Medical emergencies in dental practice–management requirements and international practitioner proficiency. A scoping review. *Australian Dental Journal*, *63*(4), 455-466.

Yamalik, N., & Pérez, B. P. (2012). Patient safety and dentistry: what do we need to know? Fundamentals of patient safety, the safety culture and implementation of patient safety measures in dental practice. *International Dental Journal*, 62(4), 189-196.

REVIEW ARTICLE Open Access

Orthodontic pain – the state of the evidence

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Abstract

Pain is a common side effect of orthodontic treatment. An understanding of its mechanism, implications and subsequent management is essential for any orthodontist to improve patient compliance and satisfaction with treatment. This paper provides a comprehensive review and state of the evidence on orthodontic pain from the viewpoint of clinicians and patients – clinical features, its pathways, factors influencing pain perception, and finally the pharmacological and non-pharmacological management of orthodontic pain.

Keywords: *orthodontics, pain, pain perception, pain management*

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Introduction

Pain is an unpleasant sensory and emotional subjective experience associated with actual or potential tissue damage (Treede, 2018) and is a common phenomenon reported by patients undergoing any form of dental treatment, including orthodontic treatment. 90% of orthodontic patients complained of pain and discomfort especially after placement and activation of fixed, functional or removable appliances (Sawada *et al.*, 2015; Antonio-Zancajo *et al.*, 2020). This subjective feeling is often expressed as sensation of pressure, tension and soreness by patients. Previous research has indicated that the type of pain is usually mild to moderate in nature, starts two hours after orthodontic appliance placement, peaks at 24 hours after appliance activation and lasts for about five to seven days, with the pain occurring on exertion such as during mastication (Johal *et al.*, 2018; Costa *et al.*, 2020).

Pain can have a negative impact on oral health-related quality of life (Antonio-Zancajo *et al.*, 2020). High pain level affects compliance (Jawaid *et al.*, 2020) which may affect the patient's relationship with the practice and lead to early termination of orthodontic treatment (Brown & Moerenhout, 1991). Furthermore,

orthodontic pain can result in anxiety among patients, and this would in turn exacerbate the pain among them. A survey data collected from orthodontic providers revealed that most orthodontists were not aware that their patients had taken pain medication to ameliorate pain caused during treatment, and unsurprisingly underestimated their patients' pain level (Seers *et al.*, 2018). It is therefore crucial for clinicians to understand mechanism of orthodontic pain, factors influencing pain perception and finally appropriate pain management for their patients.

Pain Pathways

Nociceptors in the peripheral tissues respond to noxious stimuli (mechanical, heat, chemical) and produce nerve impulses. The messages initiated are transmitted by primary afferent nociceptor of trigeminal nerve origin (Aδ and C nerve fibres), which are then conducted to second-order pain transmission neurons in the spinal cord through dorsal root ganglion (Yam *et al.*, 2018). Aδ fibres are myelinated primary afferent fibres which respond to mechanical and thermal stimuli and are associated with acute pain. C fibres, on the other hand, are unmyelinated and are associated with slower, persistent pain.

Second-order neurons ascend in the anterolateral tract and relay the message to third-order neurons in the thalamic nuclei, either directly via the spinothalamic tract or indirectly via the reticular formation and the reticulothalamic pathway. From the thalamus, the message is relayed to the cerebral cortex (Figure 1).

Apart from the direct stimulation of nociceptive nerve fibres described above, pain sensation can also be initiated indirectly via the release of inflammatory mediators such as histamine, serotonin, bradykinin, prostaglandins (PG) and leukotrienes (Baral *et al.*, 2019). These pain-producing chemicals may be released by damaged tissue cells, or are synthesized by enzymes activated by tissue damage, and are found in areas of pain and inflammation.

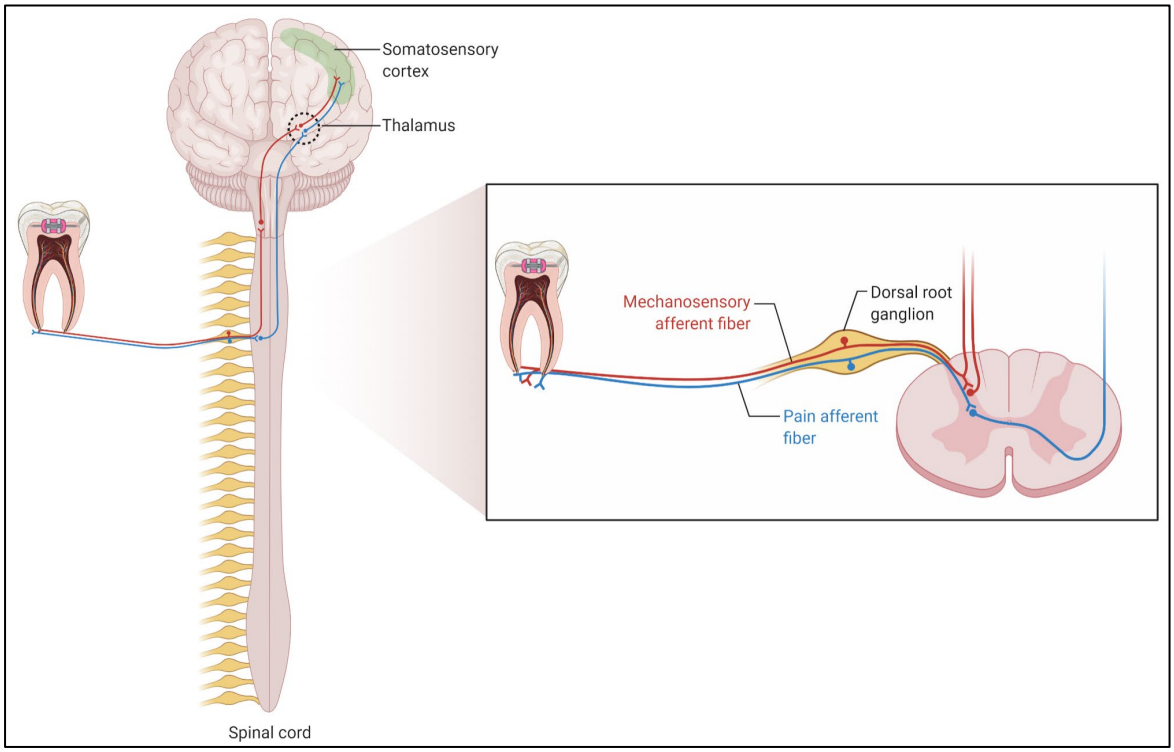

Figure 1. Somatosensory afferents convey information from periphery to central cortex.

Factors influencing pain perception

There is a wide variability of individual pain responses when similar orthodontic forces are applied to the teeth (Bucci *et al.*, 2021). Since pain is a subjective event, its perception can be influenced by psychological, physiological, cultural and social factors (Lamarca *et al.*, 2018). According to gate control theory, nociceptive impulses that arise from the brain stem can be altered at the dorsal horn of spinal cord resulting in less or no pain sensation (Melzack & Wall, 1965). Nociceptive impulses entering a calm and normal functioning brainstem may never reach the higher centres to elicit a pain response. On the contrary, if the same impulse enters the brainstem of patient suffering from chronic pain, a significant pain response may be produced (Therkildsen & Sonnesen, 2022).

The emotional state and psychological factors influence the patient's adaptation to pain and discomfort. When the nociceptive impulses enter the thalamus, they are directed to the cortex and limbic structures where pain is evaluated at an emotional state. The limbic system consists of few structures such as amygdala (which is involved in emotions) and hippocampus (which is responsible for pain memory). The perception of pain by the amygdala can precipitate certain emotions such as fear and anxiety (Topolski *et al.*, 2018). These pain signals are then sent to the cortex in which pain is perceived and emotion associated with the pain is generated, for example anxiety. This information is further transmitted back to the amygdala and to the descending system that influences the final pain sensations (Ossipov *et al.*, 2010).

Stress can significantly perpetuate the degree of pain; the increase in sympathetic nervous activity occurs in spite of the absence of physical threat. Stress reduces the pain threshold levels, in which the perception of normally painless impulse would be perceived as painful (Ireland *et al.*, 2017). Psychological stress can exacerbate inflammatory process and have a negative impact on the regulatory process of neuroendocrine pathway leading to neuroinflammation (Rivat *et al.*, 2010).

Previous pain experiences may influence clinical orthodontic pain (Costa *et al.*, 2020). Repetition of similar circumstances could generate clinical pain associated with former traumatic experiences, despite the fact that no noxious stimulation occurs. In this respect, memory of previous orthodontic pain experience may alter pain perception, and this could be attributed to the role of hippocampus (Ding *et al.*, 2016). When pain impulse reaches the cortex, the cortex searches pain memory and this information is then sent to the limbic system for processing after which it is returned to the cortex again. The present pain information and past memory pain information are then integrated, ultimately modifying the current pain perception.

There is a body of literature on the cultural influences on pain perceptions and behaviours (Bates *et al.*, 1993; Wang *et al.*, 2018; Craig & Mackenzie, 2021). In 1952, the pioneer work by Zborowski (1952) showed that different culture has its own language of distress when experiencing pain. Pain coping styles are different across different ethnicities, with one meta-analysis reported African Americans or black individuals experience higher pain intensity across clinical and experimental modalities compared with white individuals (Meints *et al.*, 2016). It has also been suggested patients from the Far East have higher pain tolerance than those from the West (Khalaf & Callister, 1997). Therefore, orthodontic practitioners should be sensitive towards patients' cultural beliefs, values, pain coping strategies and life experiences when managing pain arising during treatment.

Findings of the effect of age on pain perception has been inconsistent. A systematic review and meta-analysis conducted in 2017 reported that older patients had higher pain threshold and therefore experienced less pain than younger patients (Lautenbacher *et al.*, 2017). Interestingly, another systematic review and meta-analysis conducted in the same year concluded there was no difference

between the different age groups and pain perception (Monk *et al.*, 2017). The inconsistent evidence could be due to the difficulty in measuring age-related differences of pain since there are different treatment protocols for young and older patients. In the same vein, evidence surrounding the effect of gender on pain perception is also equivocal, with one meta-analysis revealed females displayed greater pain sensitivity than males (Mcdougall *et al.*, 2021), whilst Raak *et al.* (2022) argued that there was no gender differences following initial archwire placement.

Orthodontic procedures inducing pain

(A) Separator placement

Pain has been significantly associated with separator placement. A study in Switzerland assessed children's pain level following separator placement and found that tooth displacement with separators induced pain which resulted in the rapid release of biochemical mediators in gingival crevicular fluid. The pain experience peaked at day one and subsequently reduced one week after. The initial pain intensity was attributed by the presence of PGE_2 levels, whilst pain intensity one day later was due to the increase in interleukin (IL)-1β levels (Giannopoulou *et al.*, 2006). In terms of the types of orthodontic separators, there was some evidence that elastomeric separator was considered to be more painful than spring separator although the difference was not significant (Tripathi *et al.*, 2019).

(B) Bond up and initial archwire placement

Orthodontic pain peaks at 24 hours following first archwire placement and reduces gradually subsequently (Raak *et al.*, 2022). A Cochrane review by Wang *et al.* (2018) found there was no evidence that the use of any archwire material / type for initial alignment has any effects on perceived pain. Similarly, neither types of brackets bonded (conventional / self-ligating brackets) nor bracket slot size (0.022" / 0.028" slot) has any significant effects on pain perception (El-Angbawi *et al.*, 2019). However, placement of brackets at the lingual surface is associated with soft tissue discomfort especially with regards to tongue ulceration, as compared to brackets bonded labially (Papageorgiou *et al.*, 2016).

(C) Fixed versus removable appliance treatment

Previous studies have shown that fixed appliances produced greater intensity of pain compared to removable appliances (Diddige *et al.*, 2020), possibly due to the application of constant force used in fixed orthodontic appliance compared with intermittent force used with removable appliance. A recent randomized controlled trial (RCT) by Wiedel & Bondemark (2016) reported pain of low to moderate levels in both groups, albeit the difficulty with eating being more pronounced in the fixed group.

(D) Orthopaedic appliances

Rabah *et al.* (2022) have recently compared the pain and discomfort levels in patients treated with either slow or rapid maxillary expansion (RME) and concluded that RME resulted in higher levels of pain and more chewing difficulties, presumably due to the mechanical forces of increased magnitude being transmitted and absorbed by the craniofacial complex. Despite this, these difficulties slowly decreased over time as treatment progressed. Another extraoral orthopaedic appliance, headgear, which is commonly used for extraoral anchorage and traction purposes produces discomfort after 24 hours, after which the pain declines after three days (Cureton, 1994).

(E) Debonding

The action of applying rotational or torqueing forces to remove orthodontic brackets / bands and their residual adhesive from the enamel has been shown to induce pain as forces are transmitted to the teeth (Kilinc & Sayar, 2019). Pain varies according to the teeth being debonded, with upper and lower anterior segments experiencing greater pain than posterior segments. In

terms of bracket types, ceramic brackets removal caused significantly greater pain than either plastic or metal brackets (Nakada *et al.*, 2021). It has been suggested applying finger pressure onto the teeth (Bavbek *et al.*, 2016), or asking patient to bite onto a cotton roll could minimise the pain associated with bracket debonding (Gupta *et al.*, 2022), presumably due to the stabilising intrusive force.

Management of orthodontic pain

The control of pain during orthodontic treatment is of great interest to clinicians. Although it is not possible to remove pain completely despite the developments in understanding pain mechanism, it should be every orthodontist's objective to minimize pain as much as possible.

