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Letter from the Editor

All of us must pay attention to what is termed "information from the internet", especially from our patients. Some of the information is true, in the old sense of the word – what is claimed is a fact, as sure as the sun rises in the east. Some however are true in the new sense of the word – the information is found in the internet but the information is not a fact – there is no truth in it, it is misinformation.

Since information is now so accessible and we humans seem to be hooked on getting more information whether they be true or not, we may end up believing half-truths and absolute lies as truth. Social media on the internet aid the proliferation of misinformation. We have all observed some people walking along the road with their eyes glued on the electronic device in the day and the blue glow on their faces as they walk around at night.

Misinformation is not limited to that presented in social media. There is much misinformation through other sources, including billboard and television advertisements, websites, brochures printed by various companies and organisations for the purpose of marketing their services and products. Sometimes, these advertisements come with certain endorsements, the use of *argumentum ad verecundiam* – using respect for great men, customs, institutions, and authority in an attempt to strengthen the advertisers' position.

The amount of misinformation is so high in social media that scientists have decided to analyse it and see how it is spread along. No less than the Proceedings of the National Academy of Sciences (USA) has published an article (PNAS 2016 vol. 113 | no. 3 | 553–559) titled "The Spreading of Misinformation online". In their conclusion they wrote (and I quote *ad verbatim*) "Our findings show that users mostly tend to select and share content related to a specific narrative and to ignore the rest. In particular, we show that social homogeneity is the primary driver of content diffusion, and one frequent result is the formation of homogeneous, polarized clusters."

In other words, despite that there may be voices to the contrary of a certain "fact", people believe what they want to believe and will not read what they do not believe in. All told, we learn that it is most important to hear all sides of the story and evaluate each facet to see if it is logical, possible, and plausible before believing in any report and not just to cling on to what is safe for us to believe in or what is usual for us to believe is right, because new information can make a believe turn on its head.

There is much misinformation about dentistry and health on the internet and we as a profession could do more to help dispel the mistruths that are out there. One of the mistruths that I know about, which is used very often when a dentist is presenting to patient to do implants is this: "Implants last a long time – greater than 90% success for over twenty years". Yet what I read in reviews is this – one in four implants will end in peri-implantitis. This news was devastating enough for the English newspaper "The Telegraph", which devoted an article to it (accessed on 18 Nov 2017 <http://www.telegraph.co.uk/news/features/10964601/Peri-implantitis-The-time-bomb-in-dental-implants.html> titled "Peri-implantitis: The 'time bomb' in dental implants".

When you next present to patients for implants – frame your thoughts carefully before you begin, otherwise you may be guilty of chanting a mistruth that misguides a patient. In that instance, would you not be guilty of the tendency of "to select and share content related to a specific narrative and to ignore the rest"? As responsible dentists, we have to remember that many reports of success with implants are done in well controlled circumstances and not in an individual practice situation. Hence, in our own practices, the selection of patients, the control of post treatment management and follow-up may not be as stringent and the success rate may therefore be lower.

In this issue we have published an article on the management of "Peri-implantitis". The truth is – once peri-implantitis sets in, it is simply downhill for the implants till it is explanted. The battery of activities that we may choose to perform to try to stop it has not been reported to work effectively as yet, though it may help to prolong the time to "explantation". The paradox is this – rough implants have been reported to integrate better than smoother ones. Rough implants allow more plaque build-up!

Make choices with your patients carefully!

Editor
Sum CheePeng

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Review

Infective endocarditis - An update for dental surgeons

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ABSTRACT

Infective endocarditis (IE) is associated with significant morbidity and mortality. The prevention of infective endocarditis, for many years, has involved the identification of at risk patients undergoing medical or dental procedures and the use of pre-procedural antibiotic prophylaxis. However, evidence regarding the effectiveness of such measures is lacking while evidence is mounting for the adverse effects of inappropriate antibiotic use. International guidelines for antibiotic prophylaxis were amended, radically in some cases to reflect this. Subsequent epidemiological observations of IE have shown mixed results, strengthening calls for well conducted randomised control trials, now that there is genuine clinical equipoise among clinicians about this question.

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Introduction

Infective endocarditis (IE), is a rare but serious condition which currently still carries a mortality of up to 25% [1]. A yearly incidence of 3–10 per 1000,000 people has been reported [2]. Clinical features of IE are non-specific and include high fever (which may be absent in the elderly or immunocompromised), loss of weight, lethargy, shortness of breath, new or changing heart murmurs and possibly skin manifestations. Major complications include sepsis, stroke

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and heart failure from valvular dysfunction. Treatment is with prolonged intravenous antibiotics with a significant proportion requiring valvular surgery. Long term complications include the increased risk of re-infection, mechanical complications requiring repeated procedures and possibly life-long anticoagulation with its own attendant complications if prosthetic heart valve replacement is needed [2,3].

Risk factors

Traditional risk factors for the development of IE include the presence of a prosthetic heart valve, structural or congenital heart disease, intravenous drug use (IDU) and a recent history of an invasive medical or dental procedure. Of note, up to 50% of IE cases may develop in patients without a previously known cardiac valvular lesion [3].

The most common microorganisms identified as pathogens in IE include streptococci (including oral streptococci – viridans group streptococci [VGS]), staphylococci and enterococci species. *Staphylococcus aureus* IE and prosthetic valve IE are both associated with poorer outcomes. Indeed, a mortality of 40% or more among patients with prosthetic-valve infective endocarditis due to *Staphylococcus aureus* has been reported [3]. The mortality from IE due to VGS involving native valves is much lower and is estimated at 5% compared to up to 20% when prosthetic valves are involved [4]. The epidemiology of IE cases has shifted, in high-income countries, from underlying rheumatic heart disease with IE caused by VGS to underlying degenerative valvular disease, prosthetic valves or indwelling cardiac devices such as cardiac pacemakers and implantable cardio-defibrillators and infections caused by Staphylococci – both *S.aureus* and coagulase negative Staphylococci [1,5]. In recent years *Enteroccoccus faecalis* IE has also increased especially in the elderly, some of whom have had concomitant colorectal neoplasms detected; an association between the two has been suggested although robust data are lacking [6].

Infective endocarditis in Singapore

Data on IE cases locally have recently been published from the two tertiary hospitals in Singapore [7,8]. For instance, at the National University Hospital (NUH), 233 patients were diagnosed with IE over a 11 year period (2001 to 2011). The mean age of patients was 50 years with a slight male predominance. The commonest organism implicated was Staphylococcus species in 65% of cases, the remainder were due to streptococci (other than VGS). The in-hospital mortality was high at 23%. A high proportion (40–45%) of patients had underlying chronic kidney disease and diabetes mellitus, with a only a relatively small number having a known pre-existing cardiac condition such as congenital heart disease (9.1%) or a prosthetic valve (13%) [7]. Similar patient characteristics were reported from a study at National Heart Centre, Singapore General Hospital by Pang et al. in a review of 191 patients [8].

IE in children in Singapore is uncommon. In a 7-year period (May 1997 to April 2004), at KK Women's and Children Hospital [9], 27 children were diagnosed with IE. The mean age of the affected children was 8 years. Most of the children had a pre-existing congenital heart condition (either cyanotic or acyanotic). Only one child had a history of rheumatic valvular disease. The most common causative agent was VGS followed by *Staphylococcus aureus*. Forty percent of patients had a medical/surgical or dental procedure performed 2 to 6 months prior to the diagnosis of IE. The majority of these patients were given antibiotic prophylaxis perioperatively for their respective procedures. Of note, there was one affected child who had a dental procedure performed without antibiotic cover. These children also suffered significant adverse effects with 25.9% having a major embolic complication (transient ischaemic attack, cerebrovascular accident, pulmonary embolism) and two recorded fatalities in the study cohort.

A small but significant cohort of patients affected by IE in Singapore are the injecting drug users/abusers. Affected individuals are normally males in the younger age group (third decade), where right sided S. aureus IE predominates, and who traditionally have poorer outcomes, a mortality of 45% recorded in one such cohort of buprenorphine (Subutex) abusers in NUH during the period 2005-6 [10].

Infective endocarditis and antimicrobial prophylaxis

Due to the substantial morbidity and mortality associated with the development of IE, the reported “significant” role of “oral streptococci” (VGS) bacteraemia, presumably after dental procedures, in IE development, expert committees and professional societies have made several recommendations for antimicrobial prophylaxis for the prevention of bacterial endocarditis secondary to dental procedures since 1955 [4]. All these guidelines have been expert based rather than evidence-based as the efficacy of preprocedural antibiotics for prevention of IE has never been proven in a double-blinded randomised control trial. A 2013 Cochrane Database systematic review of antibiotic prophylaxis of IE in dentistry [11], concluded that there is no evidence to determine whether antibiotic prophylaxis before dental procedures is effective or ineffective. A recent publication by Cahill TJ et. al., 2017 [12] is the most extensive systematic review and meta-analysis of all studies available from 1960 to 2016 on antibiotic prophylaxis for infective endocarditis. The reviewers found limited evidence for benefit or harm and could not come to any definite conclusion on the effectiveness of antibiotic prophylaxis.

Additionally, in recent years, questions were raised on the relative importance of infrequent dental procedures causing IE compared with the cumulative impact of recurrent bacteraemia associated with daily activities such as toothbrushing, flossing, mastication, which, curiously, normally cause no harm. Further, doubt was cast on case reports linking IE to dental procedures as in many of these reports, IE developed many months after the procedure and were not caused by oral streptococci. To this end, it was felt that the maintenance of optimal oral health was more important to reduce the incidence of bacteraemia (and IE) from daily activities

than preprocedural prophylactic antibiotics for dental procedures. This has been borne out in a recent analysis [13]. Additionally, the adverse effects (anaphylaxis, antibiotic resistance) of antibiotics were felt to outweigh the benefits of prophylactic antibiotic use [4,14,15].

This led to various expert groups particularly in Europe, UK and US, acknowledging the absence of robust evidence based data for antibiotic prophylaxis, thus issuing major revisions to their guidelines from 2007 onwards. The American Heart Association (AHA)/American College of Cardiology (ACC) in 2007 [4] and the European Society for Cardiology (ESC) in 2009 [14] recommended restriction of antibiotic prophylaxis to those at highest risk. This included patients with previous IE, cyanotic congenital heart disease, prosthetic valves and recipients of cardiac transplants who had developed valvulopathy. This meant that those at intermediate or moderate risk were not indicated for antibiotic prophylaxis. The latter group included those with pre-existing native valve disease (including common conditions such as mitral valve prolapse, calcific aortic stenosis, bicuspid aortic valve) or rheumatic heart disease. In an update in June 2017, AHA/ACC included patients with transcatheter prosthetic valves and patients with prosthetic material used for cardiac valve repair as those in the high-risk category requiring IE prophylaxis, as well (Table 1). These additional indications were added following recent observational studies noting high risk of IE and high risk of adverse outcomes from patients in these subgroups [16]. The National Institute for Health and Care Excellence (NICE) of UK, in 2008 [15], however recommended against use of antibiotics prophylaxis *entirely*. This was modified in July 2016, to state that antibiotics should "not routinely" be recommended as prophylaxis for dental procedures [17].

Infective endocarditis trends post-guideline changes

Since the restriction of indications for antibiotic prophylaxis, there have been several observational studies in US, UK and Europe on the epidemiology of IE as this was a major shift in dental and medical practice. Initial studies [18], showed no increased incidence of IE but later studies (with longer observational periods) show mixed results with some reporting no increase while others indicating possible upward trend in IE (Table 2). Of note, supporting data on the microbiology of IE from many of these studies are lacking, in particular the proportion of infections due to VGS, the organism most likely to be influenced by the changes in IE prevention guidelines in dentistry. Additional most of the studies do not report on the specific dental procedures that the patient might have undergone.

In UK, where absolute restriction on antibiotic prophylaxis was recommended in 2008, a study in 2011 by Thornhill et al. [19] which analysed data from the entire UK'S National Health System, did not demonstrate any significant increase of IE in the 2 years post-NICE guidelines changes. This was despite a demonstrable fall of nearly 80% in antibiotic prescriptions for prophylaxis. However, when the study was extended for another 5 years, the authors noted in March 2015 [20], that there was a small but statistically significant increase incidence of IE, which by March 2013 accounted for an excess of 35 more IE cases per month. Notably, the increase included patients in the low and moderate cardiac risk category as well. The authors also recorded an almost 90% decrease in the use of antibiotic prophylaxis in this extended study period. The study did not include incidence data on the microbiology of IE, or adverse reactions to antibiotics, although in a later publication the adverse reactions notably, to the use of clindamycin for prophylaxis were documented [21].

Two large US population studies analysing cases of VGS – IE were conducted [22,23]. Both studies showed that the incidence of VGS-IE had not increased since the AHA, 2007 guideline changes. There was a reduction of 56% in antibiotic prophylaxis for patients in the moderate risk cardiac category after AHA, 2007 guidelines publication without any reported increase in endocarditis [24].

Table 1 – Patients at risk of developing infective endocarditis(AHA recommendations) [4,16].

High-risk	Low-risk
Prophylaxis against IE is reasonable before dental procedures that involve manipulation of gingival tissue, manipulation of the periapical region of teeth, or perforation of the oral mucosa in patients with the following: 1. Prosthetic cardiac valves, including transcatheter implanted prostheses and homografts 2. Prosthetic material used for cardiac valve repair, such as annuloplasty rings and chords 3. Previous IE 4. Unrepaired cyanotic CHD 5. Completely repaired CHD with prosthetic material or device by surgery or catheter intervention during the first 6 months after the procedure 6. Repaired CHD with residual shunts or valvular regurgitation at the site of or adjacent to the site of a prosthetic patch or prosthetic device. 7. Cardiac transplant with valve regurgitation due to a structurally abnormal valve	Prophylaxis is no longer recommended for the following patients: 1. Mitral valve prolapse 2. Rheumatic heart disease 3. Congenital heart conditions (atrial septal defect, ventral septal defect, hypertrophic cardiomyopathy) 4. Calcific aortic stenosis 5. Bicuspid aortic valve

IE – Infective endocarditis; CHD – Congenital heart disease.