A) Pharmacological

Non-steroidal anti-inflammatory drugs (NSAIDs) inhibit cyclooxygenase (COX) enzyme, which is the enzyme that converts arachidonic acid into prostaglandin (PG), subsequently inhibit the synthesis of PG, specifically PGE_2, the primary mediators of inflammatory response. Some commonly used NSAIDs include ibuprofen, aspirin, naproxen sodium, piroxicam and the recently introduced COX-2 inhibitor, rofecoxib (Sari *et al.*, 2004). These drugs are categorised as being non-opioid and peripherally acting analgesics. Different NSAIDs demonstrate different effects. Ngan *et al.* (1994) conducted a double-blind, RCT to compare the analgesic efficacy of ibuprofen, aspirin and placebo. The pain intensity in the three groups were recorded using visual analogue scale, and ibuprofen was found to relieve pain and discomfort associated with post-orthodontic adjustment better than aspirin and placebo. In the same vein, Monk *et al.* (2017) pointed out that analgesic use is more successful in reducing orthodontic pain than no treatment or placebo in a recent Cochrane systematic review.

Previous studies have reported the use of pre-emptive analgesic to control orthodontic pain (Alqahtani *et al.*, 2017; Eslamian *et al.*, 2017; Eslamian *et al.*, 2019). Polat *et al.* (2005) showed that analgesics administration one hour before archwire placement significantly reduced pain severity thereafter, and suggested additional postoperative dose for sufficient pain relief. It could be that afferent nerve impulses are blocked before they can reach the central nervous system. If NSAIDs are given preoperatively, the body absorbs the analgesics before tissue damage can occur, subsequently reducing the inflammatory damage.

There has been some evidence to suggest NSAIDs delay the rate of orthodontic tooth movement (Walker & Buring, 2001), thus prolonging overall duration of orthodontic treatment. The rationale behind this was that NSAIDs affect the synthesis and action of inflammatory mediators including PG and interleukins, which are the primary mediators of inflammatory response following mechanical force application to the teeth. Subsequently, the drugs may reduce the inflammatory and bone resorptive processes and thus orthodontic tooth movement, since tooth movement is closely associated with bone remodelling which involves a complex series of events that act synergistically and antagonistically (Iwasaki *et al.*, 2009). In a molecular study which was set out to determine the effects of NSAIDs on the COX-PG pathway, Kyrkanides *et al.* (2000) reported that there was an increase in the levels of collagenase activity along with matrix metalloproteinases (MMPs)-2 and -9, with concomitant decrease in procollagen synthesis as a result of NSAIDs administration, causing altered remodelling of bone and periodontal ligament and ultimately possible reduction in the speed of tooth movement.

Overall, there seems to be some evidence to indicate that NSAIDs administration could potentially affect the efficacy of orthodontic tooth movement. However, Grewal *et al.* (2020) pointed out that the use of NSAIDs during orthodontic treatment for pain control is transient, and any effect on tooth movement is probably clinically insignificant.

B) Non-pharmacological

Some non-pharmacological approaches that have been tested to alleviate pain arising from orthodontic procedures include low level laser therapy (LLLT), chewing gum/bite wafers, cognitive behavioural treatment, vibratory stimulation and Transcutaneous Electrical Nerve Stimulation (TENS).

(i) LLLT

LLLT have been used in medical and dental fields due to its non-invasiveness (Topolski *et al.*, 2018). It is believed that LLLT reduces pain by hyperpolarization of nerve cell membrane which results in the increase of pain threshold, inhibiting C-fibre activity and secretion of inflammatory substance such as bradykinin, and stimulation of endorphin release (Bakshi *et al.*, 2022). However, the efficacy result of LLLT in orthodontic pain management has been contradictory, with some studies found the procedure to be effective (Nobrega *et al.*, 2013; Almallah *et al.*, 2016; Deana *et al.*, 2017; Martins *et al.*, 2019), whilst others refuted its effectiveness (Furquim *et al.*, 2015; Farsaii & Al-Jewair, 2017). A recent systematic review demonstrated that the effective laser wavelength for orthodontic pain relief was in the range of 780 – 830 nm (Dominguez Camacho *et al.*, 2020) when applied immediately after orthodontic adjustment. However, as discussed earlier, it is the pre-emptive analgesic use, rather than post-treatment, which has been shown to be most effective for pain control.

(ii) Chewing gum

The use of chewing gum to reduce orthodontic pain was first proposed by Proffit (2000), in which the cycles of chewing, along with periodontal ligament compression and decompression helps loosen the tightly packed periodontal fibres, thus reducing the ischaemia, oedema and inflammation and therefore restoring the vascular and lymphatic circulation (Santos & Jr, 2021). In clinical orthodontic practice, clinicians tend to advise patients against gum chewing in fear of appliance breakages. A recent RCT by Al Shayea (2020) found that there was no significant difference between chewing gum group and control group on the frequency of orthodontic appliance breakages. Ireland *et al.* (2016) in their multi-centre RCT study suggested chewing soft, sugar-free gum to reduce the amount of ibuprofen uptake by patients following initial bond up and first archwire change. Together these studies seem to provide promising result on the use of chewing gum in relieving orthodontic pain.

(iii) Cognitive behavioural treatment (CBT)

CBT interventions cited in the literature included relaxation training, guided imagery, activity pacing, problem solving and learning to deal with pain-related anxiety (Peters *et al.*, 2019). These techniques aim to improve pain-coping efficacy and reduce pain-related disability. The first RCT study of CBT on orthodontic pain management was undertaken by Wang *et al.* (2012), and showed CBT was as effective as ibuprofen in controlling pain suggesting its potential clinical usage.

(iv) TENS

Using a small battery-powered device with cutaneous electrodes placed adjacent to the painful area, this mode of non-pharmacological intervention delivers short, low amplitude electrical impulse to reduce pain. Following electrical stimulation, the impulse from β-fibres (large nerve fibres responsible for touch and pressure sensation) reaches the central nervous system before the impulse from the slower A and C nerve fibres (small nerve fibres responsible for pain sensation). In other words, the β impulse blocks the pain impulses. In addition, the electrical impulse stimulates the production of β endorphin and substance 'P' in the nerve cells, and serotonin in the brain, raising the patient's pain tolerance (Vance *et al.*, 2014). TENS has been demonstrated to effectively control acute and chronic pain in dentistry that affects the maxillofacial area (Devi *et al.*, 2021).

(v) Vibratory stimulation

This non-invasive pain reduction method employs the use of a patient-controlled apparatus that has a battery-powered vibrating motor attached to a soft acrylic mouthpiece, with vibration being transmitted to all the teeth. There is a consensus among earlier clinicians that the appliance need to be used before the onset of pain (Cochrane, 2019). This confirms the theory that blood supply to the teeth and surrounding tissues is re-established following vibration action and this effect intercepts the ischaemic phenomenon that induces pain (Bakdach & Hadad, 2020). However, once orthodontic pain manifests, the vibratory effect is not effective in ameliorating the pain, and most patients reported not being able to tolerate the vibratory stimulation once discomfort was present (Thammanichanon *et al.*, 2020).

Collectively, these studies provide important insights into the management of orthodontic pain in order to maximize patient's experience during treatment. Overall, there is very little high quality evidence for the use of non-pharmacological interventions for orthodontic pain control. Future studies should consider long term follow-up and patient-reported outcomes to evaluate the effectiveness of these non-pharmacological approaches.

Conclusion

In summary, although pain is unavoidable in every stage of orthodontic treatment and is impossible to eliminate it completely, it is important that orthodontists understand pain in order to improve pain management, patient compliance and ultimately treatment acceptance and overall patient satisfaction. Patient needs to be informed about each phase of treatment along with the pain associated with it. The evidence thus far suggests that pre-emptive analgesic with the least possible side effects can be prescribed, or soft, sugar-free chewing gum can be considered to reduce analgesic intake. Most importantly, patient's anxiety level should be reduced as much as possible to avoid pain exacerbation associated with orthodontic treatment, since trusting relationships between orthodontist and patient can reduce anxiety and pain.

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References

Al Shayea, E. I. (2020). Comparative assessment between ibuprofen, chewing gum, and bite wafers in pain control following first archwire placement in orthodontic patients. *Journal of Contemporary Dental Practice*, 21(4), 416-420.

Almallah, M. M., Almahdi, W. H., Hajeer, M. Y. (2016). Evaluation of low level laser therapy on pain perception following orthodontic elastomeric separation: A randomized controlled trial. *Journal of Clinical and Diagnostic Research*, 10(11), ZC23-ZC28.

Alqahtani, N., Alwakeel, A., Alzamil, A., Alturki, S., Aldawsari, G., Aljabaa, A. *et al.* (2017). Comparison of two analgesics used for pain relief after placement of orthodontic separators. *Saudi Pharmaceutical Journal*, 25(8), 1169-1174.

Antonio-Zancajo, L., Montero, J., Albaladejo, A., Oteo-Calatayud, M. D., Alvarado-Lorenzo, A. (2020). Pain and oral-health-related quality of life in orthodontic patients during initial therapy with conventional, low-friction, and lingual brackets and aligners (invisalign): A prospective clinical study. *Journal of Clinical Medicine*, 9(7), 2088.

Bakdach, W. M. M., Hadad, R. (2020). Effectiveness of supplemental vibrational force in reducing pain associated with orthodontic treatment: A systematic review. *Quintessence International*, 51(9), 742-752.

Bakshi, P. V., Setty, S. B., Kulkarni, M. R. (2022). Photobiomodulation of human gingival fibroblasts with diode laser - a systematic review. *Journal of Indian Society of Periodontology*, 26(1), 5-12.

Baral, P., Udit, S., Chiu, I. M. (2019). Pain and immunity: Implications for host defence. *Nature Reviews: Immunology*, 19(7), 433-447.

Bates, M. S., Edwards, T. W., Anderson, K. O. (1993). Ethnocultural influences on variation in chronic pain perception. *Pain*, 52(1), 101-112.

Bavbek, N. C., Tuncer, B. B., Tortop, T., Celik, B. (2016). Efficacy of different methods to reduce pain during debonding of orthodontic brackets. *Angle Orthodontist*, 86(6), 917-924.

Brown, D. F., Moerenhout, R. G. (1991). The pain experience and psychological adjustment to orthodontic treatment of preadolescents, adolescents, and adults. *American Journal of Orthodontics and Dentofacial Orthopedics*, 100(4), 349-356.

Bucci, R., Koutris, M., Simeon, V., Lobbezoo, F., Michelotti, A. (2021). Effects of acute pain and strain of the periodontium due to orthodontic separation on the occlusal tactile acuity of healthy individuals. *Clinical Oral Investigations*, 25(12), 6833-6840.

Cochrane, D. J. (2019). The inclusion of vibration therapy in rehabilitating a gastrocnemius tear: A case study in master athlete. *The Journal of Physical Therapy Science*, 31(9), 738-742.

Costa, E. O. D., Blagitz, M. N., Normando, D. (2020). Impact of catastrophizing on pain during orthodontic treatment. *Dental Press Journal of Orthodontics*, 25(1), 64-69.

Craig, K. D., Mackenzie, N. E. (2021). What is pain: Are cognitive and social features core components? *Paediatric and Neonatal Pain*, 3(3), 106-118.

Cureton, S. L. (1994). Headgear and pain. *Journal of Clinical Orthodontics*, 28(9), 525-530.

Deana, N. F., Zaror, C., Sandoval, P., Alves, N. (2017). Effectiveness of low-level laser therapy in reducing orthodontic pain: A systematic review and meta-analysis. *Pain Research and Management*, 2017, 8560652.

Devi, M. S., Ranjan, R., Devi, T. D., Sorokhaibam, B. J. I. J. O. F. M., Toxicology (2021). Application of transcutaneous electrical nerve stimulation in dentistry. 15(3).

Diddige, R., Negi, G., Kiran, K. V. S., Chitra, P. (2020). Comparison of pain levels in patients treated with 3 different orthodontic appliances - a randomized trial. *Medicine and Pharmacy Reports*, 93(1), 81-88.

Ding, T. T., Xu, X. X., Cao, Y., Liu, C. R., Gan, Y. H., Xie, Q. F. (2016). Inflammatory pain memory facilitates occlusal interference-induced masticatory muscle hyperalgesia in rats. *European Journal of Pain (London, England)*, 20(3), 353-364.

Dominguez Camacho, A., Bravo Reyes, M., Velasquez Cujar, S. A. (2020). A systematic review of the effective laser wavelength range in delivering photobiomodulation for pain relief in active orthodontic treatment. *International Orthodontics*, 18(4), 684-695.

El-Angbawi, A. M., Yassir, Y. A., Mcintyre, G. T., Revie, G. F., Bearn, D. R. (2019). A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: Part 3-biological side-effects of treatment. *European Journal of Orthodontics*, 41(2), 154-164.

Eslamian, L., Kianipour, A., Mortazavi, S. a. R. (2017). The analgesic efficacy of 5% naproxen gel for pain associated with orthodontic separator placement: A randomized double-blind controlled trial. *Anesthesia and Pain Medicine* 7(2), e42708.

Eslamian, L., Torshabi, M., Motamedian, S. R., Hemmati, Y. B., Mortazavi, S. A. (2019). The effect of naproxen patches on relieving orthodontic pain by evaluation of vas and il-1β inflammatory factor: A split-mouth study. *Dental Press Journal of Orthodontics*, 24(6), 27e21-27e27.

Farsaii, A., Al-Jewair, T. (2017). Insufficient evidence supports the use of low-level laser therapy to accelerate tooth movement, prevent orthodontic relapse, and modulate acute pain during orthodontic treatment. *Journal of Evidence-Based Dental Practice*, 17(3), 262-264.

Furquim, R. D., Pascotto, R. C., Rino Neto, J., Cardoso, J. R., Ramos, A. L. (2015). Low-level laser therapy effects on pain perception related to the use of orthodontic elastomeric separators. *Dental Press Journal of Orthodontics*, 20(3), 37-42.

Giannopoulou, C., Dudic, A., Kiliaridis, S. (2006). Pain discomfort and crevicular fluid changes induced by orthodontic elastic separators in children. *Journal of Pain*, 7(5), 367-376.

Grewal, S., Harris L. M. J., Ponduri, S., Naish, H., Ellis, P., Sandy, J. R. *et al*. (2020). Orthodontic pain. *Orthodontic Update*, 13, 50-56.

Gupta, S. P., Rauniyar, S., Prasad, P., Pradhan, P. M. S. (2022). A randomized controlled trial to evaluate the effectiveness of different methods on pain management during orthodontic debonding. *Progress in Orthodontics*, 23(1), 7.

Ireland, A. J., Ellis, P., Jordan, A., Bradley, R., Ewings, P., Atack, N. E. *et al.* (2016). Comparative assessment of chewing gum and ibuprofen in the management of orthodontic pain with fixed appliances: A pragmatic multicenter randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics*, 150(2), 220-227.

Ireland, A. J., Ellis, P., Jordan, A., Bradley, R., Ewings, P., Atack, N. E. *et al.* (2017). Chewing gum vs. Ibuprofen in the management of orthodontic pain, a multi-centre randomised controlled trial - the effect of anxiety. *Journal of Orthodontics*, 44(1), 3-7.

Iwasaki, L. R., Chandler, J. R., Marx, D. B., Pandey, J. P., Nickel, J. C. (2009). Il-1 gene polymorphisms, secretion in gingival crevicular fluid, and speed of human orthodontic tooth movement. *Orthodontics & Craniofacial Research*, 12(2), 129-140.

Jawaid, M., Qadeer, T. A., Fahim, M. F. (2020). Pain perception of orthodontic treatment - a cross-sectional study. *Pakistan Journal of Medical Sciences*, 36(2), 160-165.

Johal, A., Ashari, A. B., Alamiri, N., Fleming, P. S., Qureshi, U., Cox, S. *et al.* (2018). Pain experience in adults undergoing treatment: A longitudinal evaluation. *Angle Orthodontist*, 88(3), 292-298.

Khalaf, I., Callister, L. C. (1997). Cultural meanings of childbirth: Muslim women living in Jordan. *Journal of Holistic Nursing*, 15(4), 373-388.

Kilinc, D. D., Sayar, G. (2019). Evaluation of pain perception during orthodontic debonding of metallic brackets with four different techniques. *Journal of Applied Oral Science*, 27, e20180003.

Kyrkanides, S., O'banion, M. K., Subtelny, J. D. (2000). Nonsteroidal anti-inflammatory drugs in orthodontic tooth movement: Metalloproteinase activity and collagen synthesis by endothelial cells. *American Journal of Orthodontics and Dentofacial Orthopedics*, 118(2), 203-209.

Lamarca, G. A., Vettore, M. V., Monteiro Da Silva, A. M. (2018). The influence of stress and anxiety on the expectation, perception and memory of dental pain in schoolchildren. *Dentistry Journal (Basel)*, 6(4).

Lautenbacher, S., Peters, J. H., Heesen, M., Scheel, J., Kunz, M. (2017). Age changes in pain perception: A systematic-review and meta-analysis of age effects on pain and tolerance thresholds. *Neuroscience and Biobehavioral Reviews*, 75, 104-113.

Martins, I. P., Martins, R. P., Caldas, S., Dos Santos-Pinto, A., Buschang, P. H., Pretel, H. (2019). Low-level laser therapy (830 nm) on orthodontic pain: Blinded randomized clinical trial. *Lasers in Medical Science*, 34(2), 281-286.

Mcdougall, J. F., Bailey, N. G. N., Banga, R., Linde, L. D., Kramer, J. L. K. (2021). The influence of examiner gender on responses to tonic heat pain assessments: A preliminary investigation. *Frontiers in Pain Research (Lausanne)*, 2, 729860.

Meints, S. M., Miller, M. M., Hirsh, A. T. (2016). Differences in pain coping between black and white americans: A meta-analysis. *Journal of Pain*, 17(6), 642-653.

Melzack, R., Wall, P. D. (1965). Pain mechanisms: A new theory. *Science*, 150(3699), 971-979.

Monk, A. B., Harrison, J. E., Worthington, H. V., Teague, A. (2017). Pharmacological interventions for pain relief during orthodontic treatment. *Cochrane Database of Systematic Reviews*, 11, CD003976.

Nakada, N., Uchida, Y., Inaba, M., Kaetsu, R., Shimizu, N., Namura, Y. *et al.* (2021). Pain and removal force associated with bracket debonding: A clinical study. *Journal of Applied Oral Science*, 29, e20200879.

Ngan, P., Wilson, S., Shanfeld, J., Amini, H. (1994). The effect of ibuprofen on the level of discomfort in patients undergoing orthodontic treatment. *American Journal of Orthodontics and Dentofacial Orthopedics*, 106(1), 88-95.

Nobrega, C., Da Silva, E. M., De Macedo, C. R. (2013). Low-level laser therapy for treatment of pain associated with orthodontic elastomeric separator placement: A placebo-controlled randomized double-blind clinical trial. *Photomedicine and Laser Surgery*, 31(1), 10-16.

Ossipov, M. H., Dussor, G. O., Porreca, F. (2010). Central modulation of pain. *Journal of Clinical Investigation*, 120(11), 3779-3787.

Papageorgiou, S. N., Golz, L., Jager, A., Eliades, T., Bourauel, C. (2016). Lingual vs. Labial fixed orthodontic appliances: Systematic review and meta-analysis of treatment effects. *European Journal of Oral Sciences*, 124(2), 105-118.

Peters, L., Romano, M., Byrow, Y., Gregory, B., Mclellan, L. F., Brockveld, K. *et al.* (2019). Motivational interviewing prior to cognitive behavioural treatment for social anxiety disorder: A randomised controlled trial. *Journal of Affective Disorders*, 256, 70-78.

Polat, O., Karaman, A. I., Durmus, E. (2005). Effects of preoperative ibuprofen and naproxen sodium on orthodontic pain. *Angle Orthodontist*, 75(5), 791-796.

Proffit, W.R., Fields, H.W., Larson, B., Sarver, D.M. (2018). Contemporary Orthodontics, 6th ed. St Louis: Mosby Elsevier, pp. 268.

Raak, C. K., Ostermann, T., Schönenberg-Tu, A. L., Fricke, O., Martin, D. D., Robens, S. *et al.* (2022). No gender differences in pain perception and medication after lumbar spine sequestrectomy-a reanalysis of a randomized controlled clinical trial. *Journal of Clinical Medicine*, 11(9).

Rabah, N., Al-Ibrahim, H. M., Hajeer, M. Y., Ajaj, M. A., Mahmoud, G. (2022). Assessment of patient-centered outcomes when treating maxillary constriction using a slow removable versus a rapid fixed expansion appliance in the adolescence period: A randomized controlled trial. *Cureus*, 14(3), e22793.

Rivat, C., Becker, C., Blugeot, A., Zeau, B., Mauborgne, A., Pohl, M. *et al.* (2010). Chronic stress induces transient spinal neuroinflammation, triggering sensory hypersensitivity and long-lasting anxiety-induced hyperalgesia. *Pain*, 150(2), 358-368.

Santos, D., Jr, J. C. (2021). Chewing gum as a non-pharmacological alternative for orthodontic pain relief: A randomized clinical trial using an intention-to-treat analysis. *The Korean Journal of Orthodontics* 51(5), 346-354.

Sari, E., Olmez, H., Gurton, A. U. (2004). Comparison of some effects of acetylsalicylic acid and rofecoxib during orthodontic tooth movement. *American Journal of Orthodontics and Dentofacial Orthopedics*, 125(3), 310-315.

Sawada, A., Usui, N., Shimazaki, K., Taira, M., Ono, T. (2015). The effects of cognitive behavioral therapy on experimental orthodontic pain. *Orthodontic Waves*, 74(1), 10-14.

Seers, T., Derry, S., Seers, K., Moore, R. A. (2018). Professionals underestimate patients' pain: A comprehensive review. *Pain*, 159(5), 811-818.

Thammanichanon, P., Kaewpitak, A., Binlateh, T., Leethanakul, C. (2020). Interval vibration reduces orthodontic pain via a mechanism involving down-regulation of trpv1 and cgrp. *In Vivo*, 34(5), 2389-2399.

Therkildsen, N. M., Sonnesen, L. (2022). Bite force, occlusal contact and pain in orthodontic patients during fixed-appliance treatment. *Dentistry Journal (Basel)*, 10(2).

Topolski, F., Moro, A., Correr, G. M., Schimim, S. C. (2018). Optimal management of orthodontic pain. *Journal of Pain Research*, 11, 589-598.

Treede, R. D. (2018). The international association for the study of pain definition of pain: As valid in 2018 as in 1979, but in need of regularly updated footnotes. *Pain Reports*, 3(2), e643.

Tripathi, T., Singh, N., Rai, P., Khanna, N. (2019). Separation and pain perception of elastomeric, kesling and kansal separators. *Dental Press Journal of Orthodontics*, 24(2), 42-48.

Vance, C. G., Dailey, D. L., Rakel, B. A., Sluka, K. A. (2014). Using tens for pain control: The state of the evidence. *Pain Management*, 4(3), 197-209.

Walker, J. B., Buring, S. M. (2001). Nsaid impairment of orthodontic tooth movement. *Annals of Pharmacotherapy*, 35(1), 113-115.

Wang, J., Jian, F., Chen, J., Ye, N. S., Huang, Y. H., Wang, S. *et al.* (2012). Cognitive behavioral therapy for orthodontic pain control: A randomized trial. *Journal of Dental Research*, 91(6), 580-585.

Wang, K., Kim, H. A., Felson, D. T., Xu, L., Kim, D. H., Nevitt, M. C. *et al.* (2018). Radiographic knee osteoarthritis and knee pain: Cross-sectional study from five different racial/ethnic populations. *Scientific Reports*, 8(1), 1364.

Wang, Y., Liu, C., Jian, F., Mcintyre, G. T., Millett, D. T., Hickman, J. *et al.* (2018). Initial arch wires used in orthodontic treatment with fixed appliances. *Cochrane Database of Systematic Reviews*, 7, CD007859.

Wiedel, A. P., Bondemark, L. (2016). A randomized controlled trial of self-perceived pain, discomfort, and impairment of jaw function in children undergoing orthodontic treatment with fixed or removable appliances. *Angle Orthodontist*, 86(2), 324-330.

Yam, M. F., Loh, Y. C., Tan, C. S., Khadijah Adam, S., Abdul Manan, N., Basir, R. (2018). General pathways of pain sensation and the major neurotransmitters involved in pain regulation. *International Journal of Molecular Sciences*, 19(8).

Zborowski, M. (1952). Cultural components in responses to pain1. 8(4), 16-30.

TECHNICAL REPORT Open Access

Fabrication of Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) post and core using indirect digitalisation technique

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Abstract

The advancement of digital technology in dentistry signifies an opportunity for the clinician to explore novel techniques in fabricating post and core. Conventional custom-made post and core is constructed in the laboratory with very limited material either gold, nickel-chromium or cobalt-chromium. Apart from higher modulus elasticity compared to dentin, the colour of the conventional custom-made post and core was also unaesthetic making it inferior to be used with all ceramic crown. This article describes post and core fabrication technique using computer-aided design and computer-aided manufacturing (CAD/CAM) technology with acrylic resin pattern build-up and indirect digitalisation method. The same procedure for custom-made metal post and core was adopted in this case to capture the anatomical shape of the root canal before digital technology was incorporated in the fabrication of post and core manufacture using CAD/CAM. With the CAD/CAM approach, an increased in quality, productivity, workflow efficiency and consistency of prosthetic rehabilitation may be obtained. It also enables clinicians to fabricate post and core using tooth colour material with better physical properties and improved mechanical qualities to achieve the best result in restoring endodontically treated teeth.

Keywords: *computer-aided design, computer-aided manufacturing, core, post*

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Introduction

Custom-made cast post is indicated when there is extensive loss of tooth structure, wide, non-circular or extremely tapered canal (Soares *et al*., 2014; Pang *et al*., 2019). The main advantage is that it can be tailor-made to the shapes of the root canal, however, the choice of substrate material is limited. Gold, cobalt-chromium (Co-Cr) and nickel-chromium (Ni-Cr) are mainly the material of choice for the fabrication of custom-made post and core (Fraga *et al*., 1998; Martinez-Insua *et al*., 1998; Khaledi *et al*., 2015). However, due to the different modulus of elasticity between post material and dentin, they tend to produce excessive functional stress leading to the root fracture. (Fraga *et al*., 1998; Akkayan & Gülmez, 2002). Ideally, the material for post and core should have comparable physical and mechanical properties of dentin such as optical properties, comprehensive strength, tensile strength, and thermal expansion

coefficient (Manhart, 2009; Gonzaga & Correr, 2017; Machado *et al*., 2017). Computer-aided design/computer-aided manufacturing (CAD/CAM) offers new technique and a wide range of tooth-colour materials for the fabrication of custom-made post and core. Previous studies had reported diversities of materials in fabricating the CAD/CAM post and core namely ceramic (zirconia, leucite-reinforced ceramics or lithium disilicate) (Awad & Marghalani, 2007; Sipahi *et al*., 2011 Eid *et al*., 2019a; Eid *et al*., 2019b; Oguz *et al*., 2019), resin (Spina *et al*., 2018; Oguz *et al*., 2019) or experimental block of customized glass-fiber reinforced (Tsintsadze *et al*., 2017; Garcia *et al*., 2018; Tsintsadze *et al*., 2018). These materials have the advantage of similar optical properties as well as comparable modulus elasticity with the natural teeth. Furthermore, the monobloc effect of CAD/CAM post and core may lower the likelihood of failure as it combines into a single unit (Vinothkumar *et al*., 2011).