Table 2 – IE incidence after antibiotic prophylaxis guidelines changes.

References	Country	Increase in IE	Increase in Oral Streptococcus IE (VGS IE)	Study period
Rogers et al. [18]	U.S. (San Francisco)	NO	NR	May 2007-Jan 2008
Thornhill et al. [19]	England	NO	NO	April 2008-April 2010
DeSimone et al. [22]	U.S. Olmsted County, Minnesota	NO	NO	1999–2010
Pasquali et al. [26]	U. S. (<18yrs)	NO	NO	2003–2010
Duval et al.[31]	France[a]	NO	NO	(1991,1999,2008)
Dayer et al. [20]	England	YES	NR	Jan 2000-July 2013
DeSimone et al. [23]	U.S. Olmsted County, Minnesota	NO	NO	1999–2013
Pant et al. [25]	U. S.	YES	NR (increase in Streptoccoccus IE)	2000–2011
Bates et al. [27]	U.S. (5–18 yr old)	NO	NO	2003–2014
Mackie et al. [30]	Canada	NO	NO (decrease)	April 2002-March 2013
Bizmark et al. [28]	U.S. (< 18 yrs)	NO	YES (in 10–17 yr old age group)	2001–2012
Toyoda et al. [29]	U.S (California, NY)	NO	NO	1998–2013
Keller et al. [32]	Germany	YES	NR (increase in Streptoccoccus IE)	2005–2014
Van den Brink et al., 2017 [33]	Netherlands	YES	YES	2005-2011

NR: Not Recorded.
[a] In France antibiotic prophylactic restrictions were implemented in 2002.

Conflicting results were observed in studies on US paediatric IE cases. Two earlier published studies showed no increase in IE cases in children [26,27]. Bizmark et al., 2017 [28], used a larger US patient database, the Nationwide Inpatient Sample to analyse paediatric hospitalisations between 2001 to 2012. The investigators found no overall change in IE incidence or severity pre and post guideline changes. However, IE cases specifically due to VGS in the older children (10–17 years) increased significantly in the period after the guidelines changes. The authors postulated that this increase may be due to this older group requiring more dental care which increases their risk of exposure to bacteraemia, and hence IE, during invasive dental procedures. If these findings are replicated this could have implications for dental prophylaxis for those with a broader range of congenital heart disease.

The findings of other recent studies are summarised in Table 2. Locally and in other parts of Asia where American Heart Association guidelines are generally recommended and followed, data on post-guideline changes of IE incidence are lacking.

Discussion

Epidemiological studies worldwide indicate changes in the profile of IE from a predominantly streptococcal disease in patients with previously known rheumatic heart disease to a predominantly staphylococcal healthcare-related disease in the elderly suffering from several comorbidities and with prosthetic cardiac devices. Such trends are also being seen in Singapore. In recent years there has been a shift in emphasis from dental procedure associated bacteraemia causing IE and the use of preprocedural antibiotic prophylaxis, to the maintenance of optimal oral health to prevent "everyday bacteraemia" [4,13,14]. These have been reflected in the restrictions in guideline recommendations for prescribing antibiotics prophylaxis.

There have been mixed findings in epidemiological studies conducted to evaluate the impact of restriction of antibiotic prophylaxis on IE trends. The reasons for the differences in observed findings are unclear. Besides the generalised inherent limitations of large observational, non-randomised studies, with differing methodologies and follow up periods, conducted, on heterogenous population groups, other reasons that may account for the differences include: an increase in the number of at risk patients undergoing invasive procedures resulting in bacteraemia, an increase in the high risk population prone to IE such as the elderly, patients with diabetes mellitus, renal failure, chronic dialysis and those with intra-cardiac prosthetic devices. Other contributing factors suggested include lower diagnostic thresholds, changes in hospital coding practices, using different or wrong diagnostic codes for IE, using administrative data rather than clinical data and recapturing patients data more than once due to readmission or retreatment at different times or hospitals [19–31]. Overall, the existing data we have do not provide strong evidence that the restrictions in antibiotic prophylaxis have impacted the incidence of, in particular, VGS IE. Instead it has raised concerns and caused confusion amongst some clinicians [34].

The need for a randomised controlled trial to evaluate the efficacy of antibiotic prophylaxis is long overdue. For such a trial to have sufficient statistical power, a multinational, multicentre collaborative effort is needed to recruit a large number of individuals at risk, randomised to placebo or antibiotics, and followed through for several years. Design of such a study must also take into account the low incidence of IE, the need for enough subjects with each of the various subtypes of cardiac conditions and the different dental procedures and oral disease states [35,36].

Conclusions

Infective endocarditis is a serious condition with a mortality of up to 25% at 1 year, a prognosis worse than most cancers.

The importance of various patient and procedural (especially dental) predisposing risk factors for IE are uncertain as is the effectiveness of antibiotic prophylaxis. An international collaboration is needed to design and conduct a randomised controlled trial to settle these issues definitively. This should involve individuals from both developed and low/middle income countries worldwide. In the meantime, the best approach that the dental surgeon can take is to follow AHA, 2007 guidelines and the 2017 AHA/ACC focused update (the next guideline publication is not expected before 2018) in prescribing antibiotic prophylaxis for high risk cardiac patients and to emphasise the importance of optimising oral health to reduce the incidence of bacteraemia from activities of daily living such as chewing, brushing, flossing. Dental practitioners should have a low threshold to refer patients for medical assessment if any at risk cardiac patient develops signs and symptoms suggestive of IE after invasive dental procedures or even in the course of routine treatment for oral disease.

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Review

Management of peri-implantitis – A contemporary synopsis

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ABSTRACT

Prevalence of peri-implant complication is expected to be on the rise with the increased number of implants being placed. Depending on the degree of osseous involvement, the clinician needs to decide if the treatment goal is to arrest the disease progression, regeneration or explantation and replacement. Host's medical status, defect configuration, aesthetic outcome, ability to access for plaque control post-treatment, and the patient's wishes are key factors to consider. The purpose of this review is to provide a contemporary synopsis on the management of peri-implantitis with emphasis on explantation. Guidance on the identification of factors/situations where salvaging an implant may be less favourable is discussed and the various techniques to remove a fractured, or peri-implantitis-affected non-mobile implant are described.

Contents

Introduction

Peri-implant complications range from minor soft tissue inflammation to significant progressive bone loss. Peri-implant mucositis is a condition similar to gingivitis, described as a reversible inflammatory lesion affecting the soft tissue in the area immediately around implants whereas peri-implantitis is an inflammatory process of the soft tissue surrounding an implant accompanied by bone loss that exceeds normal physiological remodeling [1]. As one in four patients receiving implant therapy are likely to show signs of peri-implant diseases with varying degrees of severity

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throughout the lifespan of the implants [2,3], clinicians will be confronted with peri-implant complications requiring appropriate management.

Whilst the infection is confined to the soft tissues, full resolution of infection can be expected on the removal of the contributing factors and adequate plaque control [4,5]. As the disease progresses to involve the osseous structures, surgical intervention is usually indicated [6,7]. Depending on the degree of osseous involvement, the clinician needs to decide if the treatment goal is to arrest the disease progression, regeneration or explantation and replacement [8–10]. Host's medical status, defect configuration, aesthetic outcome, ability to access for plaque control post-treatment, and the patient's wishes are key factors to consider.

Much has been reported in the literature on the treatment of peri-implantitis [11–15]. Though the most predictable treatment modality has yet to be agreed upon, the consensus remains that effective surface decontamination is a prerequisite [15]. However, the use of rough surfaced implants has cast doubts on the feasibility of a full resolution of infection [16,17]. Once exposed, the microstructures of the rough surface have a higher affinity for biofilm development that is robust, tenacious to remove and difficult to maintain plaque free [18]. Recent developments in implant removal devices have allowed for more conservative methods of explantation such as reverse-torque devices in place of the traditional approach of trephining [19]. The minimal invasiveness has made implant removal a viable treatment option for management of peri-implantitis.

The purpose of this review is to provide a contemporary synopsis on the management of peri-implantitis with emphasis on explantation. Guidance on the identification of factors/situations where salvaging an implant may be less favourable is discussed and the various techniques to remove a failed, fractured, or peri-implantitis-affected non-mobile implant are described.

Host factor

More implants are placed in older populations with increasing longevity younger patients with decades of life expectancy is likely that patients develop medical conditions that mitigate the host defenses after years of implant in service.

Patients with systemic conditions that are risk factors for periodontitis (such as uncontrolled diabetics, heavy smokers and the immunosuppressed) are more vulnerable to develop peri-implantitis [20–21]. Similarly, the treatment outcome this group of patients is less predictable; the prognosis in patients who develop these debilitations is also less certain. Until the systemic condition is under control, management of peri-implant complication should remain conservative, including mechanical debridement, antiseptics, antibacterial drugs and adequate home care. Approach should be employed in patients undergoing head and neck radiotherapy and patients with a history of, or vulnerable to medication-related osteonecrosis of the jaw (MRONJ), such as intravenous bisphosphonate [22]. MRONJ is a painful condition that is difficult to manage and can lead to devastating defects. Recent studies have shown bone sequestration can occur in already osseointegrated implants bisphosphonate administration [23] (Fig. 1).

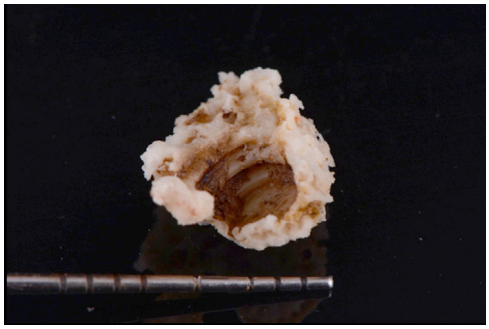


Fig. 1 – En-bloc bone sequestration removed from a failing implant of a patient with a long history use of bisphosphonate; note the implant thread marks seen on the inside of the sequestrum.

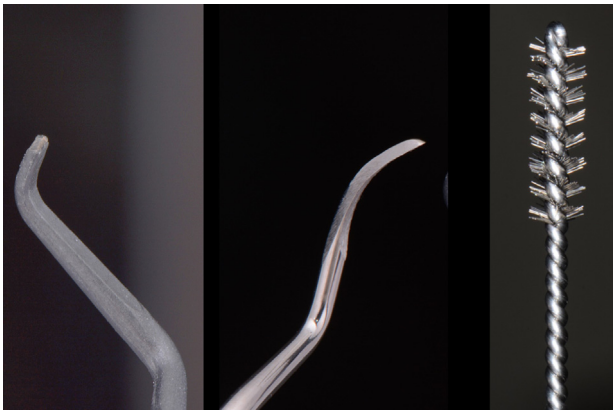


Fig. 2 – Implant-specific scalers and curettes with tip design to prevent scratches or other damage to the implant. (Left)-Carbon scaler; (Middle)-Titanium scaler; (Right)-Titanium brushes for surgical debridement.

Severity of disease and defect configuration

Early detection of biofilm progression to peri-implant mucositis is crucial as it is treatable with biofilm disruption [24]. Plaque induced peri-implant mucositis is characterized by redness, swelling and bleeding on gentle probing clinically. The inflammatory process of peri-implant mucositis is akin to gingivitis around natural teeth, but the magnitude and severity of tissue inflammation may be more severe and challenging to reverse with treatment in comparison to teeth of the natural dentition [24]. Mechanical debridement is effective in controlling peri-implant mucositis in terms of probing depth reduction. Usage of chlorhexidine in combination with mechanical debridement has been shown to improve clinical and microbiological parameters [25]. Implant-appropriate curettes, such as titanium or carbon curettes or brushes should be used to debride the implant surface thoroughly under local anesthetics (Fig. 2). Ultrasonic scaling should be avoided to prevent release of titanium particles which may aggravate inflammation [41].

Untreated mucositis can progress into peri-implantitis in which the local host response mediates bone resorption in a similar way to periodontitis, resulting in decreased bone-to-

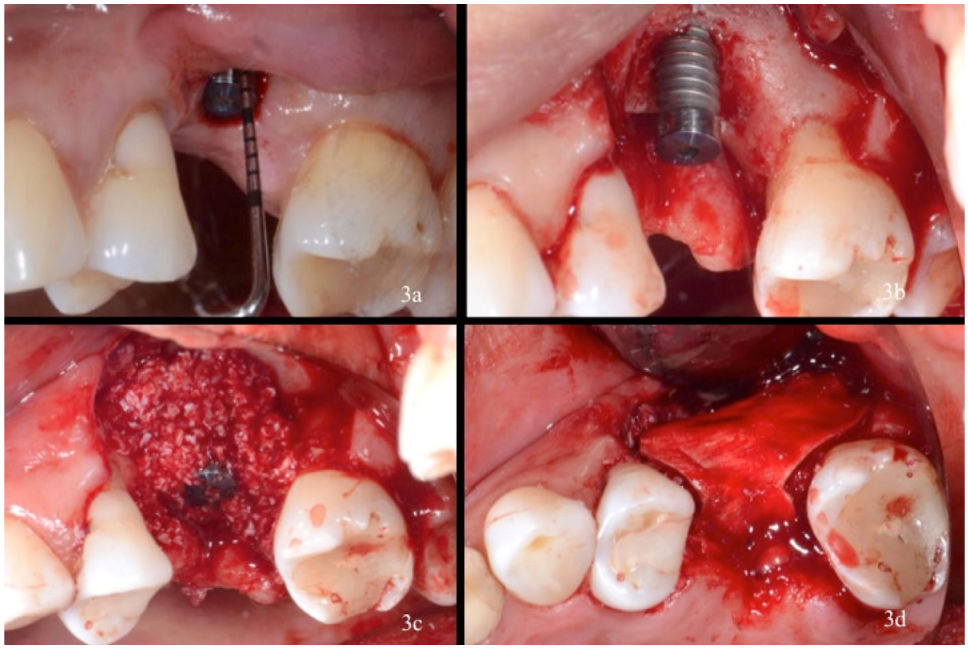


Fig. 3 – a. Clinical view of a peri-implantitis affected implant with bleeding on probing, suppuration, and bone loss. b. Flap reflection revealed infrabony defect. c. Bone graft substitutes were packed along the exposed implant threads following surface decontamination. d. A resorbable membrane was used to contain the graft.

implant contact over time [25]. It is characterized by bleeding on probing, suppuration and radiographic evidence of progressive bone loss. Administration of systemic or local antibiotics coupled with non-surgical intervention can be effective when the radiographic evidence of bone loss is less than 2 mm [26]. Surgical access is recommended in defects more than 2 mm in order to achieve complete removal of granulation tissue and to gain access for the decontamination of the implant surface [25,26]. Methods of surface decontamination include mechanical debridement alone, or in combination with saline, antiseptics, lasers, photodynamic therapy, air powder abrasion or implantoplasty [11–15].

The decision to further remedy the defect with resective or regenerative therapy is based on the bone defect configuration, containment of the bone graft substitute, the desired aesthetic outcome and the patient's ability to maintain plaque control. The regenerative approach has better predictability when the presentation of the defect is infrabony or circumferential [27–29] (Fig. 3a–d). In other words, the more the remaining sound bone walls are around a defect, the better the outcome. Defects of such configuration can better maintain the graft stability and regain the scaffold around the implant, thereby reducing the probing depth, and increasing bone-to-implant contact. Regenerative procedures using bone graft substitutes combined with resorbable membrane and submerged healing, or with bone substitutes alone; or in combination with a resorbable membrane in a non-submerged model have all demonstrated positive clinical outcomes [29]. Reviews have failed to reveal any correlation between any specific regenerative therapy and positive clinical outcomes. However, surface access for surface decontamination appeared to be a critical factor in the decontamination process. Furthermore, the frequency of post-surgery professional maintenance schedule also seemed to be important [15].

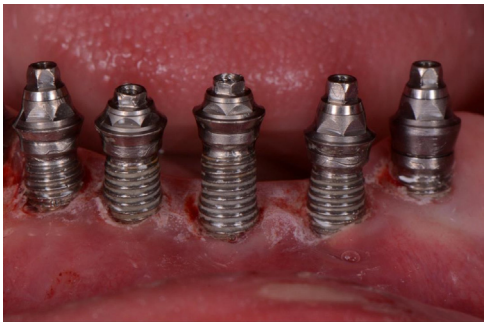
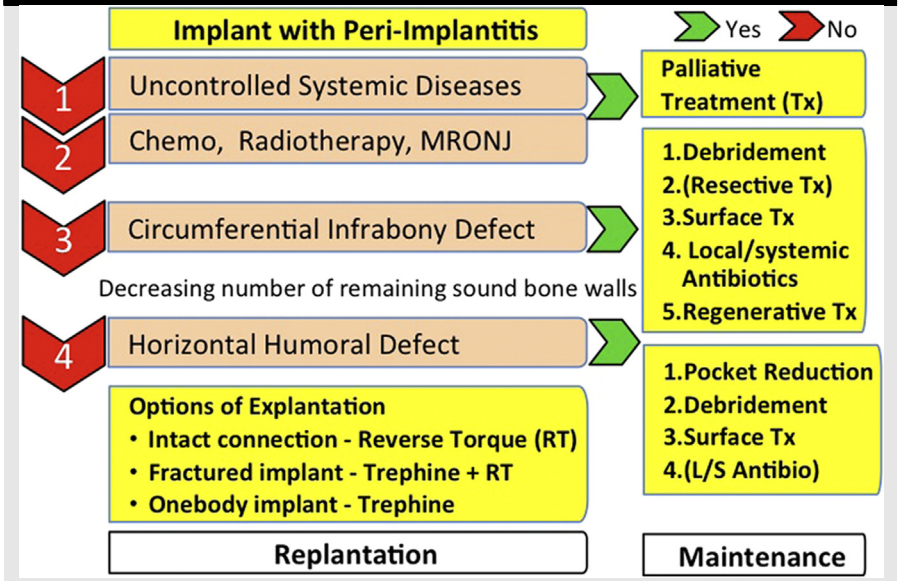


Fig. 4 – Resective procedures performed on peri-implantitis affected implants with horizontal bone loss, note the band of keratinized tissues around the implants to facilitate hygiene.

A resective approach is indicated when the peri-implant defect is horizontal and containment of bone graft substitutes is difficult. It eliminates disease progression through pocket reduction via an apically repositioned flap, bone re-contouring and surface decontamination, or implantoplasty if [30–32]. The purpose of implantoplasty is to remove the biofilm retentive site, and to provide a smooth implant surface for easier hygiene maintenance. A threshold value (Ra of 0.2 μm) has been shown to be adequate in terms of final surface roughness and it can be achieved with the use of rotary diamond burs in decreasing roughness, followed by an arkansas stone [33]. It should be noted that the resective procedure can have an unaesthetic outcome (Fig. 4); and implantoplasty may impact the mechanical strength of the implant [34].

Regardless of the choice of therapy, when the goal of treatment is to save the implant, the clinician should first ensure an effective method of surface decontamination, which eliminates the biofilm and allows access for cleaning, repair

Table 1 – Decision tree for the management of peri-implantitis and options for explantation.



and/or regeneration of the hard and soft tissue around the implant [15]. Patients with concomitant active periodontal disease need to have their periodontal disease controlled and the patient's oral hygiene has to be at an optimal level prior to definitive treatment of peri-implantitis by surgical means.

Explantation

Decision-making for explanation should be based on the presence of mobility, amount of bone loss, prosthesis design, condition of the implant, predictability of treatment outcome and patient's preference. The literature is in agreement that a mobile implant has to be removed, but consensus has not been reached on ailing implants [35]. It has been suggested that removal is indicated when ongoing bone loss exceeds more than ½ of the implant length [26]. However, this guideline may not be applicable to short and tapered implants (implants < 8 mm) as the total remaining bone-to-implant contact may not justify salvaging.

The prosthesis design can influence the decision to save or remove a peri-implantitis affected implant. When the long-term prognosis of a multi-unit splinted prosthesis is not compromised by the removal of one ailing implant, explantation is the most cost effective measure. Conversely, if the ailing implant is in a position that is strategically important to the supported prosthesis or if the supported restoration is aesthetically satisfactory, saving the implant may be more prudent. The type of implant can also effect the decision. Threaded screw type implants are easier to remove than circumferential plateau design such as Bicon dental implants. Lastly, the patient's wishes need to be respected. The extensive procedures involved to augment the defect following explantation can be both financially and emotionally stressful. Conversely, multiple attempts may be required for the regenerative approach to achieve an ideal outcome. Patients need to be informed of the risks and benefits of all treatment options before a decision is reached (Table 1).

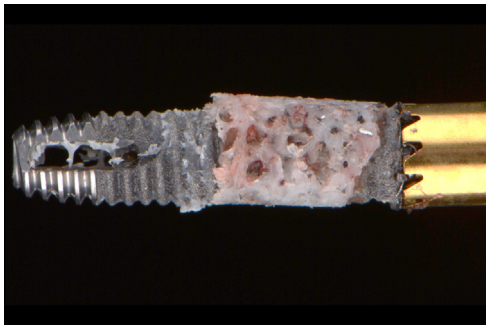


Fig. 5 – Example of a commercial implant removal device (3I implant removal kit).

Fig. 6 – Examples of implant company explantation devices (Straumann, Switzerland). The device engages the abutment screw chamber and attaches to a reverse torque wrench for implant removal.

Once the decision for explantation is confirmed, the most conservative technique to remove the affected implant

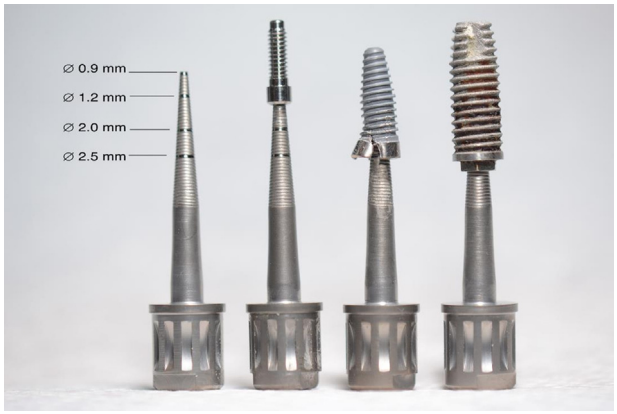


Fig. 7 – Universal reverse screw device, which engages deeper into the screw chamber beyond the abutment screw threads, is designed to remove implants with damaged platform or stripped/fractured abutment screw camber (EBI, South Korea).

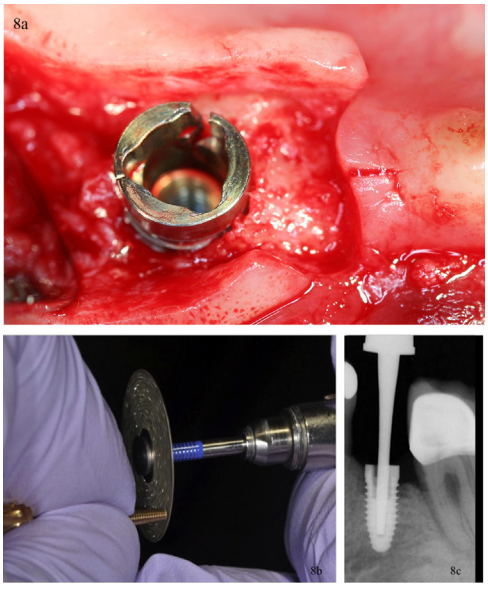


Fig. 8 – a Tri-lobe platform damaged under high torque force upon implant removal. b. A reverse screw device adjusted with a diamond disk to an appropriate length to engage the screw chamber of the implant. c. Periapical radiograph confirming the engagement of the adjusted reverse screw device.

should be employed. Since most implants on the markets are screw-types, the least invasive technique for explantation is to unscrew the implant by breaking the bone-to-implant interface. Many commercial implant removal kits are available (Fig. 5). Reverse torque techniques with implant drivers, explantation devices (Fig. 6) or reverse screw devices (Fig. 7) are designed to unscrew the implants with minimum destruction to the surrounding tissues [19]. Threaded, tapered implants can usually be removed easily with reverse torque techniques. Excessive torque force should be avoided to prevent damage to the implant platform (Fig. 8a). Once damaged, the implant driver can no longer engage the implant and a reverse screw device which engages beyond the platform is used for implant removal (Fig. 8b,c). The reverse screw device is also used when the abutment screw chamber within the implant is stripped or fractured off (Fig. 9a,b) as it can engage deeper into the screw chamber beyond the abutment screw threads (Fig. 10).

A combination of coronal bone removal and reverse torque are sometimes needed to remove fractured implants.

Fig. 10 – Cross-sections of a reverse screw engaging an implant with an internal connection (left) and an implant with an external connection (right), note the difference in length of engagement.

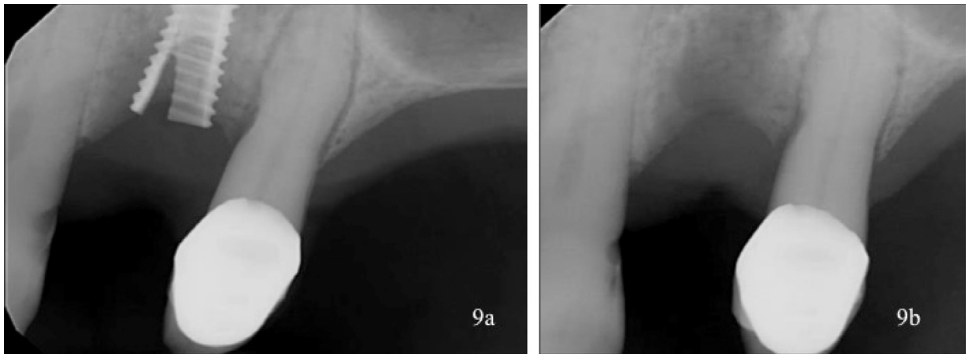


Fig. 9 – a. Periapical radiograph of an implant with its abutment screw chamber fractured off. b. Periapical radiograph after implant removal with a reverse screw device.