The fabrication of CAD/CAM post and core can be divided into direct digitalisation using scan post and indirect digitalisation using an impression of the post space with a resin pattern, gypsum material, or poly-vinyl siloxane (PVS) impression (Hamid & Ahmad, 2022). Although direct digitisation is desirable as it allows the clinician to quickly identify and rectify the preparation margin, reducing clinical and laboratory procedures, the system was not readily available in Malaysia at the moment. In addition, a previous study also showed that the current system can only capture canal post lengths of 10 mm or less (Kalyoncuoğlu *et al*., 2015). Thus, this paper aimed to describe the indirect digitalisation technique of impression of post canal space using resin pattern for post and core fabrication using CAD/CAM technology utilising the available CAD/CAM machine.

Technical Report Methods

Tooth preparation prior to fabrication of CAD/CAM post and core

After completion of endodontic obturation for the maxillary central incisor, the gutta percha was removed with a low-speed Gates-Glidden instruments up to the size 3 (Dentsply Sirona, USA). Post space preparation was performed using ParaPost® XP™ drills (Coltène Whaledent, Germany) in conventional sequences, leaving 5mm of gutta percha as apical seal (Mattison *et al*., 1984). Root canal were lubricated with petroleum jelly before application of autopolymerizing acrylic resin (GC Pattern Resin; GC Corp, America) on the ParaPost® XP™ plastic lab burnout post (Coltène Whaledent, Germany) with a brush and the post was placed into the canal and core was build-up. The core was refined into desired incisor shape of 4 mm height using diamond rotary cutting tools (Figure 1). Crown preparation was completed with 2-mm ferrule as crown finish line (Morgano & Brackett, 1999; Bittner *et al*., 2010)

Scanning and designing procedure of CAD/CAM post and core

The resin pattern was sent to the laboratory for the digitalisation process. The incisal portion of the resin pattern was attached to a putty silicone base. Then, an optical scan of the resin pattern was obtained using an intraoral scanner (Aoralscan 3, Shining 3D Scanner, China). The optical scan was processed within a CAD design software (Ceramill Match; Amann Girrbach, Austria) utilising the inlay set-up mode as there was no proprietary post and core design mode within the software.

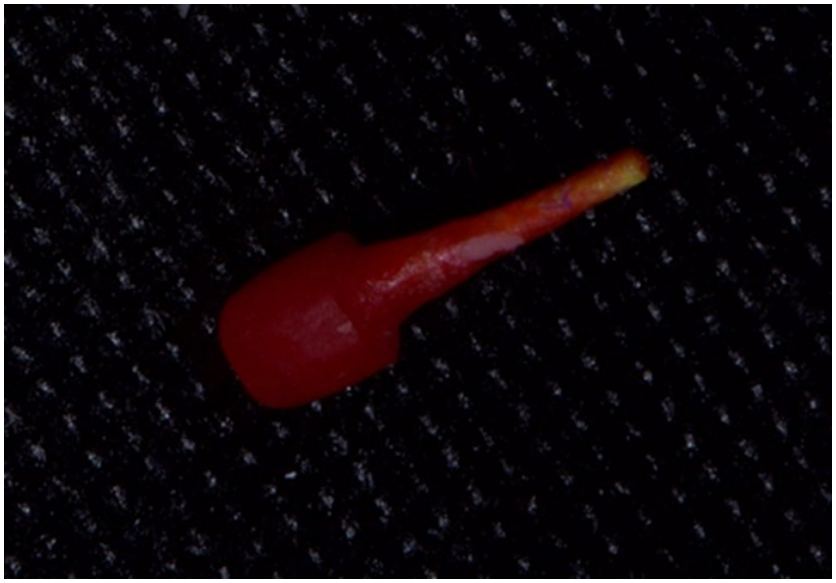

Figure 1. Post and core fabricated using acrylic resin pattern

Milling procedure of CAD/CAM post and core

Following the completion of scanning and designing process (Figure 2a and Figure 2b), the milling was done using 5-axis milling machine (Ceramil Motion 2, Amann Girrbach, Austria). In the present study, the clinician manipulated the digital file to make the milling with a 14-mm CAD-CAM polymer-infiltrated ceramic-network Vita Enamic® block (VITA Zahnfabrik, Germany) permissible. The digital file of the post and core was angulated to give a 2-mm sprue, 4-mm core height and 9-mm post length to fit in the Vita Enamic® block. The post length was longer in this case because of the use of the central incisor tooth (Figure 3). The maximum post length would be 8-mm if no angulation was applied for milling of a 14-mm Vita Enamic® block. A completed post and core was milled with the sprue connection using a rotary diamond RFID cutting bur size 1.8, 1.4, 1.0 and 0.4 (Amann Girrbach, Austria) under cooling. After milling, the post and core was placed into the post space to evaluate the fit by using the silicone disclosing agent (Fit Checker Advanced Blue; GC America) to assess the fitting. Any interferences were relieved using a finishing diamond rotary cutting instrument in a high-speed handpiece before the cementation process. Figure 4 showed the comparison of milled post and core (left) and resin pattern (right).

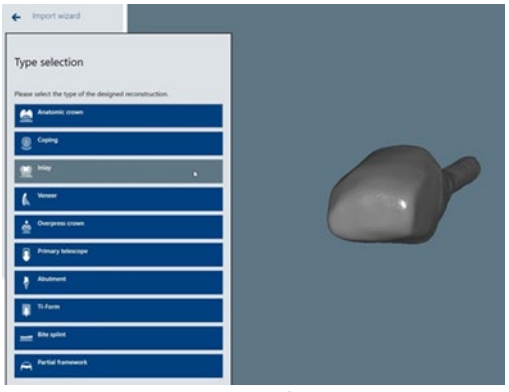

Figure 2a

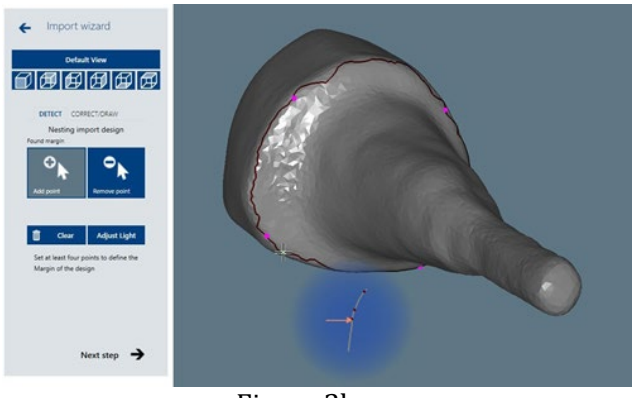

Figure 2b

Figure 2a. An inlay set up was chosen in the CAD software; Figure 2b. Core margin was marked.

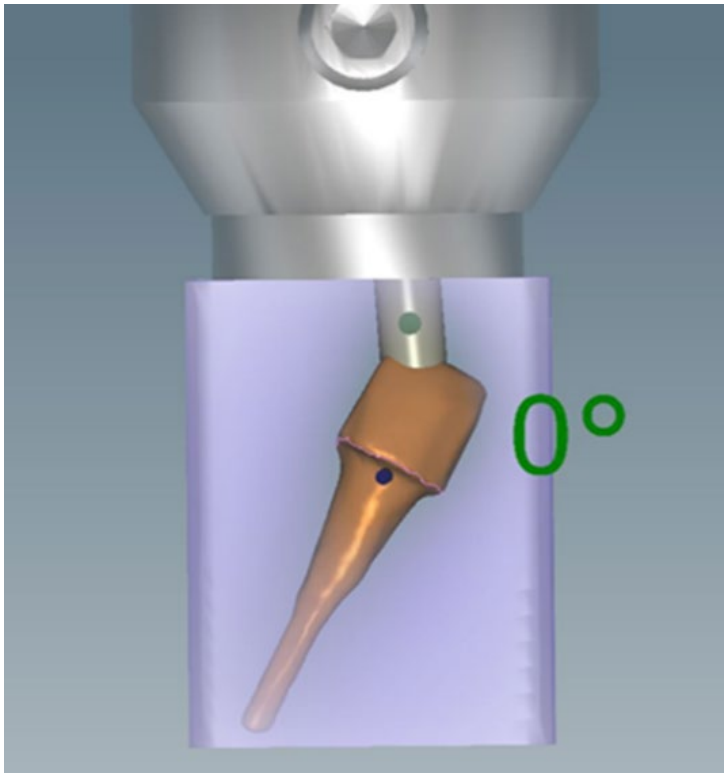

Figure 3. The digital file of the post and core has been angulated to make a 13-mm post and core fit in the 14-mm Vita Enamic® block for milling process

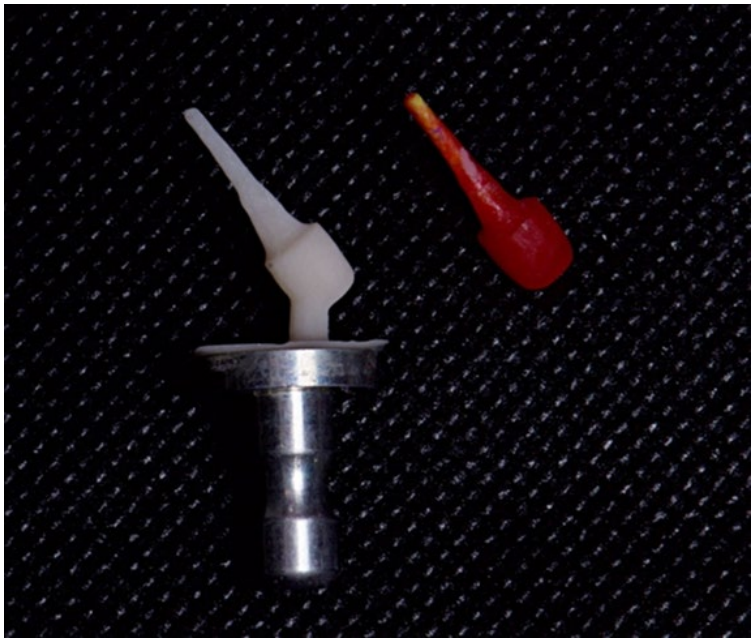

Figure 4. Comparison of milled (right) and pattern resin (left) of post and core

Discussion

It is important to understand and use appropriate material for the construction of post and core to ensure a positive treatment outcome. To date, no CAD/CAM material blocks are indicated specifically for the fabrication of post and core. Nevertheless, most case reports and *in vitro* studies used tooth-coloured materials that had a comparable modulus of elasticity to dentin. The combination of positive properties of both ceramic and composite materials in this hybrid ceramic block offer optimum performance with a modulus of elasticity that is close to the human dentin which allows uniform stress distribution along the post structure especially during mastication (Pontius & Hutter, 2002; Ausiello *et al*., 2004). A post with high rigidity and higher modulus of elasticity than the dentin might exhibit higher stress distribution throughout the post and root structures which can promote post separation and unfavourable root fracture (Fokkinga *et al*., 2006). Evaluation of tooth preparation prior to scanning and milling of CAD/CAM post and core is extremely important. The clinician must make sure that absence of acute angle on the junction of post surface and apical surface of the core to reduce any risk of fracture during milling process. A round internal line angle on the post structure was recommended (Awad & Marghalani, 2007; Streacker & Geissberger, 2007).

3Shape (Trios,Denmark) is the only fully digital option that available in the market with a special scan post to scan depth of post and core restorations while most of the CAD/CAM systems available in the market are focused on the extracoronal restorations (3Shape, 2013). There are variety of shapes and lengths of scan posts available, which can be employed intraorally or extraorally in a dental laboratory. Two intraoral scans (one of the prepared tooth and another one with the scan post inserted in the prepared canal) are needed for a CAD software to construct the final post and core restoration. Different size and shape of the root canal require different type of scan post; thus, this will add an additional step and is not a cost-effective process as clinicians need to buy the entire scan post system depending on the clinical cases. The fitting of the scan post is very important as it can lead to inaccuracies of the final restoration especially on the apical part (Kanduti *et al*., 2021). Nevertheless, although the system had been in the market since 2013, the clinical evidence on the effectiveness of the scan post is still scarce. Several studies stated that direct digitalisation process was faster as it can eliminate conventional process (Yuzbasioglu *et al*., 2014; Ting-shu & Jian, 2015), but current available Chairside Economical Restoration of Esthetic Ceramics (CEREC) system had indicated that post and core length must be either 10 mm or less if direct digitalisation technique was opted. This is due to unreliable scanning procedure causing incomplete volume reading in narrow post space area which will limit the usage especially for longer root canals. (Pinto *et al.*, 2017).

The presented technique eliminates the need for a scan post in the CAD component and uses the available CAD/CAM system available (Aoralscan 3, Shining 3D Scanner, China) to scan the CAD/CAM post and core. The impression of post space using acrylic resin build-up eliminates the length issue depicted in the direct digitalisation scanning process. However, it is important to note that most of the available length of CAD/CAM block are either 12-mm or 14-mm (Shofu, 2017; Zahnfabrik,, 2021). This can be further explained by the need 2-mm sprue, with core height of 4 to 5-mm leaving only 7 to 8-mm of block material left for the post length. As presented in this case, the CAD/CAM block was angulated to achieve post and core milling of 15-mm in length. Thus, further improvement on inventing a longer block dimensions or production of a disk form will be beneficial in such situation.

The present study utilized the five-axis milling machine that was set to a high-quality; slow speed technique which took around 30 minutes to complete the milling process of the post and core. It is important to note that, the milling of a post and core system requires a slower, low-stress machining approach due to their fine shape, which demands an approach to minimise

vibrations, inaccuracy, and failure of the machining process (Alghazzawi, 2016; Libonati *et al*., 2020).

Conclusion

This article presents a scanning technique for post and core of indirect digitalisation technique using impression of post space with acrylic resin build-up. Acrylic resin build-up aids in reproducing accurate canal anatomy and detailed length prior to the digital fabrication process.