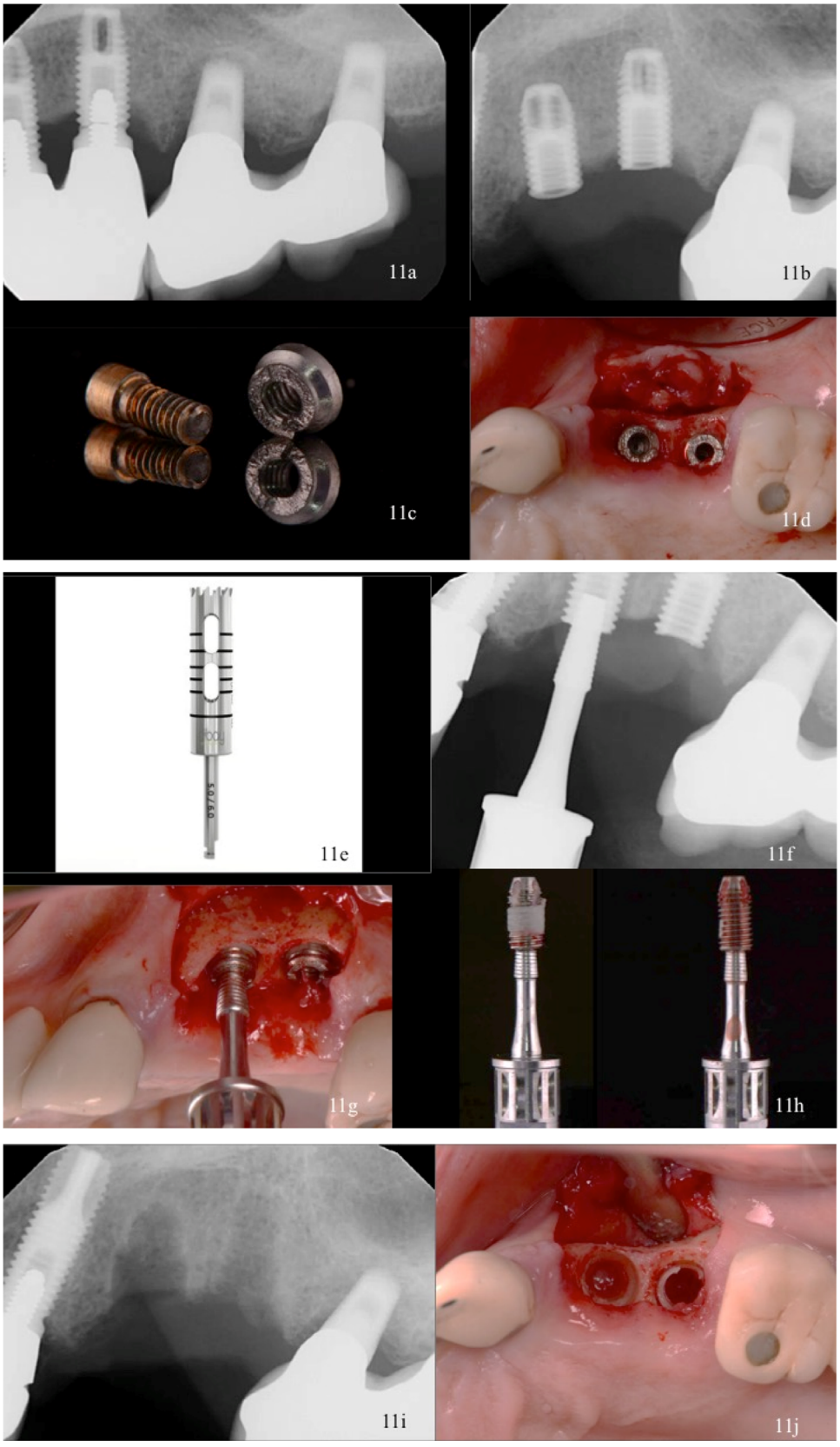


Fig. 11 – a. Periapical radiograph of two implants (maxillary left first and second premolars) with fractures below the implant-abutment connections. b. Periapical radiograph of the fractured implants with the prosthesis removed. c. Removed fractured head of the implant and the abutment screw. d. Intra-oral view of the fractured implants, note the bone surrounding the implants. e. Example of a trephine bur. f. Periapical radiograph showing the space created parallel to the coronal 1/2 of the implants by the trephine bur and a reverse screw device attached to the implant. g. A reverse screw device used to engage the implants and implants removed with a reverse torque wrench. h. Removed implants, note the bone attached to the implant at the trephined portion. i. Periapical radiograph after explantation, note the depth and size of the defect size. j. Intra-oral view of post-implant removal.

Oftentimes, once the fractured portion is removed, the remaining part of the implant is surrounded by dense bone. In these cases, a trephine is used initially to remove sufficient supporting bone around the coronal parts of the implant fragment to loosen the implant. After which, the reverse torque ratchet on a reverse screw device is attached to the implants to unscrew the implants (Fig. 11a-j).

Trephining is the most invasive option for implant removal and should only be employed when all other methods are exhausted. It is indicated for removal of one-body implants since implant drivers for one-piece designs are unable to sustain the reverse torque needed for unscrewing (Fig. 12). Trephining is also used to remove non-threaded circumferential plateau type of implant, for example Bicon dental implants, because implants of such design cannot be unscrewed (Fig. 13a–e). Since trephining can lead to both hard and soft tissue defects, the smallest effective size trephine should be selected where the internal diameter of the trephine is only slightly larger than the implant to avoid engaging the implant body, and at the same time minimizing.

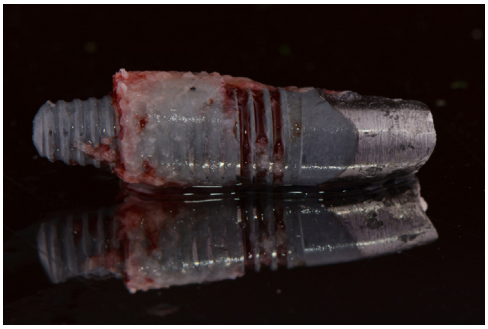


Fig. 12 – A peri-implantitis affected one-body implant removed with trephining.

Treatment planning and post-delivery care

All factors should be taken into consideration when deciding on salvaging or explanting a peri-implantitis affected non- mobile implant. The risks and benefits of each need to be assessed thoroughly. The extensive and costly procedures involved augmenting the defect following explantation need to be anticipated and clearly communicated to the patient. Conversely, multiple attempts may be required if treatment goal is to save the implant. Whilst various treatment modalities are available for the management of peri-implantitis, and development in devices has made explantation easier and less invasive; prevention of the diseases remains more effective than treatment.

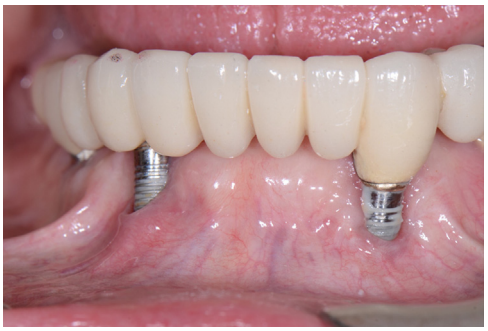


Fig. 14 – The buccally placed implants coupled with a thin gingival biotype has led to recession exposing the rough surfaced implants, note the plaque accumulation on the threads.

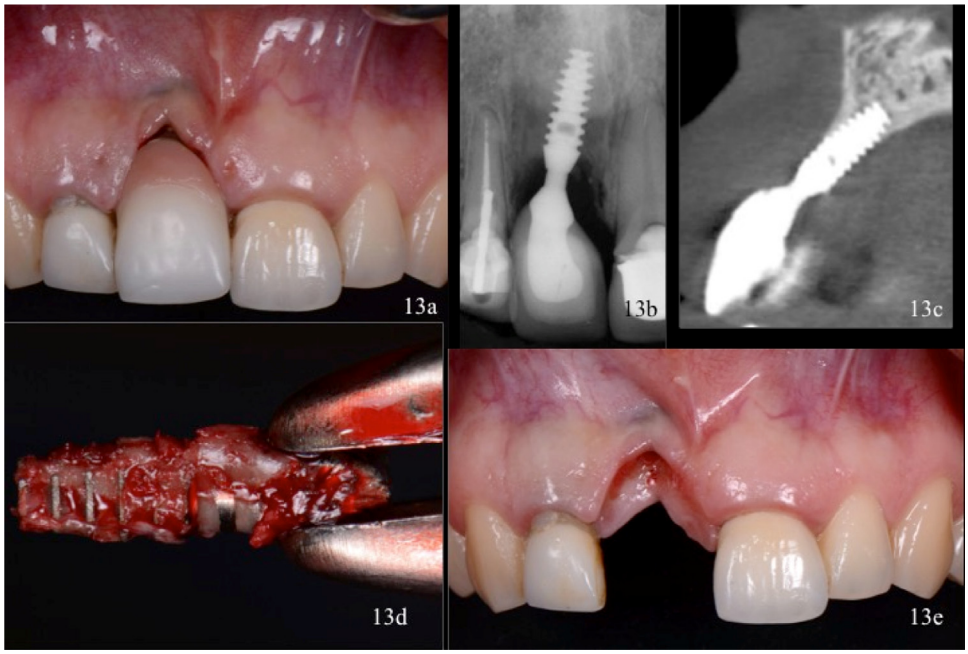


Fig. 13 – a. Clinical view of a peri-implantitis affected plateau dental implant with unsatisfactory aesthetics. b. Periapical radiograph of a peri-implantitis affected dental implant. c. CT-scan image demonstrating bone loss bucally and palatally. d. A trephine bur was used to separate the implant-to-bone contact and the implant was gently luxated and removed with a pair of forceps. e. Extensive hard and soft tissue defects following implant removal.

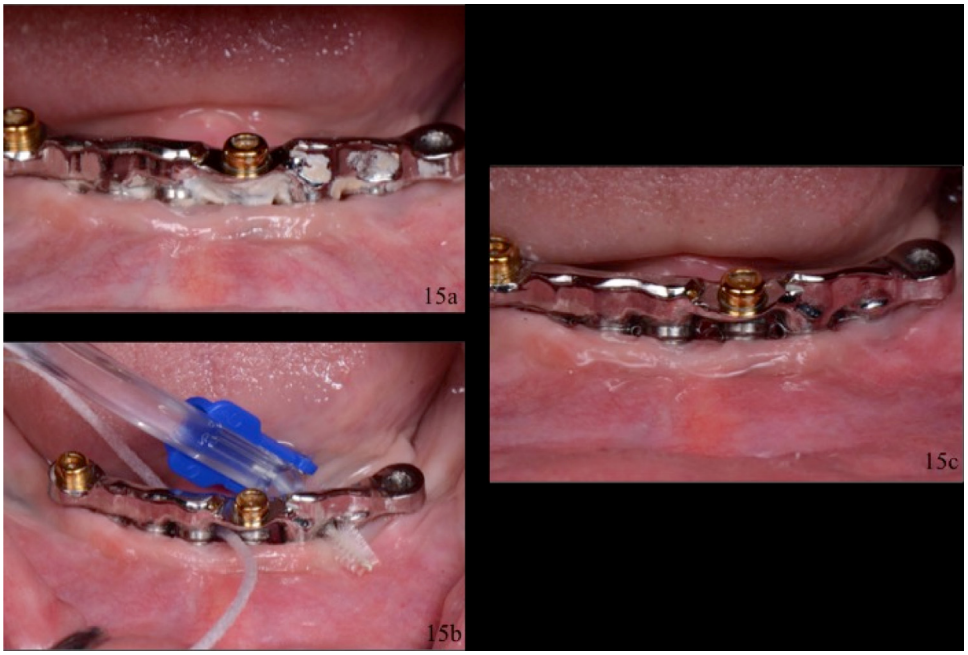


Fig. 15 – a. Calculus built-up underneath a mesostructure of an overdenture. b. The mesostructure design and the presence of a band of keratinized tissue facilitate oral hygiene measures and maintenance. c. The patient was able to maintain the implants despite the exposed threads.

Implant placement not only should be prosthetically driven, it has to be "cleansability" directed. Prosthetic designs need to facilitate hygiene measures professionally and at home. Correct three-dimensional implant placement has to be followed to enable adequate running room and emergence profile. Over contoured restorations with abrupt emergence profiles often result from implants placed too superficially or too palatally. Access to hygiene may be hindered in implants placed too deeply. Recession can result from implants placed too buccally leading to exposed implant threads (Fig. 14). A minimum of 2 mm remaining buccal bone following implant placement has been advocated to accommodate for bone remodeling and long-term stability [36].

Screw retained prostheses avoid the need to for cement and their retrievability enables easier access for modification and cleaning if needed. When cement restoration is indicated, care must be taken to avoid excess cement. Excess cement acts as a plaque retentive site, or causes a foreign body reaction, which leads to a localized acute inflammation. Different types of cement have different to biofilm formation and those tend to leave more undetected excess also have a higher prevalence for peri-implant inflammation [37].

The need for a band of keratinized tissue around dental implants has been highlighted [38]. Despite a lack of strong evidence with regard to the benefits of the presence of keratinized mucosa and crestal bone level, the bound-down keratinized tissues improves patient comfort and facilitates oral hygiene, thereby maintaining better peri-implant health is facilitated [39](Fig. 15a–c).

A customized maintenance program coupled with adequate home care is essential for the long-term success of dental implant treatment. It has been demonstrated that peri-implant mucositis was less likely to progress into peri-implantitis in patients who had regular maintenance compared to those who were not maintained [40]. The frequency of the recall should be based on individual patient's risk factors and prosthesis design. Regular maintenance at three months internals has been advocated for patients with increased risk factors [15].

Conflict of interest

The authors have not received any institutional, private, or corporate financial support for the study reported herein. In addition, the authors do not have a financial interest in the companies that manufacture the products used in this study.

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Short Communication

The use of an iced cotton bud as an effective pre-cooling method for palatal anaesthesia: A technical note

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ABSTRACT

The palatal injection of anaesthesia is more painful for the patient when compared to other sites of the oral cavity. Pre-cooling (cyro anaesthesia) is a well-known method practiced to reduce pain, with the use of ice or refrigerant spray on the affected site. The already known methods of ice application to the palatal site have few practical drawbacks. Therefore, this technical note highlights the use of an iced cotton bud as a novel way of providing effective pre-cooling for palatal anaesthesia. Commercially available cotton buds were dipped in clean water and then placed in the freezer. Next the frozen cotton bud was placed on the proposed anaesthetic site for one minute and anaesthesia less than 0.5CC local anaesthetic solution was delivered at a slow pace while maintaining pressure using the iced-cotton cotton bud. All patients tested showed a 0 pain response to a visual analogue scale of 0–10. This technique can be valuable to dental practitioners who are aiming for a pain free anaesthetic experience for their patients. There is potential for further research and evaluation of this technique.

Introduction

Injection of local anaesthetics naturally causes pain, and is is a reason for anxiety amongst dental patients [1]. Dental anaesthesia is given in multiple intra oral sites, that commonly include maxillary buccal infiltrations, palatal infiltrations, mandibular nerve blocks and intra-ligamentary infiltrations. The provision of intra oral palatal anaesthesia can be potentially more painful for the patient when compared to other sites of the oral cavity, as palatal tissues are tightly bound to the hard palate with limited tissue space between it and the periosteum [2]. As the injection is given, pressure builds up within the palatal tissues causing pain. Due to this reason, even with use of topical anaesthesia operators are unable to deliver pain free injections. In contrast, the buccal mucosa is not as tightly bound and as anaesthesia is delivered the tissue expands with the volume of anaesthesia injected, thus less pain is felt by the

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patient. The use of topical anaesthetics to reduce pain during the delivery of intra oral anaesthesia have been ongoing since the 1980s [3].

In addition to topical anaesthesia, pressure application or ice application to the site are practiced to reduce the pain from tissue expansion in the palatal region. Pressure application is described by the use of the mirror handle or a cotton bud. Pre-cooling (cyro anaesthesia) is the use of ice or refrigerant spray on the anaesthetic site to prevent nerve conduction of pain from the site [4]. This method is used in both dental and non-dental applications [5].

Pre-cooling has a number of tried and tested methods. Ice sticks have been prepared by filling water in glove finger and freezing it [6], use of empty anaesthetic cartridges filled with water and freezing them [7] or a custom-made ice cone [8]. Refrigerant sprays are applied using special cotton application tips [8].

Although these methods have their limitations including; the ice slipping from operators hand due to wetness, water droplets when ice melts and also the ice cools the operator's fingers. However, pre-cooling is thought to be one of the most effective methods to reduce pain when administering intra oral anaesthetics. This technical note highlights the use of an iced cotton bud as a novel way to provide effective pre-cooling method for palatal anaesthesia.

Method of preparation and anaesthesia

A new pack of commercially available cotton buds were dipped in clean water and then placed in the freezer allowing the water to freeze (Fig. 1).

In the patient, the frozen cotton bud was held by its plastic tubing and the cold cotton end placed on the proposed anaesthetic site (palatal mucosa) with light pressure for 60 s (Fig. 2).

A 27 gauge needle (Fig. 3) was used to deliver less than 0.5CC anaesthesia at a slow pace while maintaining pressure using the cotton bud (27 gauge needle is freely available in Sri Lanka for dental practitioners as smaller sizes are not).

Discussion

The concept of iced cotton bud as a method for pre-cooling has been presented here as an alternative to the existing practices. All patients tested showed a 0 pain response to the visual analogue scale of 0–10. Other studies that have assessed the effectiveness of pre-cooling is predominately based on paediatric studies. The sites tested are mainly the buccal mucosa and lower inferior dental nerve block [6,7].

These studies have mainly compared topical anaesthetic application in comparison to ice packs or ice sticks. The time for application of the ice was been between 1 and 2 min. Pre-cooling has been found to be more effective in these studies than use of topical anaesthetic use. It has also been suggested that topical anaesthetic use is not as effective as a pre-anaesthetic treatment as previously thought [9,10]. The pain on delivery of anaesthesia may be numbed due to the effect of cooling of the entire thickness of the palatal tissue unlike in topical anaesthesia.

Contrasting to the use of ice packs or ice sticks, the technique described by the authors allows application of cold to the precise site of needle penetration while maintaining pressure and cold. The use of cotton buds is cost effective, easy to prepare and apply, minimal risk of slipping from operators hand due to wetness. In addition, no dripping of water droplets upon melting ice, not cooling the operators hand during application and the ability to pre cool the exact site of needle penetration due to the size of the cotton bud can be considered advantageous.

Conclusion

This technique can be valuable to dental practitioners who are aiming for a pain free anaesthetic experience for their patients. There is potential for further research and evaluation in this technique and a clinical trial has been proposed

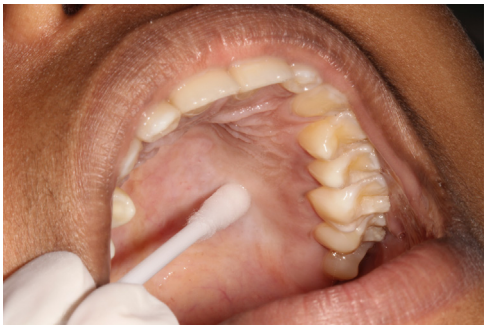

Fig. 2 – Application of Iced cotton bud to proposed anesthesia site.

Fig. 1 – Iced cotton buds following wetting and freezing.

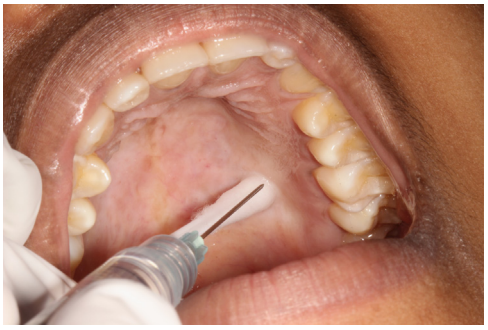

Fig. 3 – administration of local anesthesia to iced site.

by the authors to be conducted comparing other known techniques. Research into pre-cooling anaesthesia has been limited to paediatric studies and none have looked into the use of iced cotton buds amongst adult patients.

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Scientific article

Branching of mandibular canal on cone beam computed tomography images

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ABSTRACT

Background: Mandibular neurovascular canal contents may be vulnerable to damage during mandibular surgical procedures. Greater knowledge of the location and configuration of the mandibular canal can help in the safe performance of these procedures in the dental clinic. Cross-sectional CBCT imaging is a good modality for studying the course, location, configuration and accessory branches of the mandibular canal. The aim of this study was to observe the branching of the mandibular canal at different segments of the mandible and mandibular tooth groups.

Methods: CBCT images of 116 mandibular halves were included in this study. The presence of secondary branching of the mandibular canal in the ramus, retromolar area, molar and premolar teeth as well as the length, diameter and angle of these branches were observed.

Results: sixty nine mandibular halves (59.5%), had a main canal with no branching, There were 36 IAC (31%) with one, 8 (6.9%) with two, 2 (1.7%) with three and 1(0.9%) with 5 accessory branches. Of these secondary branches, 16 (25.4%) were in the ramus, 16(25.4%) in the retromolar, and 31(49.2%) in the molar regions.

Conclusion: Advanced cross-sectional imaging modalities especially CBCT is a suitable tool for observing anatomic characteristics of mandibular canal to preserve this vital structure in surgical procedures.

Introduction

The mandibular canal which passes through the mandible from the mandibular foramen to the mental foramen and includes the inferior alveolar artery, vein and nerve; and may be vulnerable during surgical procedures such as impacted third molar extractions, dental implants placement, sagittal split ramus osteotomy, and fixation of mandibular fractures. Greater knowledge of the location and configuration of the mandibular canal can help in safer performance of different procedures in the dental clinic [1,2].

Variations in the course of the mandibular canal have been reported using cadavers and dry skulls [3]. Some of these variations (so called bifid and trifid mandibular canals)

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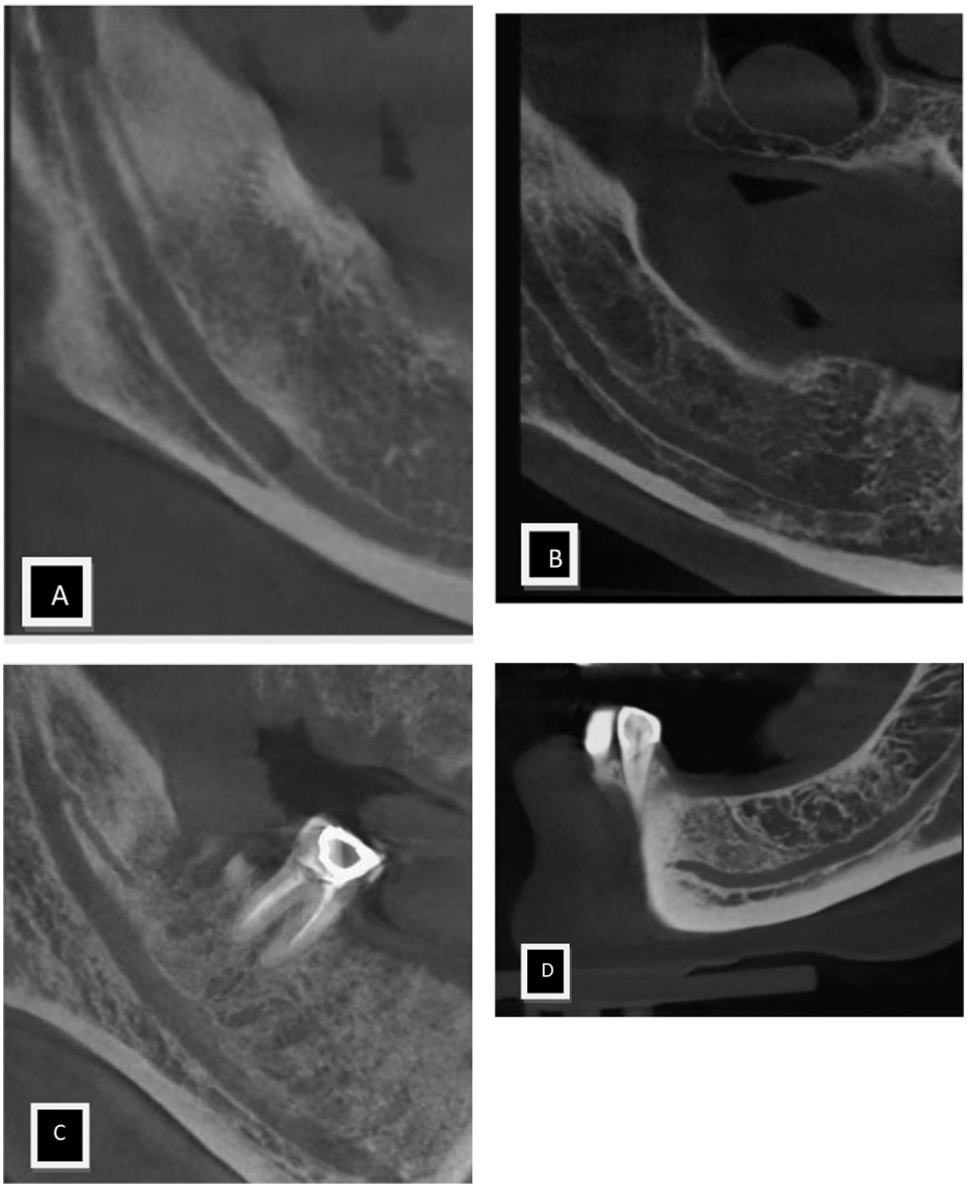

Fig. 1 – Secondary Branches of Mandibular Canal in Different Segments of Mandible. A: Ramus-B and C: Retromolar Area. D: Molar Area.

have been reported using different imaging modalities [2]. However; estimation of the location, size and configuration of the inferior alveolar nerve during mandibular surgery is usually difficult using conventional two dimensional panoramic images. Compared with panoramic images, Cone Beam Computed Tomographic (CBCT) is a better tool at displaying the neurovascular bundle giving better visualization of this vital structure during surgical procedures of jaw bones cone beam CT can provide high-resolution three-dimensional images and detect accessory canals with a narrow diameter including those that bifurcate in any direction. Furthermore, it can correctly differentiate true from false mandibular accessory canals [4]. The distribution of these accessory canals is not distinctly depicted on the spiral CT images owing to their lower resolution.

The cross-sectional limited CBCT images show features that coincide with those of the gross anatomical sections. Also the trabecular bone and bifid mandibular canal walls can be discriminated on these images [5]. The nerve along with the inferior alveolar artery and vein sends branches to innervate posterior teeth through the inferior alveolar canal (IAC) before splitting into incisive and mental components [2]. In CBCT images, occasionally small tubular structures with diameters even less than 1 mm are detected which originate from the main mandibular canal travelling parallel to the canal or toward the different mandibular teeth groups. In the literature, there are many studies that have examined the incidence and patterns of mandibular canal bifidity. But, most of the reports do not include these smaller branches. This descriptive study aimed to determine the presence,

Table 1 – Distribution of accessory canals in right and left side hemimandibles.

Hemimandibles	No accessory branch	One accessory branch	Two accessory branch	Three accessory branch	Four accessory branch	Five accessory branch	Total
Right side	34	16	6	1	0	1	58
Left side	35	20	2	1	0	0	58

angle, length and diameter of all visible branches leaving the mandibular canal on CBCT images.