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References

3Shape (2013). 3Shape Releases CAD Solution for Post and Core Restorations. Retrieved 17 July 2013, from https://www.3shape.com/en/press/2013/cad-solution-for-post-and-core-restorations

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

Alghazzawi T. F. (2016). Advancements in CAD/CAM technology: Options for practical implementation. *Journal of Prosthodontic Research*, 60(2),72-84.

Ausiello, P., Rengo, S., Davidson, C. L. and Watts, D. C. (2004). Stress distributions in adhesively cemented ceramic and resin-composite Class II inlay restorations: a 3D-FEA study. *Dental Materials*, 20(9),862-872.

Awad, M. A. and Marghalani, T. Y. (2007). Fabrication of a custom-made ceramic post and core using CAD-CAM technology. *The Journal of Prosthetic Dentistry*, 98(2),161-2.

Bittner, N., Hill, T. and Randi, A. (2010). Evaluation of a one-piece milled zirconia post and core with different post-and-core systems: An *in vitro* study. *The Journal of Prosthetic Dentistry*, 103(6),369-379.

Eid, R., Juloski, J., Ounsi, H., Silwaidi, M., Ferrari, M. and Salameh, Z. (2019a). Fracture resistance and failure pattern of endodontically treated teeth restored with computer-aided design/computer-aided manufacturing post and cores: A pilot study. *The Journal of Contemporary Dental Practice*, 20(1), 56-63.

Eid, R. Y., Koken, S., Baba, N. Z., Ounsi, H., Ferrari, M. and Salameh, Z. (2019b). Effect of fabrication technique and thermal cycling on the bond strength of CAD/CAM milled custom fit anatomical post and cores: an *in vitro* study. *Journal of Prosthodontics*, 28(8), 898-905.

Fokkinga, W. A., Kreulen, C. M., Le Bell-Rönnlöf, A. M., Lassila, L. V., Vallittu, P. K. and Creugers, N. H. (2006). *In vitro* fracture behavior of maxillary premolars with metal crowns and several post-and-core systems. *European Journal of Oral Sciences*, 114(3),250-256.

Fraga, R., Chaves, B., Mello, G. and Jr, J. S. (1998). Fracture resistance of endodontically treated roots after restoration. *Journal of Oral Rehabilitation* (11),809-813.

Garcia, P.P., da Costa, R.G., Garcia, A.V., Gonzaga, C.C., da Cunha, L. F., Rezende, C.E.E., and Correr, G.M. (2018). Effect of surface treatments on the bond strength of CAD/CAM fiberglass posts. *Journal of Clinical and Experimental Dentistry*, 10(6), 591-7.

Gonzaga, C. C. and Correr, G. M. (2017). CAD/CAM post-and-core using different esthetic materials: Fracture resistance and bond strengths. *American Journal of Dentistry*,30(6),299-304.

Kalyoncuoğlu, E., Ural, Ç., H. Aydemir, H., Aslan, M. A. and Balkaya, V. (2015). Effect of 1-piece post and core fabrication techniques on fracture strength. *Journal of Applied Biomaterials & Functional Materials*, 13(3),253-258.

Kanduti, D., Korat, L., Kosec, T., Legat, A., Ovsenik, M., Kopač, I. (2021). Comparison Between Accuracy of Posts Fabricated Using a Digital CAD/CAM Technique and a Conventional Direct Technique. *International Journal of Prosthodontics*, 34(2): 212-220.

Khaledi, A., Sheykhian, S. and Khodaei, A. (2015). Evaluation of retention of two different cast post-core systems and fracture resistance of the restored teeth. *Journal of Dentistry Shiraz University of Medical Sciences*, 16(2),121-128.

Libonati, A., Di Taranto, V., Gallusi, G., Montemurro, E. and Campanella, V. (2020). CAD/CAM customized glass fiber post and core with digital intraoral impression: a case report. *Clinical, Cosmetic and Investigational Dentistry*, 12,17-24.

Machado, J., Almeida, P., Fernandes, S., Marques, A., and Vaz, M. (2017). Currently used systems of dental posts for endodontic treatment. *Procedia Structural Integrity*, 5,27-33.

Manhart, J. (2009). Fiberglass reinforced composite endodontic posts. *Endodontic Practice*, 16,6-20.

Martinez-Insua, A., Da Silva, L., Rilo, B. and Santana, U. (1998). Comparison of the fracture resistances of pulpless teeth restored with a cast post and core or carbon-fiber post with a composite core. *The Journal of Prosthetic Dentistry*, 80(5),527-532.

Mattison, G., Delivanis, P., Thacker, R. and Hassel, K. (1984). Effect of post preparation on the apical seal. *The Journal of Prosthetic Dentistry*, 51(6),785-9.

Morgano, S. M. and Brackett, S. E. (1999). Foundation restorations in fixed prosthodontics: Current

knowledge and future needs. *The Journal of Prosthetic Dentistry*, 82(6), 643-657.

Abdul Hamid N. F., Ahmad R. (2022). Computer-aided Design/Computer-aided Manufacturing (CAD/CAM) machines with scanning and milling capabilities for fabricating custom posts and cores: a narrative review. *Malaysian Journal of Medicine and Health Sciences*, 18(2),1-7.

Oguz, B. A., Egilmez, F., Ergun, G. and Cekic, I. N. (2019). Surface treatment effects on bond strength of CAD/CAM fabricated posts to root canal dentin. *American Journal of Dentistry*, 32(3): 113-117.

Pang, J., Feng, C., Zhu, X., Liu, B., Deng, T., Gao, Y., Li, Y. and Ke, J. (2019). Fracture behaviors of maxillary central incisors with flared root canals restored with CAD/CAM integrated glass fiber post-and-core. *Dental Material Journal*, 38(1),114-9.

Pinto, A., Arcuri, L., Carosi, P., Nardi, R., Libonati, A., L. Ottria, L. and V. Campanella, V. (2017). *In vitro* evaluation of the post-space depth reading with an intraoral scanner (IOS) compared to a traditional silicon impression. *Oral & Implantology* ,10(4), 360-368.

Pontius, O. and Hutter, J. W. (2002). Survival rate and fracture strength of incisors restored with different post and core systems and endodontically treated incisors without coronoradicular reinforcement. *Journal of Endodontics*, 28(10),710-715.

Shofu. (2017). SHOFU Block, SHOFU Disk HC Ceramic Based Aesthetic CAD/CAM Restorative. Retrieved 6 July 2021, from https://www.shofu.de/wp-content/uploads/2017/03/SHOFU-Block-HC-BRO-UK-2017-03.pdf.

Sipahi, C., Toksoy, F., Ayyildiz, S. and Özcan, M. (2011). Effect of physical and physicochemical surface treatment methods on the tensile strength of CAD/CAM-fabricated zirconia posts and cores luted to root canals. *The International Journal of Periodontics and Restorative Dentistry*, 31(5),64-67.

Soares, L. P., de Souza, P. G., Garcia, C. and Barino, B. (2014). Designing a custom-made post and core using CAD/CAM technology's CEREC system. *Canadian Journal of Restorative Dentistry & Prosthodontics*, 7(3),40-48.

Spina, D. R. F., da Costa, R. G., Correr, G. M. and Rached, R. N. (2018). Scanning of root canal impression for the fabrication of a resin CAD-CAM-customized post-and-core. *The Journal of Prosthetic Dentistry*, 120(2),242-245.

Streacker, A. B. and Geissberger, M. (2007). The milled ceramic post and core: A functional and esthetic alternative. *The Journal of Prosthetic Dentistry*, 98(6), 486-487.

Ting-shu, S. and Jian, S. (2015). Intraoral digital impression technique: a review. *Journal of Prosthodontics,* 24(4),313-321.

Vinothkumar, T. S., Kandaswamy, D. and P. Chanana, P. (2011). CAD/CAM fabricated single-unit all-ceramic post–core–crown restoration. *Journal of Conservative Dentistry*, 14(1),86-89.

Yuzbasioglu, E., Kurt, H., Turunc, R. and Bilir, H. (2014). Comparison of digital and conventional impression techniques: evaluation of patients' perception, treatment comfort, effectiveness and clinical outcomes. *BMC Oral Health*, 14(1),1-7.

Zahnfabrik, V. (2021). Vita Enamic. Product specifications. Retrieved 6 July 2021, from http://vikadent.lt/download/vita/VITA_1780E_ENAMIC_PS_EN_V02.pdf

CASE REPORT Open Access

Osteonecrosis of the jaw in patients taking Atorvastatin: Case series

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Abstract

Osteonecrosis of the jawbones commonly seen in patients taking bisphosphonates, denosumab, and several antiangiogenic medications with several oral factors such as tooth extraction or dental infection. Currently, patients taking Simvastatin, a medication commonly used to treat hypercholesteremia, were reported of developing osteonecrosis of the jaw. Thus, it is important that clinicians know about the risk of osteonecrosis for patients taking this hypercholesteremia medication. It is not known if the undesirable effect only occurs with Simvastatin or other types of statin medication. We report in detail three cases of osteonecrosis of patients taking Atorvastatin calcium, a second-generation statin medication.

Keywords: *bisphosphonate, MRONJ, mevalonate pathway, osteonecrosis, statin*

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Introduction

Medication-related osteonecrosis of the jaw (MRONJ) can be diagnosed when a patient treated with bone modifying agents or angiogenesis inhibitor presented with the exposed bone for more than eight weeks, without a history of radiation therapy (He *et al.,* 2020). When a patient taking medications known to induce MRONJ, coupled with several oral factors such as dental infection, ill-fitting denture, tooth extraction, or other dental surgery procedures, the development of MRONJ could be triggered (Fede *et al.,* 2018). Common medications associated with MRONJ include bisphosphonate, denosumab, and bevacizumab (He *et al.,* 2020).

Recently, three cases of osteonecrosis of the jaws in patients taking Simvastatin were reported (Giladi *et al.,* 2020; Samieirad *et al.,* 2021). We want to add three more cases of patients taking Atorvastatin calcium for the treatment of hypercholesteremia, presented with osteonecrosis following the tooth extraction procedure. This manuscript was prepared according to the CARE Guidelines

for reporting case reports and case series (Riley *et al.,* 2017).

Case description

Three patients taking Atorvastatin, prescribed by the physician for the treatment of underlying hypercholesteremia. All of them went to the dental practice for tooth extraction procedures. Normal tooth extraction was performed smoothly. Subsequently, the patients developed exposure of necrotic bone after the tooth extraction procedure in both the maxilla and mandible. The patients also complained of pain at the extraction socket, after the procedure.

None of the patients have undergone radiation therapy, taking steroid and bisphosphonate medications, or smoking. Two of the patients were also diagnosed diabetes mellitus. Clinical diagnosis of osteonecrosis of the jaw was made for all cases, based on the complain and the clinical presentation of necrotic bone exposure and the non-healing extraction socket.

The treatments done for the management of osteonecrosis include surgical debridement of the necrotic bone and primary wound closure technique. All patients were reviewed until healing of the extraction area. The cases took up to four months duration for healing. The cases were reviewed again after six months to confirm the healing. The details about the three cases are summarized in Table 1, and one case is illustrated in Figure 1 and Figure 2.

Table 1.Summary of cases.

Case	Age/ gender	Atorvastatin calcium dosage	Location	Surgical procedure	Duration for healing
1	53, Male	80mg	Mandible	Extraction 36	Three months
2	71, Female	10mg	Maxilla	Extraction 11 and 12	Four months
3	61, Male	10mg	Mandible	Extraction 33	Three months

Figure 1. Osteonecrosis in the maxilla after extraction of 11 and 12 (Case 2)

Figure 2. Wound debridement and suture placed in Case 2.

Discussions

According to the American Association of Oral and Maxillofacial Surgeons, MRONJ can be defined by clinical presentation by ongoing or history of antiangiogenic or antiresorptive drugs, absent of history of radiation therapy and metastasis to the jaw, and exposed bone or presence of an intraoral or extraoral fistula in the maxillofacial region persisting for more than 8 weeks (Ruggiero *et al.,* 2014). Even though our cases did not satisfy the first criteria, the clinical presentation are similar to the reported MRONJ cases.

MRONJ is a serious adverse reaction developed by patients taking certain medications resulting in the destruction of maxillary and mandibular bone. The common medications associated with MRONJ are used in the treatment of osteoporosis and cancer. The condition is a challenge to clinicians because the treatment is not easy (Beth-Tasdogan *et al.,* 2017). The pathophysiology of MRONJ is still not well understood, and TGF-β1 signalling pathway is considered a vital element of the development of MRONJ, by disrupting the balance of osteoclast and osteoblast activity during the bone remodelling of the jaw bone. Other factors that can cause MRONJ include

the particular characteristic of the jaw, oral infection, and altered angiogenesis (He *et al.,* 2020).

Statin drugs are HMG CoA reductase inhibitors that disrupt cholesterol production by inhibiting the conversion of HMG CoA enzyme to mevalonate (Uzzan *et al.,* 2007). Similar action can be seen in bisphosphonates containing nitrogen through its R2 chain, also inhibit the HMG CoA reductase and consequently disrupting the mevalonate pathway (Giladi *et al.,* 2020). Thus, Giladi *et al.* highlighted a common mechanism for bisphosphonates and statins in the development of osteonecrosis for patients taking prolonged, high dosage statin when publishing the first case report about this issue (Giladi *et al.,* 2020).

Underlying systematic diseases, such as diabetes mellitus (DM), could be one of the risk factors for patients developing MRONJ. DM can alter the bone remodelling, increase apoptosis of osteoblast and osteocyte, altering the immune response, in addition to microvascular damage and oxidative stress

(He *et al.,* 2020). However, the exact relationship between DM and MRONJ is still debatable and not conclusive (Peer & Khamaisi, 2015). Two of our MRONJ patients have an underlying DM in addition to hypercholesteremia. The other two reported cases by Giladi *et al.* did not have DM (Giladi *et al.,* 2020) while Samieirad et al. did not mention the DM status for their patient (Samieirad *et al.,* 2021).