Methods and materials

In this cross-sectional study, CBCT images of patients referred to a maxillofacial imaging center for different purposes were selected. Subjects with lesions, fractures and severe alveolar resorption were excluded from the study. A CBCT unit (VATECH Pax Duo 3-D, Korea) with a flat-panel detector, field of view of 120 mm × 85 mm and voxel size of 0.2 mm was used. The exposure parameters were set based on patient size as recommended by the manufacturer. For positioning, the occlusal plane was set parallel to the horizon using a bite block and a chinrest. Two-dimensional images of various planes, mainly axial were reconstructed using a 3D visualization and measurement software (EZ3D, VATECH, Korea). Oblique sections were reconstructed centered at the mandibular foramen in axial images. Then, longitudinal oblique sections were rotated and moved bucco-lingually and postero-anteriorly studying the part of mandibular canal between mandibular and mental foramen in all directions to detect any possible branching and to distinguish the tubular bony structures of these branches in the marrow spaces. Cross-sectional images were made to detect buccal or lingual accessory canals. Density and contrast of images were adjusted to clarify the mandibular canals. Subsequently, the number of secondary branches were observed and classified according to their location into ascending ramus, retromolar, molar and premolar groups (Fig. 1). Further, the diameters and lengths of the branched canal as well as the angles between the long axes of the main canal and the branched canal were also measured.

Results

Number of branched canals

CBCT images of 116 hemimandibles, 58 right and 58 left halves were examined. In 69 halves (59.5%), there was a main canal with no branching and 47 halves (40.5%) had at least one branch of which, 24 hemimandibles were from the right side and 23 hemimandibles were from the left side. There were 36 IAC (31%) with one, 8 (6.9%) with two and 2 (1.7%) with three and 1(0.9%) with 5 accessory canals (Table 1).

Location of branching

Of the 63 detected accessory canals, 16 (25.4%) cases presented with branching in the ramus, 16(25.4%) in the retromolar, and 31(49.2%) in the molar regions (Table 2).

Length of branched canals

The length of branched canals varied from 3.90 to 48.50 mm with the mean length of 13.61 mm. Kruskal-Wallis test results showed that there was no statistical difference between the mean lengths of branched canals in different location groups (p value = 0.1).

Diameter of branched canals

The detected branched canals had a diameter ranging from 0.40 to 3.60 mm. The mean diameter was 1.12 mm. *One Way ANOVA test* was used to compare the mean diameter of accessory canals in different location groups. The mean diameter of accessory canals branching in the ramus was significantly larger than the mean diameter of branched canals in molar region. ($p=0.03$). Mean Diameters of accessory canals in other location groups were not statistically different ($p>0.05$).

Angle of branching

The angle of branching of detected accessory canals was 0 (parallel to the main canal in a case with two mandibular foramens) to 93.80° with the mean of 23.52°. *One Way ANOVA test* results showed that there was no statistical difference between the mean angles of branched canals in different location groups (Table 3).

Discussion

During prenatal development, intramembranous ossification spreads posteriorly from the site of division of IAN into mental and incisive branches which results in mandibular canal formation [1,6]. In the embryologic course, 3 inferior dental nerves and smaller branches form to innervate each of the 3 groups of mandibular teeth. Passing time, further fusion of these branches occurs and bony canals develop around such nerve paths. Incomplete fusion of these nerves would explain the occurrence of accessory mandibular canals in some patients [7]. Based on Fukami *et al.* retromolar branch is the first branch leaving the IAN and lies parallel to the main trunk, then turns upward to innervate the third molar and retromolar region. The Molar branch is the second branch to leave the main trunk or retromolar branch and runs parallel

Table 2 – Distribution of accessory canals in ramus, retromolar, molar and premolar regions.

Number of accessory branches in....	Ramus	Retromolar region	Molar region	Premolar region	Total
Right side hemimandibles	8 (22.2%)	10 (27.8%)	18 (50%)	0	36
Left side hemimandibles	8 (29.6%)	6 (22.2%)	13 (48.1%)	0	27
Total	16 (25.4%)	16 (25.4%)	31 (49.2%)	0	63

Table 3 – Length, angle and diameter of accessory branches.

	Length			Angle			Diameter		
	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
Ramus accessory canals	3.90	48.50	16.89	0.00	84.20	17.37	0.70	3.60	1.42
Retromolar accessory canals	4.1o	20.00	10.47	5.50	93.80	29.73	0.40	1.80	1.02
Molar accessory canals	4.90	26.20	13.55	7.30	66.10	23.50	0.40	1.80	1.00

to the main trunk until giving off its dental branches. At the anterior loop, the third incisor branch originates, runs toward the midline where dental branches are given off [5]. In a cadaveric study done by Wadu et al. it was demonstrated that "soon after entering the canal, a molar branch leaves the IAN. The premolars are innervated by a plexus of fibers arising from the main nerve trunk or from the molar, mental and incisive branches. Unlike the obliquely orientated fibers supplying the molar teeth, those supplying premolars emerge at right angles to the common trunk" [8]. But in our study, we could not detect any accessory branching from the IAN in premolar teeth area.

Naitoh et al Classified bifid mandibular canal in four groups:

i) Forward canal: the branch arising from the superior wall of the main canal.
ii) Buccolingual canal: the branch arising from the buccal or the lingual wall of the main canal.
iii) Dental canal: in this case, the end of the bifurcated canal reached the root apex of the molars.
iv) Retromolar canal: the branch arising from the main canal, opening at the retromolar foramen [9]. Different studies examined the frequency and typing of mandibular canal bifurcation on panoramic, spiral CT and CBCT images based on this classification [3,4,9–12]. But there was no report of accessory canal frequency according to different groups of mandibular teeth and ramus.

Out of 116 hemimandibles imaged in this study, 36 with one accessory canal, 8 with two, 2 with three and 1 with five accessory canals were detected.

Secondary branches leave the main mandibular canal at the ramus, retromolar and molar teeth regions before mental foramen have been detected on CBCT images. Of these, 49.2% originated from the main canal in molar teeth region and remaining were ramus and retromolar branches with equal proportion (25.4%).

From the sixteen accessory canals which detected in ramus area, three originated from a separate mandibular foramen. In one case, the bifurcation point was exactly the mandibular foramen. Out of total 63 accessory canals, two had buccal and two had lingual orientation related to the main mandibular canal.

Retromolar branches mostly had a curved path toward the alveolar crest. Three of sixteen retromolar branches detected in this study ended to a detectable foramen, one in alveolar crest and two in buccal cortical plate. Cases in which the retromolar foramen was not detected, had a narrow retromolar canal with less than 1 mm diameter which faded before reaching the cortical boundaries. The reported values for the presence of retromolar foramen in different cadaveric studies range from 6.1% to 72% [13].

Naitoh et al., (2010) observed the artery branched from the inferior alveolar artery and nerves derived from the inferior alveolar nerve trunk within the retromolar canal [3]. In a cadaveric study performed by Bilecenoglu et al., (2006) they reported 10 retromolar foramens in 40 mandibles studied. Their results revealed that retromolar neurovascular bundles include striated muscle fibers and thin myelinated nerve fibers, numerous venules and a muscular artery having a lumen of 120–130 μm [14].

In our investigation, 46% of detected secondary branches had a diameter smaller than 1 mm and 54% were equal to or larger than 1 mm. Sometimes, bone trabeculae are arranged in a manner which can complicate differentiation from secondary mandibular canal branches. Fetures like increasing canal diameter in branching point and local interruption in cortical border of canal can help in distinguishing accessory branching. The potential complications of damage to these small branches can be excessive bleeding, paresthesia or traumatic neuroma.

A study observing the contents of inferior alveolar canal, demonstrated that when the teeth and consequently the bone are lost, supplying vessels will atrophy [8]. Regarding these, the importance of the presence of these small branches specially in an edentulous region in surgical procedures is not clear and more studies are needed to observe the contents of these small branches and accessory canals.

Conclusion

Knowledge of both the anatomy and the anatomical variations of neurovascular canals are necessary to preserve these structures during surgical procedures of mandible and preventing treatment complications. Advanced cross-sectional imaging modalities especially CBCT is a suitable tool for observing and identifying these vital structures and their normal anatomic variations.

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Research paper

The role of subepithelial connective tissue graft for reconstruction of interdental papilla: Clinical study

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ABSTRACT

Background: The ideal goal of periodontal therapy is regeneration of the lost periodontium. However regeneration of the lost interdental papilla has been elusive. Therefore the ability of rebuilding lost papillae in the maxillary segment has become one of the major challenges in periodontal plastic surgery. Objectives of the study: To evaluate the success and predictability of surgical technique using a sub epithelial connective tissue graft interposed in a coronally displaced flap to reconstruct the lost interdental papillae.
Methods: The purpose of this study is to evaluate the success and predictability of a surgical technique using a subepithelial connective tissue graft from the palate with coronally displaced flap to regenerate the lost interdental papilla in 11 systemically healthy patients.
Results: Post treatment follow up show statistically significant results from baseline to 3months and 6 months.
Conclusion: The present study attempted a single surgical procedure to reconstruct the lost interdental papilla using subepithelial connective tissue graft interposed in coronally displaced flap in 11 patients with Tarnow's class-II papillary recessions. At the end of 6 months it was found that the sites demonstrated significantly superior results as determined by percentage of reduction in the area of the black triangle both clinically (60.26%) and on the model (54.29%).
Clinical Implications: Although complete regeneration of interdental papilla was not achieved, the results of this study demonstrate that a predictable and an esthetically pleasing surgical outcome can be achieved in one attempt for class II papillary recessions.

Introduction

Esthetics has become a major concern in periodontal therapy. A key to an aesthetically pleasant smile is proper management of the soft tissues around natural teeth or implants. Aesthetic soft-tissue contours are described by a harmoniously scalloped gingival line, the avoidance of an abrupt change in clinical crown length between adjacent teeth, a convex buccal mucosa of sufficient thickness and a distinct interdental papilla [1].

The interdental space is a physical space between two adjacent teeth. Its form and volume are determined by the morphology of the teeth. Morphologically, the papillae had been described first in 1959 by Cohen [2]. Prior to this time, interdental papilla was considered as a gingival trait having a

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pyramidal shape and functioning to deflect food from the interproximal areas. Now it is clear that the physiology of the papilla is more complex. It not only acts as a biological barrier in protecting the periodontal structures, but also plays a critical role in the aesthetics. Hence, it is very important to respect papillary integrity during all dental procedures and to minimize traumatizing it, inducing its loss [3].

An interdental papilla is deemed complete when it fills the interdental space completely up to the contact point. There may be several reasons for loss of papilla height and establishment of "black triangles" between teeth. The most common cause in the adult individual is loss of periodontal support due to plaque associated lesions. However, the presence of naturally occurring midline diastema, abnormal tooth shape, improper contours of prosthetic restorations, orthodontic tooth movement and periodontal procedures may negatively influence the outline of the interdental papilla [4]. These conditions may create esthetic impairment, phonetic problems and food impaction leading to further loss of tissues [5].

The treatment for restoration of interdental papilla include both nonsurgical and surgical approaches. The nonsurgical approaches advocate orthodontic, restorative or prosthetic interventions. The surgical techniques aim to preserve, recontour or reconstruct the interdental papilla. Surgical techniques that have been used include the pedicle graft procedure [4]and an envelope type flap prepared for coverage of a connective tissue graft [5]. However, the results of these techniques have largely been unpredictable and are documented as case studies. No systematic reviews are available on the long term stability of surgically regained interdental papillae [5].

Subepithelial connective tissue graft has been extensively and effectively used for predictable root coverage, increasing the amount of keratinised gingiva, for treatment of furcation involvement and ridge augmentation procedures. The success of the subepithelial connective tissue graft has been attributed to the double blood supply, closer color blend of graft to the adjacent tissue [6] and absence of keloid healing. Minimal morbidity at the palatal donor site further adds to its efficacy. Therefore these advantages of subepithelial connective graft could be utilised for the reconstruction of interdental papilla [7,8].

Objectives of the study

To evaluate the success and predictability of a surgical technique using a sub-epithelial connective tissue graft interposed in a coronally displaced flap to reconstruct the lost interdental papillae with the following objectives.

1. To harmonize the pink and white elements at interdental region.
2. To increase the width of keratinized gingiva.
3. To assess the stability of the interdental tissue gained at the end of 6 months.

Materials and methods

The purpose of this study was to evaluate the success and predictability of a surgical technique using a subepithelial connective tissue graft from the palate with coronally displaced flap to regenerate the lost interdental papilla. Eleven systemically healthy patients attending the Department of Periodontics, The Oxford Dental College, Hospital and Research centre, Bangalore, fulfilling the following criteria were selected and recruited for the study. The ethics committee of the institute approved the study protocol. Written informed consent was obtained after explanation of the surgical procedure and the likely post-treatment outcomes.

Inclusion criteria

1. Patients aged above 18years.
2. Distance from the contact point to alveolar bone crest $\geq$ 5 mm.
3. Patients with Class II and Class III papillary recession, according to Nordland and Tarnow's classification systems.

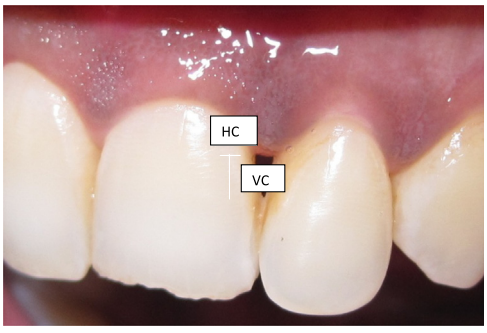
Exclusion criteria

1. Spacing between the teeth.
2. Abnormal tooth shape.
3. Severe crowding of teeth.
4. Patients with active periodontal disease.
5. Patients with systemic diseases such as diabetes mellitus, hypertension or conditions that alters the outcome of periodontal therapy.
6. Pregnant and lactating women.
7. Tobacco users.
8. Thin palatal mucosa and presence of tori.