The treatment of MRONJ is challenging and requires a long-term treatment plan. The symptoms of MRONJ may lead to a resolution of 12 months (Hinson *et al.,* 2015). Over half of the MRONJ resolved, about a quarter of the cases did not heal, while the balance developed recurrence (Beth-Tasdogan *et al.,* 2017). The standard treatment plan for managing MORNJ can be divided into nonsurgical or surgical management. The nonsurgical approach includes the use of antiseptic rinse, prescription of antibiotics. The surgical intervention includes debridement and resection of the involved area (Ruggiero *et al.,* 2014). Hyperbaric oxygen can be added to the treatment plan. However, there were no significant differences in the addition of hyperbaric oxygen with the standard care (Beth-Tasdogan *et al.,* 2017). Our patients were treated with surgical debridement and biweekly to monthly review until complete healing of the necrotic area. Similar treatment approach was utilized for the other three cases if MRONJ with Simvastatin history. However, Giladi *et al.* mentioned that their cases did not respond well so debridement (Giladi *et al.,* 2020), while Samieirad et al. included platelet rich fibrin (PRF) adaptation to the surgical site and it responded well (Samieirad *et al.,* 2020).

Conclusions

The association between statin and MRONJ is still not well established due to the limited number of patients in the case series. However, further investigations and research is required to conclude the additional side effect of this medication.

References

Beth-Tasdogan, N. H., Mayer, B., Hussein, H., & Zolk, O. (2017). Interventions for managing medication-related osteonecrosis of the jaw. *Cochrane Database of Systematic Reviews*, 2017(10).

Fede, O. Di, Panzarella, V., Mauceri, R., Fusco, V., Bedogni, A., Muzio, L. *et al..* (2018). The Dental Management of Patients at Risk of Medication-Related Osteonecrosis of the Jaw : New Paradigm of Primary Prevention. *BioMed Research International*, 2018, 2684924.

Giladi, H. Z., Gabay, E., & Machtei, E. E. (2020). Medication-Related Osteonecrosis of the Jaw in Patients Taking High-Dose Simvastatin. *Journal of Oral Maxillofacial Surgery*, 78(6), 862–863.

He, L., Sun, X., Liu, Z., Qiu, Y., & Niu, Y. (2020). Pathogenesis and multidisciplinary management of medication-related osteonecrosis of the jaw. *International Journal of Oral Science*, August, 1–11.

Hinson, A. M., Siegel, E. R., & Stack, B. C. J. (2015). Temporal correlation between bisphosphonate termination and symptom resolution in osteonecrosis of the jaw: a pooled case report analysis. *Journal of Oral and Maxillofacial Surgery*, 73(1), 53–62.

Peer, A., & Khamaisi, M. (2015). Diabetes as a Risk Factor for Medication- Related Osteonecrosis of the Jaw. *Critical Reviews in Oral Biology & Medicine Diabetes*, 94(2), 252–260.

Riley, D. S., Barber, M. S., Kienle, G. S., Aronson, J. K., von Schoen-Angerer, T., Tugwell, P., *et al.* (2017). CARE guidelines for case reports: explanation and elaboration document. *Journal of Clinical Epidemiology*, 89, 218–235.

Ruggiero, S. L., Dodson, T. B., Fantasia, J., Goodday, R., Aghaloo, T., Mehrotra, B., *et al.* (2014). American Association of Oral and Maxillofacial Surgeons position paper on medication-related osteonecrosis of the jaw--2014 update. *Journal of Oral and Maxillofacial Surgery*, 72(10), 1938–1956.

Samieirad, S., Labafchi, A., Famili, K., & Hashemzadeh, H. (2021). medication-related osteonecrosis of the jaw (MRONJ) due to simvastatin: an unusual case report. *World Journal of Plastic Surgery*, 10(1), 132–135.

Uzzan, B., Cohen, R., Nicolas, P., Cucherat, M., & Perret, G. (2007). Effects of statins on bone mineral density : A meta-analysis of clinical studies. *Bone*, 40, 1581–1587.

CASE SERIES Open Access

Restoration of posterior tooth with single shade composite: A case series

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Abstract

Composite restoration is a popular material to restore tooth structure due to dental caries as there is an increasing demand for aesthetic restoration. With the advancing technologies, it has excellent physical characteristics which increases its longevity. However, the appropriate case selection also influences the outcome as composite is technique sensitive. This material can be offered to patient seeking less time-consuming procedure, better preservation of tooth structure, affordable but acceptable aesthetic outcome. These three cases presented shows the possibility of creating a good aesthetic result in posterior tooth restoration with the use of single shade composite.

Keywords: *aesthetic, composite, single shade*

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Introduction

Dental caries is one of the most common dental diseases with a prevalence of 90%, especially among people in rural area despite having accessible dental health care services (Esa *et al.,* 2014). Nowadays, there is also an increasing demand for esthetic restoration to replace amalgam. The improved property of composite, such as increase hardness, wear resistance and translucency, makes the restoration an excellent choice for small and medium sized posterior cavities with annual failures of 1-3% depending on the cavity size (Zhou *et al.,* 2019; Lassila *et al*., 2020). Alvanforoush *et al.,* (2017), reported an improved overall success rate of their long-term clinical studies for composite in posterior tooth. The reasons of failure have also change from secondary caries, postoperative sensitivity and unsatisfactory adaptation to composite fracture, tooth fracture and endodontic treatment for the past decade (Alvanforoush *et al*., 2017). The success of composite restoration relies on knowledge of adhesives, operator's technique and skills,

size of cavity and location of tooth (Velo *et al.,* 2016).

The application of composite in oblique incremental layer has lower values of shrinkage factors and lesser debonding tendency which reduces the polymerization shrinkage stress effect. This eliminates microleakage leading to secondary caries development and postoperative hypersensitivity (Kaisarly *et al.,* 2020). Regarding the types of composite resin used, the nanoparticles and micro hybrid resins has better clinical performances compared to compactable resin. In addition, the nanoparticles resins also have a lower polymerization shrinkage and good polishing capabilities due to its higher inorganic load percentage. The adhesive system used will create a hybrid layer between adhesive systems and enamel or dentin layer for micromechanical bonding, thus, allows the tooth preparation to be minimally invasive and tooth structure can be preserved (Velo *et al.,* 2016).

Composite restoration in posterior tooth requires assessment of the patient's characteristics, tooth preparation needed, matrix utilization in Class II case and composite composition-dentin bonding. It is also susceptible to excessive wear and marginal fracture when placed in areas of high function or high masticatory stress, hence, caution must be taken when treating patient with history of teeth grinding or clenching. The composite-tooth interface is subjected to both chemical and mechanical stress during masticatory function. Over time, this leads to deterioration of the composite properties, such as covalent bond breaking, which leads to restoration failure (Bohaty *et al*., 2013).

The tooth position also has an effect on the clinical performances and longevity. For example, premolar has a lower failure rate than molar due to increase in masticatory forces and stress (Bohaty *et al*., 2013). Opdam et al., (2014), also states this in the Kaplan-Meier graph and that failure occurs over time. However, the most common cause was secondary caries and fracture. Regardless of this limitation, composite can still be considered in cases where esthetic and minimally prepared restoration is required. Another factor of failure for posterior composite is secondary caries at restorations margin which indicates inadequate seal at the composite-tooth interface, hence causing inability to resist physical, chemical, and mechanical properties. This also creates an area for plaque retention and bacteria can penetrate into the exposed dentinal tubules leading to recurrent caries, hypersensitivity, and pulpal inflammation (Bohaty *et al*., 2013).

The purpose of this study is to present three different cases that uses single shade composite to restore carious posterior tooth.

Case description

Case 1

A 27-year-old female patient came with complaints of sensitivity and food stuck after meal on her lower left back tooth. She is medically fit and healthy. Intraoral examination revealed caries on disto-occlusal of tooth 36 (ICDAS code 05). Pulp sensibility testing was done, and the tooth responds normally to both electrical pulp test (EPT) and cold test. The diagnosis made was reversible pulpitis. Upon discussion with the patient, it was decided to restore the tooth with single shade composite restoration. After obtaining the patient's consent, local anesthesia infiltration with one cartridge of 2% mepivacaine with 1:100 000 epinephrine was given. Shade selection was done, and Kerr SimpliShade Medium (Kerr Company, USA) was selected. Then, multiple teeth isolation was done with rubber dam on tooth 35 until 37. Clamp was ligated with floss and placed on tooth 37.

Removal of caries was done with round bur mounted on high-speed handpiece. Any unsupported enamel was removed. Prior to restoration of the proximal wall, Garrison sectional matrix and wedge was placed and stabilized. Since the caries removal reveals some pulpal shadowing, a thin layer of calcium hydroxide liner (CaOH) or dycal was placed as base at the deepest cavity with Glass Ionomer Cement (GIC) Fuji VII as liner.

Then, the tooth was etched with Kerr's etchant (Kerr Company, USA) of 37.5% phosphoric acid for 30 seconds on enamel and 15 seconds on dentine and washed thoroughly and dried. Kerr OptiBond Universal (Kerr Company, USA) was placed with microbrush and cured for 10 seconds. Kerr SimpliShade Medium (Kerr Company, USA) is placed into cavity incrementally and cured according to the manufacturer. Any excess was trimmed with white stone bur mounted on high-speed handpiece. Rubber dam was removed, and occlusion was assessed with articulating paper. Final restoration was polished with Soflex disc course and Eve Diacomp Twist. Patient was encouraged to maintain a good oral hygiene and advised to attend dental clinic once a year for maintenance. Patient was satisfied with the restoration and did not experience any pain or sensitivity at one week review visit

Figure 1. Pre-operative: Disto-occlusal cavity of tooth 36 with no restoration

Figure 2. Caries removal and cavity preparation: Caries removal was done on disto-occlusal of 36

Figure 3. Composite placement: Garrison sectional matrix was placed on distal of 36 and Kerr SimpliShade Medium was used to restore the cavity

Figure 4. Composite placement: Kerr SimpliShade Medium was used to build the tooth occlusal contour

Figure 5. Excess removal: Any excess composite was trimmed with white stone bur

Figure 6. Final restoration: Occlusion was assessed with articulating paper and polishing with Soflex disc course and Eve Diacomp Twist was done

Case 2

A 25-year-old female Malay came with a complaint of food stuck and sensitivity on her upper left back tooth. She is medically fit and healthy. Upon intraoral examination, there is caries on occlusal and mesial of tooth 26 (ICDAS code 04). There is no pain on palpation and percussion. Pulp sensibility reveals a positive response with no exaggerating pain on both electrical pulp test (EPT) and cold test. The diagnosis made was reversible pulpitis. Upon discussion with the patient, it was decided to restore the tooth with single shade composite restoration. After obtaining the patient's consent, local anesthesia infiltration on buccal and palatal mucosa with one cartridge of 2% mepivacaine with 1:100 000 epinephrine was given. Shade selection was done, and Kerr SimpliShade Medium (Kerr Company, USA) was selected. Then, multiple teeth isolation was done with rubber dam on tooth 24 until 26. Clamp was ligated with floss and placed on tooth 37.

Caries was removed with round diamond bur mounted on high-speed handpiece. Any unsupported enamel was removed. Sectional matrix and wedge were placed on mesial of tooth 26 before restoring with composite. Then, the tooth was etched with Kerr's etchant (Kerr Company, USA) of 37.5% phosphoric acid for 30 seconds on enamel and 15 seconds on dentine and washed thoroughly and dried. Kerr OptiBond Universal (Kerr Company, USA) was placed with microbrush and cured for 10 seconds.

Kerr Simplishade Medium (Kerr Company, USA) composite was placed incrementally and cured according to the manufacturer. Occlusion was checked and any high bite or discomfort was removed with white stone bur mounted on high-speed handpiece. Once satisfied, the restoration was polished with Soflex course and fine disc and Eve Diacomp twist. Post-operative instruction was given, and patient was advised to visit dental clinic annually for maintenance of oral health. Patient was satisfied with the restoration and there was no pain or sensitivity at one week review visit.

Figure 7. Pre-operative: Occlusal and mesial caries on tooth 26 without any restoration

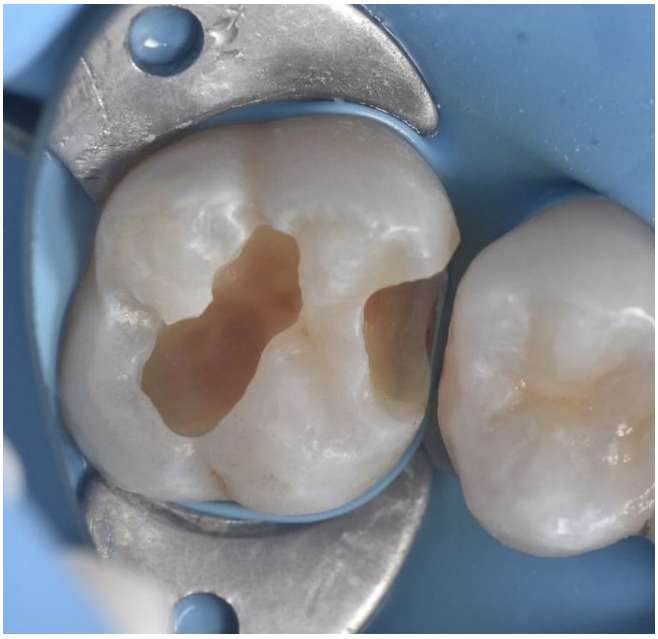

Figure 8. Caries removal and cavity preparation: Caries was removed on mesial and occlusal of 26

Figure 9. Composite placement: Composite placed incrementally and shaped to mimic tooth anatomy

Figure 10. Excess removal: Minor adjustments were made prior to removing rubber done

Figure 11. Final restoration: Removal of any high bite and final composite polishing

Case 3

A 35-year-old female patient came to dental clinic complaining of sensitivity and food stuck after meal on her upper left back tooth. She is medically fit and healthy. Intraoral examination showed presence of amalgam restoration on disto-occlusal of 25 with excess on the distal inter-proximal area and deficiency on the restoration-tooth interface (ICDAS code 43). The tooth responds normally to both electrical pulp test (EPT) and cold test, hence, a diagnosis of reversible pulpitis was made. It was decided to restore the tooth with single shade composite restoration and the patient provided consent for the treatment. Local anesthesia infiltration with one cartridge of 2% mepivacaine with 1:100 000 epinephrine was given. Shade selection was done, and Kerr SimpliShade Medium (Kerr Company, USA) was selected. Then, multiple teeth isolation was done with rubber dam on tooth 24 until 26. Clamp was ligated with floss and placed on tooth 26.

Round diamond bur mounted on high-speed handpiece was used to remove amalgam restoration of tooth 25. Then, caries was removed, and any unsupported enamel was removed. Sectional matrix and wedge were placed on distal of tooth 25 before restoring with composite. Following caries removal, some pulpal shadowing can be seen, hence, a thin layer of calcium hydroxide liner (CaOH) or dycal was applied at the deepest cavity as base with Glass Ionomer Cement (GIC) Fuji VII as liner. Selective etching with Kerr's etchant (Kerr Company, USA) of 37% phosphoric acid was done on enamel for 15 seconds and rinsed thoroughly and dried. Kerr OptiBond Universal (Kerr Company, USA) was placed with microbrush, lightly blew, and cured for 10 seconds.

Kerr Simplishade Medium (Kerr Company, USA) composite was placed incrementally and cured adequately. Occlusion was checked with articulating paper and any high bite or discomfort was removed with white stone bur mounted on high-speed handpiece. Once satisfied, the restoration was polished with Soflex course and fine disc and composite rubber polisher. Post-operative instruction was given, and patient was advised to visit dental clinic annually for maintenance of oral health. Patient was satisfied with the restoration and did not have any pain or sensitivity at one week review visit.

Figure 12. Pre-operative: Disto-occlusal amalgam restoration with excess on distal and deficiency on restoration-tooth interface.

Figure 13. Caries removal: Amalgam restoration removed and caries removal

Figure 14. Final restoration: Removal of high bite and final composite polishing

Discussion

With the advancing technologies in dental materials property, a single shade composite can achieve an excellent outcome. Although the shade selection of composite resin with surrounding teeth remains difficult, it can still provide a satisfactory aesthetic result for both patient and clinicians. The problems in colour matching of composite and tooth also depends on clinician's skills, knowledge, and experience. Hence, it is important to determine the tooth shade prior to application of rubber dam as prolong drying of teeth causes the tooth shade to become lighter (Kobayashi *et al.,* 2021).

Tooth colour is also affected by some factors, such as age, site, type of tooth, and status of tooth. Light diffusion and transmission properties of resin composite, enamel margin configuration, enamel prism orientation and age of restored tooth also influences the colour shifting at the composite margin (Kobayashi *et al.,* 2021). The enamel and dentin also have different light wave characteristics due to their structural differences. Enamel is more translucent as it has a higher mineralized prismatic structure, low organic content, and lesser water, hence causing higher light transmission than dentin (Morsy *et al*., 2020).

Following a reliable composite shade guide system is difficult due to different company colour classifications and shade guide materials. Most shade guides use plastic with different thickness which hinders the clinician capabilities to evaluate the colour responses when transilluminated. These differences are not limited to hue and chroma but includes nature and size of filler, materials thickness, dentin fluorescence, dentin's degrees of opacity and enamel's degree of translucency, opalescence, and refractive index (Paolone *et al*., 2014).

Besides that, composite thickness of enamel shell can also affect the aesthetic outcome whereby it affects the optical properties, such as translucency. Hence, care towards material thickness for enamel should be taken. The outcome of a multilayer composite restoration is also determined by the layer and dentinal proportion thickness and shade translucency. One of the suggestions was to create a custom-made shade guide which uses composite. It should have the capabilities to overlap enamel and dentin that allows the clinician to test the behaviours of different enamel thickness. The thickness should be realistic with a maximum of 0.7mm, a shank that does not restrict shade selection, and a standardized shape for every tooth with predetermined thickness (Paolone *et al*., 2014).

Aside from that, blending effects which refers to the small colour differences between composite resin and natural tooth when observed in isolation also increases with decreasing size of cavity and increasing dental material translucency. Morsy *et al.,* (2020), also stated that the blending effect of single shade universal resin composite is promising, and it manage to match the shade of enamel in a Class V restoration. In addition, the use of nanofilled composites has excellent polishing abilities as it has smaller surface roughness, thus creating a higher initial gloss (Morsy *et al.,* 2020).

The advantages of single shade composite are it reduces the need for clinician's abilities to colour match and treatment time. The size, depth, and darker colour of the cavity floor can also affect the final appearance of restoration. This problem is eliminated by using an opaque composite prior to placement of a more translucent composite (Kobayashi *et al.,* 2021). With consideration of the primary aesthetic features of tooth, simplification of the restoration with single shade composite should provide adequate reflecting and refracting light with good longevity (Fahl, 2012).

Conclusions

In conclusion, single shade composite restoration can provide a satisfactory aesthetic result, especially for non-critical area like posterior teeth. This reduces clinical time and patient's discomfort

without compromising the outcome. It is also a suitable alternative to indirect restoration, whenever indicated, as it is less time consuming and cheaper. Selection of the correct color and evaluation of the need for opaquer is essential to achieve a good result.

References

Alvanforoush, N., Palamara, J., Wong, R. H., & Burrow, M. F. (2017). Comparison between published clinical success of direct resin composite restorations in vital posterior teeth in 1995-2005 and 2006-2016 periods. *Australian Dental Journal*, 62(2), 132–145.

Bohaty, B. S., Ye, Q., Misra, A., Sene, F. & Spencer, P.(2013). Posterior composite restoration update: Focus on factors influencing form and function. *Clinical, Cosmetic and Investigational Dentistry*, 5, 33–42.

Esa, R., Ong, A. L., Humphris, G., & Freeman, R. (2014). The relationship of dental caries and dental fear in Malaysian adolescents: A latent variable approach. *BMC Oral Health*, 14(1).

Fahl N. (2012). Single shaded Direct Anterior Composite Restorations: A Simplified Technique For Enhanced Results. *Compendium of Continuing Education in Dentistry*. 33 (2), 150-4.

Kaisarly, D., El Gezawi, M., Keßler, A., Rösch, P., & Kunzelmann, K.-H. (2020). Shrinkage vectors in flowable bulk-fill and conventional composites: Bulk versus incremental application. *Clinical Oral Investigations*, 25(3), 1127–1139.

Kobayashi, S., Nakajima, M., Furusawa, K., Tichi, A., Hosaka, K., & Tagami, J. (2021). Color adjustment potential of single-shade resin composite to various-shade human teeth: Effect of structural color phenomenon. *Dental Materials Journal*, 40(4), 1033–1040.

Lassila, L., Säilynoja, E., Prinssi, R., Vallittu, P. K., & Garoushi, S. (2020). Bilayered composite restoration: The effect of layer thickness on fracture behavior. *Biomaterial Investigations in Dentistry*, 7(1), 80–85.

Morsy, Ahmad, Gamal, W., & Riad, M. (2020). Color matching of a single shade structurally colored universal resin composite with the surrounding hard dental tissues. *Egyptian Dental Journal*, 66(4), 2721–2727.

Opdam, N. J. M., van de Sande, F. H., Bronkhorst, E., Cenci, M. S., Bottenberg, P., Pallesen, U., Gaengler, P., Lindberg, A., Huysmans, M. C. D. N. J. M., & van Dijken, J. W. (2014). Longevity of posterior composite restorations. *Journal of Dental Research*, 93(10), 943–949.

Paolone, G., Devoto, W., Orsini, G., & Putignano, A. (2014). Composite Shade Guides and Color Matching. *The International Journal of Esthetic Dentistry*, 9(2), 164–182.

Velo, M. M., Coelho, L. V., Basting, R. T., Amaral, F. L., & França, F. M. (2016). Longevity of restorations in direct composite resin: Literature review. *RGO - Revista Gaúcha De Odontologia*, 64(3), 320–326.

Zhou, X., Huang, X., Li, M., Peng, X., Wang, S., Zhou, X., & Cheng, L. (2019). Development and status of resin composite as dental restorative materials. *Journal of Applied Polymer Science*, 136(44), 48180.

CASE REPORT Open Access

Aesthetic rehabilitation of upper central incisors using combined direct and indirect technique: A Case report

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Abstract

Improving dental appearances generally leads to an increase in confidence, social interactions and ultimately quality of life. This case aimed to perform aesthetic rehabilitation on the upper central incisors. The patient was a 25-year-old female who was concerned with the gap in her front teeth and discolouration of her crown. The treatment started with shade matching and preliminary measurements prior to cementation of temporary crown. Later, an all ceramic e.max Lithium Disilicate crown was cemented on tooth 11 followed by direct composite restoration on tooth 21 for diastema closure. In conclusion, both the indirect and direct restorative technique when applied appropriately proved to be effective and satisfactory to the patient.

Keywords: *aesthetic, composite, crown, e.max*

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Introduction

Any problems in areas of high aesthetic concern such as the anterior teeth especially in the maxilla where the teeth can be seen during smiling and speaking can lead to confidence and self esteem issues (Nugroho & Aco, 2020). One study showed that dental aesthetic is the third most common chief complaint after pain and check up and there were significant difference between the genders where females (23.48%) were more than males (11.50%) (Abdullah & Al-Tuhafi, 2006). There are a number of treatment modalities for an aesthetic rehabilitation among which are microabrasion, direct composite restorations or a combination of both, indirect composite restorations, veneers and crowns. Each treatment modality caries its own subset of pros and cons and is selected inn propriety to an individual case (Sowmya *et al.,* 2017). This paper outlines the treatment protocol for a young female who presented with dental aesthetic concerns in which a combination of a direct composite restoration and indirect crown was performed.

There are two types of crown available for anterior teeth which are metal ceramic crown and an all ceramic crown (NurulaqmarIwani, 2020). The minimum thickness of porcelain and metal required for metal-ceramic crowns is 0.7 and 0.5 mm, respectively, it is accepted that a labial reduction of 1.5 mm is required (Jr *et al.,* 2020). Therefore, to maximise the conservation of tooth structure, it is common to place a full metal coverage on the palatal surface which is a less aesthetically critical area and a porcelain coverage on the labial side. On the other side, an all ceramic crown would require more reduction. However, a Lithium Disilicate crown the overall reduction is 1.0mm and 0.7 to 0.8mm for a zirconia crown. The advantages of an e.max crown over a zirconia crown is its enduring aesthetic quality, translucent and lifelike appearance and less risk of chipping (Dolidze & Bitarova, 2016). Based on the systematic review, all-ceramic crowns, for anterior teeth, showed survival rates at 5 years compared to those seen for metal-ceramic crowns (Pjetursson *et al.,* 2007).

Treatment options for diastema closure is chosen according to case to case basis and the etiology of diastema. They can be treated by orthodontic closure, restorative therapy, prosthodontic therapy, surgical correction or multidisciplinary approach (Andarabi *et al.,* 2015; Hwang *et al.,* 2012). The upper left permanent central incisor which was sound was used as a collateral in the process to achieve a symmetrical diastema closure. Hence, the most conservative option possible was ideal in order to preserve the tooth. A conservative and aesthetic treatment of misaligned anterior teeth by direct composite additions are considered both a valuable and effective procedure (Peumans *et al.,* 1997). Specifically, a direct composite resin restoration would allow better operator control and allow for a complete assessment of the final morphology and shade matching in a single visit compared to an indirect restoration (Andarabi *et al.,* 2015).

Case report

A 25-year-old Malay female was concerned of the gap in her front teeth and discolouration of her crown. She had her metal ceramic crown as treatment for her previously deeply carious tooth back in high school. She also had fixed orthodontic appliances which was completed back in 2014 but she was non-compliant to the retainers. Intraoral examination revealed a metal ceramic crown on tooth 11 which was non tender to percussion, no bleeding on probing and no tooth sensitivity. A diastema was noted between tooth 11 and 21. The patient also presented with good oral hygiene and a high frenal attachment on the maxillary arch. Generalised fluorosis was noted on all the teeth in the upper arch.

Full mouth scaling and polishing was done as initial treatment followed by replacement of metal ceramic crown on 11 with an all ceramic e.max Lithium Disilicate crown. Shade selection for tooth 11 was done and the patient and operator decided on shade A2 (Chu *et al.,* 2010). The colour was recorded using VITA Classical shade guide. The prosthesis was removed from tooth 11 and the tooth preparation was refined in addition to the 1mm subgingival margin placement. Impression taking was done using the putty wash technique with 3M™ Express VPS Impression Material Light body and Regular Body (3M ESPE, USA). To achieve maximal aesthetics and overcome the diastema presented, prefabrication measurements were taken using callipers (Figure 1) for the ideal size, shape and proportion of tooth 11 and 21. The lab was also informed to mimic the surface detail of mild fluorosis on the incisal third of tooth 11 and to perform wax up on tooth 21 which shall provide space for future composite build up. Thereafter, a temporary crown was constructed for tooth 11 using the 3M ™ Protemp 4 Temporization Material (3M ESPE, USA) in the shade A2 (Figure 2c).

Figure 1. Illustration of measurement method using callipers. The space between the upper lateral incisors measured and divided in half to achieve symmetry.

Tooth isolation was done on tooth 13 until 23 using silk blue rubber dam (Sanctuary Health, MALAYSIA) and a brinker B5 clamp was used on tooth 11 as the main retraction to expose the margin of prepared tooth (Figure 2a, 2b).