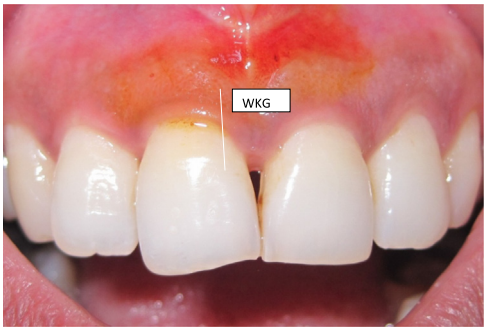
Pre-operative preparation

Prior to the surgical procedure all the patients underwent Phase I therapy. Strict home care protocol was explained to the patients.

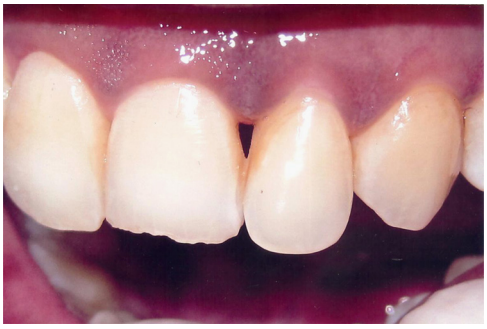
Routine blood investigations were carried out to determine the surgical fitness of the patients. Periapical radiographs for the region affected with papillary loss were



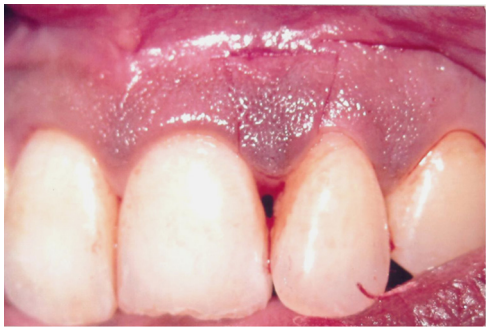
Photograph 1 – Vertical component - VC, Horizontal component – HC.



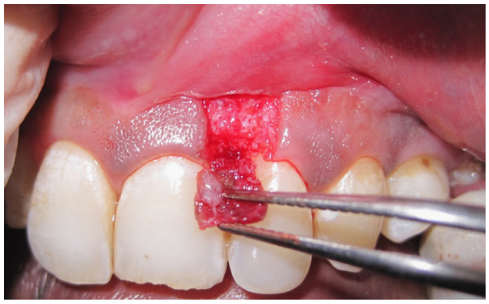
Photograph 2 – Width of the keratinized gingiva – (WKG).



Photograph 3 – Tarnow's class II papillary recession in relation to 21, 22.



Photograph 4 – Vertical, horizontal and crevicular incisions placed.



Photograph 5 – Reflection of partial thickness flap.

undertaken to assess the level of interdental bone. Rubber based impressions were taken for the upper and lower arch for preparation of study models. On completion of the Phase I treatment all patients were re-evaluated and baseline measurements were recorded. The following parameters were recorded at baseline, 3 and 6 months intervals.

Clinical measurements

1. Probing depth (PD).
2. Clinical attachment level (CAL).
3. Preoperative radiographic measurement of the distance from contact point to alveolar bone crest.
4. Vertical component (VC) - Distance from apical point of the contact area to gingival margin.
5. Horizontal component(HC) measured at line angles of adjacent teeth at the gingival margin.
6. Area of the black triangle.
7. Width of keratinized gingiva (WKG) measured from tip of the interdental papilla to the mucogingival junction.

Data was collected on the standard case history proforma (Annexure I).

Area of black triangle

See Photographs 1 and 2.

Area = ½ × **HC** × **VC**.

where **H.C** = Horizontal component {base of the triangle}

V.C = Vertical component {height of the triangle}.

Surgical technique

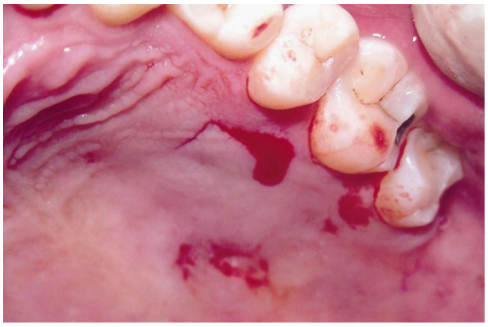
Area of the recipient and donor palatal site were anaesthetized adequately with 2% Xylocaine with 1:200,000 adrenaline (Photographs 3).

Recipient site preparation

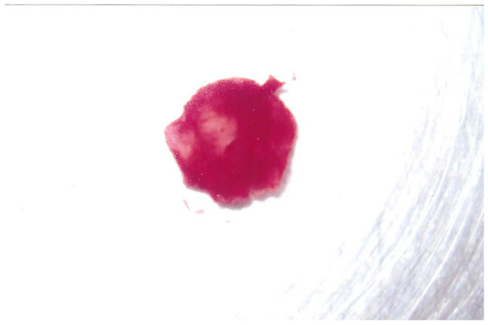
Two vertical incisions were placed from the gingival margin to the mucogingival junction away from the line angles of teeth that included the recessed interdental papilla. The two vertical incisions are joined by a horizontal incision coronal to the mucogingival junction. Partial thickness flap was reflected up to the base of the defective interdental papilla. Crevicular incisions were placed extending all around the necks of the teeth labially and palatally thereby relieving the defective papilla for advancement. Following which the flap was undermined palatally so that the papillary unit could be coronally advanced (Photographs 4 and 5).

Donor site

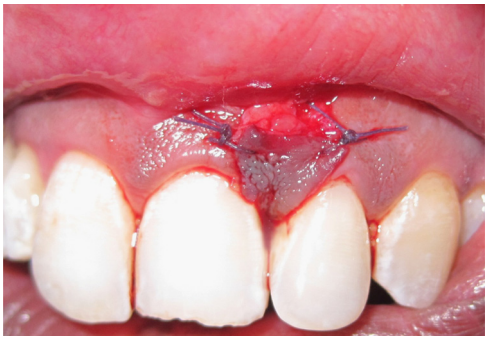
The required amount of subepithelial connective tissue graft was harvested from the ipsilateral side of palate. The extension of the incision was limited anteriorly by palatal rugae and posteriorly incision was not extended beyond midpalatal root of first molar. Lui Class II type A incision – two incision lines 'L' shaped were placed with a no. 15 blade to make a partial thickness horizontal incision with a bevel about 3mm



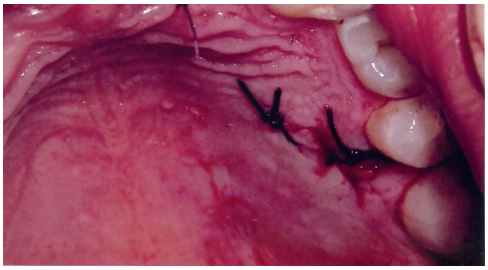
Photograph 6 – L-shaped incisions placed in the palatal donor site.



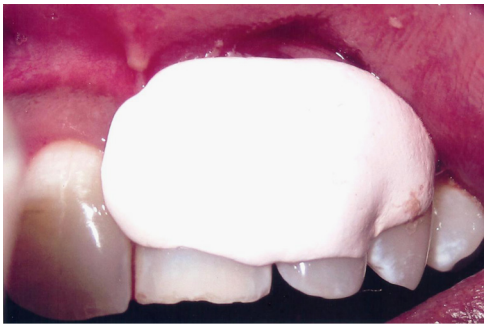
Photograph 7 – Sub epithelial connective tissue graft harvested from palate.



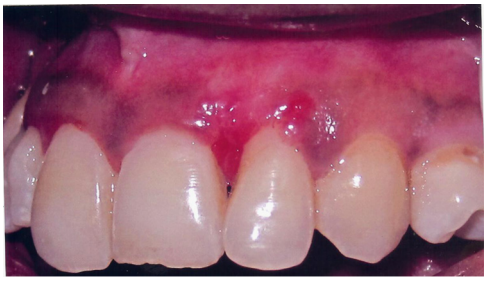
Photograph 8 – Gingivo papillary unit coronally advanced and graft stabilized with interrupted sutures using 5-0 vicryl absorbable sutures.



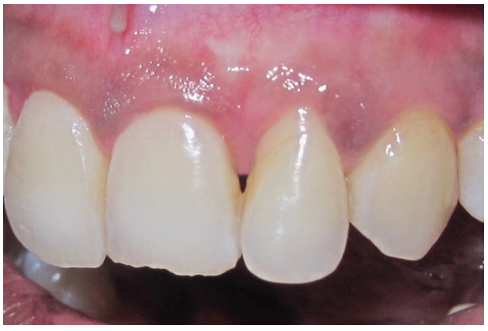
Photograph 9 – Palatal incisions sutured.



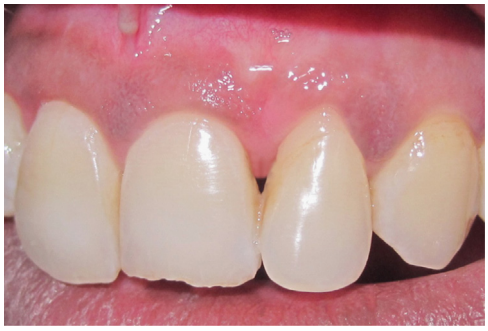
Photograph 10 – Periodontal dressing placed.



Photograph 11 – One month post operative.



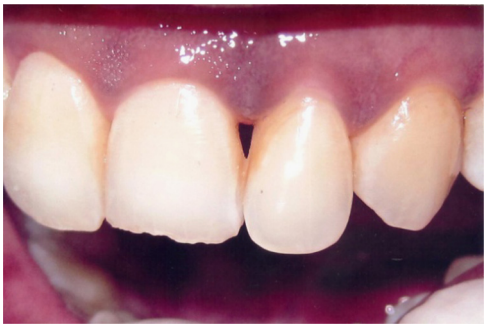
Photograph 12 – Three months post operative.



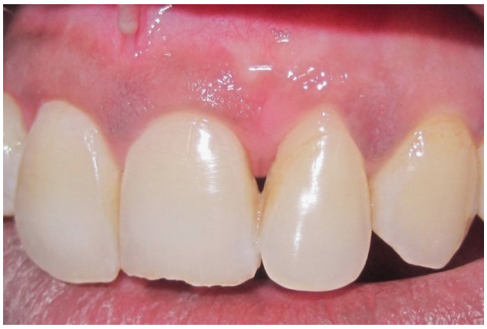
Area of the Black triangle									WKG		
Base Line			3 Months			6 Months			B	3	6
VC	HC	A	VC	HC	A	VC	HC	A			
2.08	1.60	1.66	1.80	1.06	0.95	1.75	0.86	0.75	4.3	5.5	5.6

Photograph 13 – Six months post operative.

apical to the gingival margin and a vertical incision was made mesial to horizontal incision [8]. Tissue forceps were used to lift the prepared palatal flap edge. It was reflected toward the center of the palate and the underlying connective tissue exposed. An incision perpendicular to the bone was made around the edge of the connective tissue, facilitating connective tissue reflection from the bone. Connective tissue thus harvested was placed in normal saline till use. Gauze



Photograph 14 – Tarnow's class II.



Photograph 15 – Six Months Post-operative.

was placed and the area was compressed to eliminate dead space in the donor site. The palatal wound was closed by interrupted sutures using a 3-0 non absorbable suture material [9].

Following the coronal displacement of the papillary unit, the void created between the soft tissue and bone structure was filled by the shaped subepithelial connective tissue graft. The graft was then stabilized beneath the partial thickness flap with suturing of vertical incisions using 5–0 absorbable suture material and using interrupted sutures.

The surgical site was covered with a tin foil and a non-eugenol periodontal dressing {coepak™} was placed over it.

Postoperative instructions were given to the patient. Amoxicillin 500 mg capsules thrice a day for 5 days, analgesics {ibuprofen 400 mg} thrice daily for 3 days was prescribed and 5 ml of 0.2% chlorhexidine rinses 2 times a day for 4 weeks was advised from the next day following surgery. Patients were advised to refrain from brushing and using interdental cleansing aids in the interproximal area for 4 weeks. The periodontal dressing was removed after one week, the surgical site was irrigated and a fresh pack was placed to be removed at the end of second week. Patients were recalled every week for the first four weeks. They were followed up for 6 months at monthly intervals and all clinical parameters were recorded at 3 months and 6 months post surgically. Oral prophylaxis was done if required and oral hygiene instructions reinforced (Photographs 6–15).

Table 1 – Evaluation of probing depth and clinical attachment level {In mm}.

Clinical variables		Baseline	3 month	6 month
Probing Depth	Min-Max	1.30–2.50	1.16–2.60	1.50–2.60
	Mean ± SD	1.76 ± 0.36	2.02 ± 0.43	2.03 ± 0.38
	Δ from Baseline	–	0.26	0.27
	P value from Baseline	–	0.056+	0.014*
Clinical Attachment Level	Min-Max	1.30–3.16	1.60–3.50	1.60–3.50
	Mean ± SD	2.02 ± 0.61	2.38 ± 0.47	2.43 ± 0.53
	Δ from Baseline	–	0.36	0.41
	P value from Baseline	–	0.008**	<0.001**

- The difference in the mean probing depth from baseline to 3 months was suggestive of significance and from baseline to 6 months was moderately significant statistically.
- The difference in mean clinical attachment level from baseline to 3 months and from baseline to 6 months was strongly statistically significant.