The e.max Lithium Disilicate crown surface was treated using hydrofluoric acid for 60 seconds. Then rinse and dried followed by application of rubber phosphoric acid using a microbrush for 60 seconds which was again rinse and dried. The e.max Lithium Disilicate crown was then placed in an ultrasonic cleaner bath for 5 minutes and finally a fine drop of silane was applied on the crown fitting surface and heat dried. The prepared tooth 11 surface was cleaned with pumice. Later it was sandblasted with 50 microns aluminium oxide followed by a total etch 2 step technique using 37% phosphoric acid for 20 seconds which was rinse and dried and lastly, OptiBond FL (Kerr Company, USA) adhesive was placed uncured. The same adhesive was also applied on the fitting surface of the prosthesis to improve wettability. The A2 injectable composite GC gaenial (GC, EUROPE) was used and the e.max Lithium Disilicate crown was seated. Excess luting cement was removed before light curing for 20 seconds from the labial, incisal and palatal angles. Then, glycerin gel was applied, and a final cure for 40 seconds was done from all angles (labial, incisal, palatal, mesiolabial, distolabial, mesiopalatal, distopalatal, mesioincisal and distoincisal). The margins were trimmed, finished and polished after the rubber dam was removed. Final check of occlusion was done and was proved satisfactory to the patient.

The B5 clamp on tooth 11 was removed and a B4 clamp was used on tooth 21 as the main retraction (Figure 3a). The ceramic crown on tooth 11 was covered with a polytetrafluoroethylene (PTFE) tape to protect the surface (Figure 3b). A silicone putty impression of the wax up on the study cast was used as a guide for the diastema closure. Composite build up of tooth 21 was done using 3M Filtek Z350™ (3M ESPE, USA) in shade A2 (Figure 3c). Finishing of the restoration was done using a fine (red coded) diamond bur, followed by Shofu™ Supersnap.

Finishing and Polishing Disk (Shofu Dental, GERMANY) at the interproximal surface. Finally, polishing was done using finer discs and Eve™ Diacomp Twist (EVE Dental, GERMANY) (Sowmya et al., 2017). New Essix retainer were constructed for the upper and lower arch for post orthodontic retention.

Discussions

The rehabilitation of anterior teeth can never disclude aesthetics. Apart from the spacing and discolouration, the patient also had concerns on her appearance in photographs that can most likely be attributed to the lost of natural dental features. A dramatic change in appearance from correction of these problems often results in improved confidence, personality and social life (Ritter *et al.,* 2019). Fortunately, there are various aesthetic treatment options including direct and indirect techniques of restoration, both of which were used in this case.

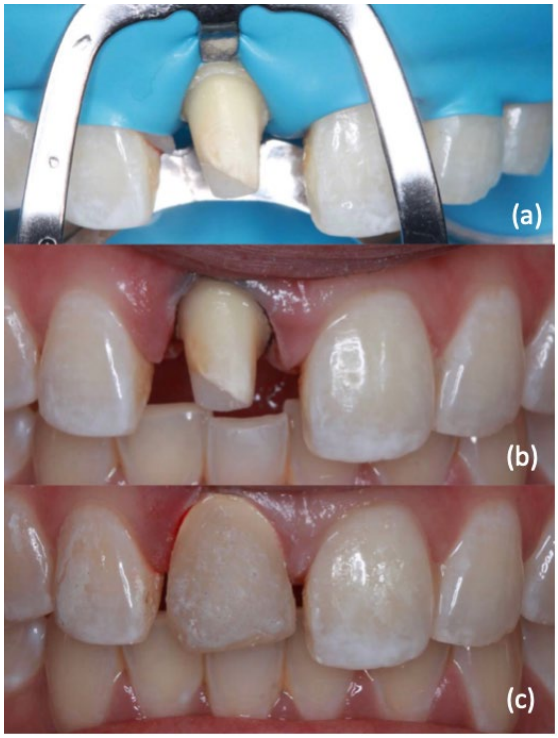

Figure 2. Rubberdam isolation of tooth 11 during the second appointment (a) Retraction of soft tissue before impression taking (b) Temporary restoration on tooth 11 (c)

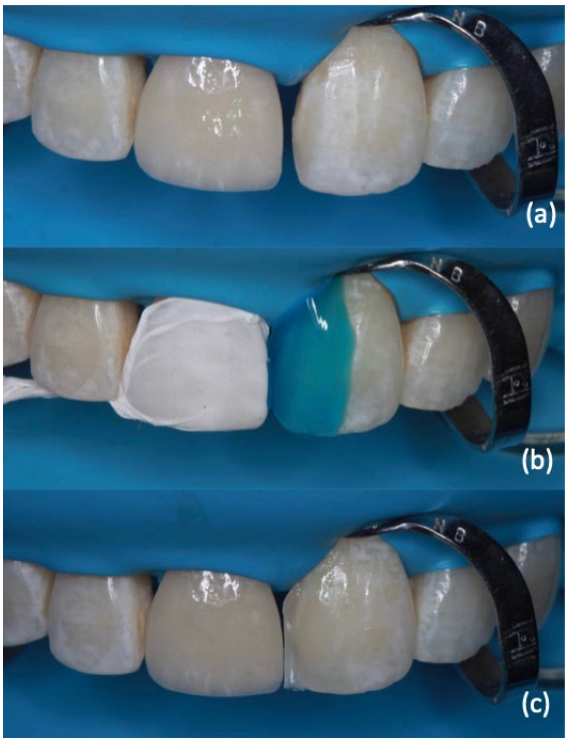

Figure 3. Rubberdam isolation of tooth 21 during the second appointment (a) Etching mesial half of tooth 21 for 30 seconds

Restoration of single tooth with an indirect restorative technique, although appears simple is actually more challenging in terms of shade matching. An all ceramic crown would offer superior aesthetics compared to a metal ceramic crown (Rathi & Verma, 2019). Especially nowadays, all-ceramic restorations are considered as the most aesthetically pleasing restorations available in dentistry, giving the tooth almost a life-like appearance, and a high degree of aesthetic satisfaction to the patient in addition to having good colour stability (Nobert *et al.,* 2019). The replacement of metal ceramic crown with an all ceramic e.max Lithium Disilicate crown would not raise concerns in terms of conservation of tooth structure since the tooth preparation requirements are almost similar. Additional tooth preparation was done only to move the preparation margin 1mm subgingival which was minimal and necessary to meet the patient's aesthetic demands.

The upper right permanent central incisor which presented with the former was replaced with the latter. The concern for that particular tooth was not symptomatic but rather an issue of un-satisfactory shade matching. There are more conservative options to an indirect crown restoration such as a direct composite restoration or an indirect veneer restoration. However, both are an objectionable choice since too much tooth structure has been loss to support the them. In addition, an all ceramic crown has a more superior colour stability compared to composite res-in (Sowmya *et al.,* 2017) and

it is an ideal substitute for porcelain-fused-to-metal crowns to overcome their aesthetic limitations (Anissa *et al.,*2016).

Diastema closure of the upper central incisors were done immediately after cementation of all ceramic crown on tooth 11 (Baia *et al,* 2018; Prakash *et al,* 2018). However, the success of this procedure was meticulously planned through various preliminary procedures. This included shade selection and measurements of the width of diastema using a calliper. The space between the upper permanent lateral incisors were measured and the space divided in half to achieve symmetry. Preliminary procedures are crucial in this case since it involves achieving equilibrium between an indirect and direct restoration. It only made sense then that the compo-site restoration only begins after we ensure that the e.max Lithium Disilicate crown was of ideal size, since the composite can be shaped to match the crown rather than the other way around. Normally, diastema closure restoration should emerge slightly below the crest to appear natural and confluent (Garg & Garg, 2015). Hence, adequate retraction should be given attention to when using rubber dam isolation.

In this patient, a combination of direct and indirect restoration was the best treatment option to solve the chief complaint. Restoring the upper right permanent central incisors with and indirect restoration allowed for a minimal reduction of the upper left permanent central incisors for the diastema closure (Oteo, 2012). The minimally invasive strategy is used to replace a failed restoration is highly beneficial in this case (Kusumasari *et al.,* 2021). Besides, despite the different long term outcomes in terms of colour stability exists for the different treatment approach for each tooth, the direct composite resin restoration could easily be repaired or replaced to match the crown in the future (Azzaldeen & Muhamad, 2015).

Reasonable aesthetics in terms of shape, colour and symmetry were achieved using both direct and indirect restorative techniques which successfully addressed the main concerns regarding natural looking restoration and closure of diastema.

Figure 4. Pre-operative photo showing metal ceramic crown on tooth 11 with gap between the upper central incisors (a) Post-operative photo showing all ceramic crown on tooth 11 and composite build up on tooth 21 (b).

Conclusions

Both all ceramic crown and the direct composite acid etch technique when applied appropriately proved to be effective and satisfactory to the patient.

References

Abdullah, B., & Al-Tuhafi, A. (2006). Chief complaints of patients attending College of Dentistry at Mosul University. *Al-Rafidain Dental Journal*, *7*(2), 201-205. Retrieved from https://rden.mosuljournals.com/article_39756_f4812e09229419c9830413659c9085c6.pdf

Andarabi, S., Zia, A., Kumar, A., & Alam, S. (2015). Closure of midline diastema by direct composite resin build-up using a customized matrix technique - a case report. *International Journal of Oral Health Dentistry*, 1(1), 46-49.

Anissa, BM., Chakroun, M., Hadyaoui, D., Nouira, Z., & Cherif, M. (2016). Zirconia based crowns for esthetic rehabilitation of severely discolored teeth:a case report. *Journal of Oral Health and Dental Science*, 1(1), 1-3.

Azzaldeen, A., & Muhamad, A. (2015). Diastema closure with direct composite: architectural gingival contouring. *Journal Of Advanced Medical and Dental Sciences Research*, 3(1), 134-139.

Baia, J., Ortiz, M., Brandao, G., Pereiro Neto, A., Araujo, J., & SIlva, C. (2018). Multidisciplinary aesthetic rehabilitation: case report. *Rio De Janeiro Dental Journal*, *3*(2), 37-41.

Chu, S., Devigus, A., Paravina, R., & Mieleszko, A. (2010). *Fundamentals of Color* (2nd ed.). Illinois: Quintessence Publishing Co.

Dolidze, T., & Bitarova, I. (2016). Advantages and disadvantages of e-max and zirconia crowns. *European Scientific Journal*, 12, 465-468.

Garg, N., & Garg, A. (2015). *Textbook of Operative Dentistry* (3rd ed.). Philadelphia: Jaypee Medical Inc.

Hwang, S., Ha, J., Jin, M., Kim, S., & Kim, Y. (2012). Diastema closure using dircet bonding restorations combined with orthodontic treatment:a case report. *Restorative Dentistry & Amp; Endodontics*, 37(3), 165.

Jr, H., Sather, D., Jr, E., Cain, J., Mitchell, D., Blanco, L., & Kessler, J. (2020). *Fundamentals of Fixed Prosthodontics* (3rd ed.). Batavia: Quintessence Publishing Co.

Kusumasari, C., Hatayama, T., & Shimada, Y. (2021). Replacement of two failed indirect restorations with direct bonded restorations using minimally invasive strategy. *Journal Of Dentistry Indonesia*, 28(3).

Norbert, A., Farina, A., Linden, M., Colussi, P., Paranhos, L., & Carli, J. (2019). Aesthetic and functional rehabilitation of anterior teeth using the in-ceram zirconia system: a case report. *Journal of Clinical and Diagnostic Research*.

Nugroho, J., & Aco, A. (2020). Porcelain veneer for a simple and esthetic treatment on anterior teeth with enamel hypoplasia: a case report. *Conservative Dentistry Journal*, *9*(2), 74-76.

Oteo, J. (2012). Additive solution to diastema closure by a combination of direct and indirect techniques. *Dentistry*, 02(03).

Peumans, M., Meerbeek, B., Lambrechts, P., & Vanherle, G. (1997). The 5-year clinical performance of direct composite additions to correct tooth form and position. *Clinical Oral Investigations*, 1(1), 12-18.

Pjetursson, B., Sailer, I., Zwahlen, M., & Hammerle, C. (2007). A systematic review of the survival and complication rates of all-ceramic and metal-ceramic reconstructions after an observation period of at least 3 years. Part I: single crowns. *Clinical Oral Implants Research*, 18, 73-85.

Prakash, L., Singh, M., Sarkar, M., & Kumar R, L. (2018). Application of CAD/CAM in esthetic rehabilitation using high translucent zirconia: a case series. *International Journal of Contemporary Medical Research*, *5*(11), 4-7.

Rathi, S., & Verma, A. (2019). Material selection for single-tooth crown restorations. *Applications Of Nanocomposite Materials in Dentistry*, 225-235.

Ritter, A., Boushell, L., Walter, R., & Sturdevant, C. (2019). *Sturdevant's Art and Science of Operative Dentistry* (7th ed.). Missouri: Elsevier.

Nurulaqmar-Iwani, S. (2020). Review article: different types of coronal restoration for endodontically treated anterior teeth: treatment recommendation. *International Journal Of Research Studies In Medical And Health Sciences*, 5(8), 26-35.

Sowmya, K., Dwijendra, K., Pranitha, V., & Roy, K. (2017). Esthetic rehabilitation with direct composite veneering: a report of 2 cases. *Case Reports in Dentistry*, *2017*, 1-3.

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Figures should be numbered consecutively in the order in which they appear in the manuscript, using Arabic numerals. Any figures should be inserted as close as possible to where they are cited in the text. The legend should explain each figure in detail. Colour figures will appear in the PDF file.

Page proofs

On acceptance of the manuscripts for publication, page proofs should be reviewed meticulously by the contributors. Changes made in proof should be limited to the correction of typographical errors. Proofs must be returned for publication with corrections and responses to queries on the date specified by the Editor.


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