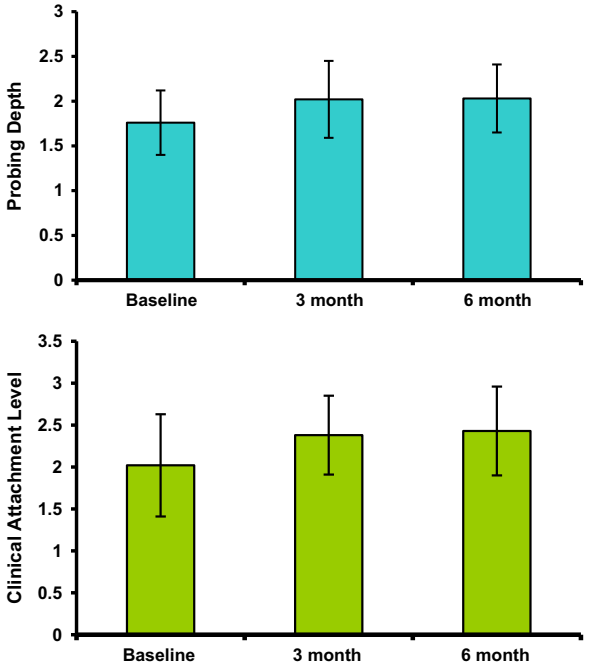


Fig. 1 – Mean probing depth. Mean clinical attachment level.

Statistical methods

Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean ± SD (Min–Max) and results on categorical measurements are presented in Number (%). Significance is assessed at 5% level of significance. Student *t* test (two tailed, dependent) has been used to find the significance of study parameters on continuous scale with in each group [10,11].

Table 2 – Radiographic Measurement From Contact Point To Crest Of Alveolar Bone.

Radiographic measurements(mm)	Number of patients	%
5.0–5.5	6	54.5
5.5–6.0	2	18.2
>6.0	3	27.3
Total	11	100.0

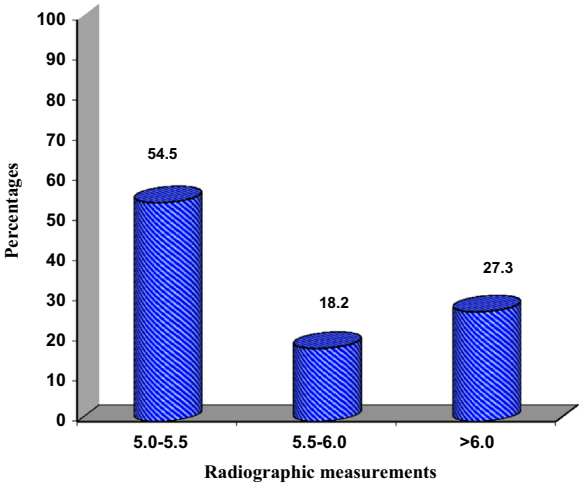


Fig. 2 – Pre operative radiographic measurements from contact point to crest of alveolar bone.

Duration of the study
The entire study was completed within 18 months.

Results

A total number of 11 systemically healthy patients, comprising 5 males and 6 females, with papillary recession in maxillary anterior region participated in the study after fulfilling all the inclusion and exclusion criteria.

Results – general considerations

All the eleven recruited patients completed the study period without any dropouts. There were no post operative complications of significance as none of the patients complained of excessive postoperative pain, haemorrhage, malaise, lassitude, intraoral/extraoral swelling.

Results – clinical parameters

Probing depth
The difference in the mean probing depth from baseline to 3 months was 0.26 which suggested a significance statistically p=0.056 and from baseline to 6 months was 0.27 this was found to be moderately significant statistically (p=0.014.).

Table 3 – Evaluation of Black Triangle: Vertical Component - Intra-Oral {In mm}.

Clinical variables		Baseline	3 month	6 month
Vertical component	Min-Max	2.08–4.30	1.40–3.10	1.32–2.75
	Mean ± SD	3.08 ± 0.62	2.15 ± 0.61	1.93 ± 0.45
	Δ from Baseline	–	0.93	1.14
	% change from baseline	–	30.19%	37.01%
	P value from Baseline	–	<0.001**	<0.001**

- The percentage of reduction of the vertical component from baseline to 3 months was 30.19% and from baseline to 6 months 37.01%.
- The difference in the mean value of the vertical component from baseline to 3 months and from baseline to 6 months were strongly statistically significant.

Clinical attachment level
The difference in mean clinical attachment level from baseline to 3 months was 0.36 with a *P* value 0.008 and from baseline to 6 months was 0.41 with a *P* value of <0.001 which was strongly significant statistically (Table 1, Fig. 1).

Preoperative radiographic measurement
The preoperative radiographic measurement of the distance from the contact point to alveolar bone crest for 6 (54.5%) patients out of 11 ranged from 5 to 5.5 mm, for 2 (18.2%) patients the range was 5.5–6 mm. For 3 (27.3%) patients the range was more than 6 mm (Table 2, Fig. 2).

Vertical component of the black triangle

Intraoral
The mean value of the vertical component of the black triangle at baseline was 3.08 ± 0.62 which decreased to 2.15 ± 0.61 at the end of 3 months and to 1.93 ± 0.45 at the end of 6 months. The percentage of reduction of vertical component from baseline to 3 months was 30.19% and 37.01% from baseline to 6 months. The difference in the mean value of the vertical component from baseline to 3 months (0.923) and from baseline to 6 months (1.144) were strongly significant (*P* < 0.001) (Table 3, Fig. 3).

Model
The mean value of the vertical component of the black triangle at baseline was 3.28 ± 0.62 which decreased to 2.37 ± 0.70 at the end of 3 months and to 2.08 ± 0.52 at the end of 6 months. Reduction of the vertical component from baseline to 3 months was 28.81% and from baseline to 6 months 36.43%. The change in the mean value of the vertical component from baseline to 3 months (0.944) and to 6 months (1.195) were strongly significant (*P* < 0.001) (Table 4, Fig. 4).

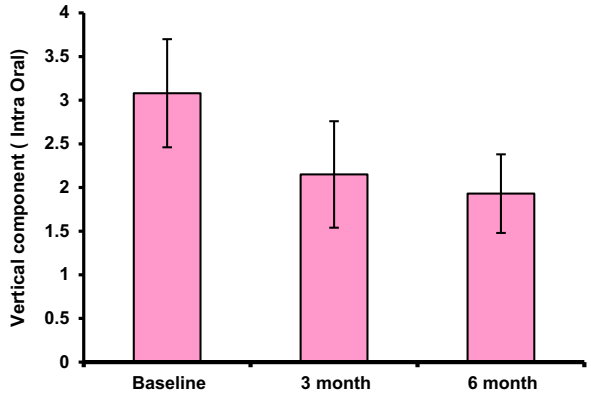


Fig. 3 – Evaluation of vertical component (mm) – INTRAORAL.

Table 4 – Vertical component – Model {In mm}.

Clinical variables		Baseline	3 Month	6 Month
Vertical component	Min-Max	2.36–4.50	1.59–3.73	1.40–3.10
	Mean ± SD	3.28 ± 0.62	2.37 ± 0.70	2.08 ± 0.52
	Δ from Baseline	–	0.945	1.195
	% change from baseline	–	28.81%	36.43%
	P value from Baseline	–	<0.001**	<0.001**

- Reduction of the vertical component from baseline to 3 months was 28.81% and from baseline to 6 months 36.43%.
- The change in the mean value of the vertical component from baseline to 3 months and to 6 months were strongly statistically significant.

Horizontal component

Intraoral

The mean value of the horizontal component of the black triangle was 1.54±0.43 at baseline which decreased to 1.18±0.31 at 3 months and 0.96+0.25 at 6 months post operative period. There was 23.25% reduction in the horizontal component from baseline to 3 months and 37.66% from baseline to 6 months. The difference in the mean value from baseline to 3 months (0.358) was moderately significant (*P* 0.021) and from baseline to 6 months (0.580) was strongly significant ($P<0.001$) (Table 5, Fig. 5).

Model: Horizontal component

The mean value of the horizontal component of the black triangle was 1.59±0.39 at baseline which decreased to 1.22±0.28 at 3months and 1.10±0.24 at 6 months post operative period. From baseline to 3 months the percentage of reduction in the horizontal component was 23.27% and 31.06% from baseline to 6 months post operative. The difference in the mean value from baseline to 3 months (0.370) and from baseline to 6 months (0.494) was strongly significant ($P<0.001$) (Table 6, Fig. 6).

Area of the black triangle

Intraoral

The mean area of the black triangle was 2.29±0.55 at baseline which decreased to 1.18±0.50 at 3 months and subsequently to 0.91±0.26 at 6 months post operative period. The percentage of reduction of the area of the black triangle from baseline to 3 months was 48.47% and 60.26% from baseline to 6 months. The difference in the mean area from baseline to 3 months (1.114) and to 6 months (1.381) was strongly significant statistically ($P<0.001$) (Table 7, Fig. 7).

Model

The mean area of the black triangle was 2.53±0.46 at baseline which decreased to 1.39±0.48 at 3 months and 1.14±0.31 at 6 months post operative period. 45.05% reduction of the area of the black triangle was seen from baseline to 3 months and 54.9% from baseline to 6 months. The difference in the mean value from baseline to 3 months (1.141) and from baseline to 6 months (1.395) was strongly significant ($P<0.001$) (Table 8, Fig. 8).

Width of keratinized gingiva

The baseline mean value of width of keratinized tissue was 4.83±1.29. At 3 months follow up mean value recorded was 6.03±1.07 and at the end of 6 months postoperative showing a gain of 6.21±1.09. The difference in the mean from baseline to 3 months (1.19) with p value of 0.002 and from baseline to 6 months (1.37) with p value of 0.001 which was strongly significant statistically (Table 9, Fig. 9).

Discussion

Gingival tissues have been designed to provide a framework for the body defense against disease. It not only acts as a biological barrier in protecting the periodontal structures, but also plays a critical role in the aesthetics [1].

Several reasons contribute to the loss of interdental papillae and the establishment of "black triangles" between teeth [12]. The most common reason in the adult population is loss of periodontal support. Several surgical and non-surgical techniques have been reported for management of interdental papillary loss [2].

In periodontal literature, the reconstruction of lost papilla for cosmetic reasons has not received much attention. Although several case reports have showed different periodontal plastic surgical, prosthetic, and orthodontic techniques for correcting lost papilla, no scientific research or reliable data are available for clinicians [13]. Most of the literature is limited towards case reports, providing no evidence of predictability and few demonstrate long term stability [6,8,14,15]. No controlled clinical trial has addressed the issue of restoring deficient interproximal spaces. The only case series reported so far is by Nemcovsky on 10 consecutively treated cases for papillae reconstruction using a palatal approach [16].

This clinical study evaluates the effectiveness of subepithelial connective tissue graft to reconstruct interdental papilla. The assessment was based upon single surgical intervention. Model analysis were used to confirm

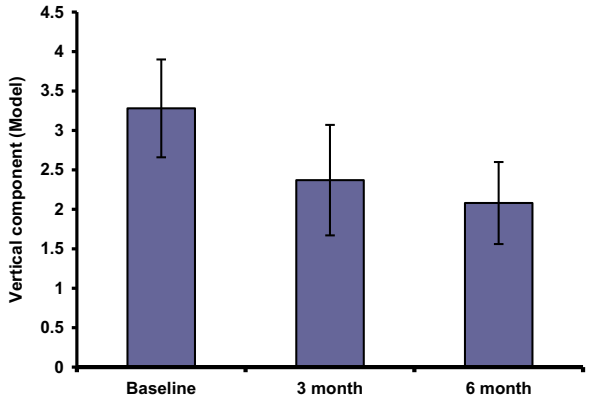


Fig. 4 – Evaluation of vertical component (mm) – MODEL.

Table 5 – Horizontal component - Intra-oral {In mm}.

Clinical variables		Baseline	3 month	6 month
Horizontal component	Min-Max	1.00–2.16	0.75–1.61	0.60–1.39
	Mean ± SD	1.54 ± 0.43	1.18 ± 0.31	0.96 ± 0.25
	Δ from Baseline	–	0.358	0.580
	% change from baseline	–	23.25%	37.66%
	P value from Baseline	–	0.021*	<0.001**

- 23.25% reduction of the horizontal component was seen from baseline to 3 months and 37.66% from baseline to 6 months.
- The difference in the mean value from baseline to 3 months was moderately significant and from baseline to 6 months was strongly statistically significant.

clinical measurements. All the patients who were included in this study were systemically healthy who presented with class II papillary recessions involving the maxillary anterior region. The clinical parameters in each patient were statistically evaluated at baseline, 3 months and 6 months.

The preoperative radiographic measurement from the contact point to the crest of the bone ranged from 5 mm to 6.05 mm and this could be correlated with the absence of the interdental papilla [17].

All the patients underwent phase I therapy prior to the surgery. A slight increase in the plaque and gingival index from baseline to 3 months and to 6 months indicates the effects of absence of complete coverage of the black triangle following surgery as well as instructions to patients refraining the use of interdental cleansing aids in the first few post operative weeks could be the reason [16,18]. However, this was not much of a clinical significance as the bleeding index showed no change during the study period.

A moderate increase seen in the probing depth from baseline (1.76 mm) to 3 months (2.02 mm) and to 6 months (2.03 mm) could be attributed to the coronal displacement of gingivo – papillary unit.

The loss in the clinical attachment from baseline to 3 months was 0.36 mm which was moderately significant and from baseline to 6 months 0.41 mm which was strongly significant the reason for this could be due the refection of flap following which repair of tissues has resulted in loss of attachment.

One of the undesirable effects seen was facial marginal gingival recession following the surgical procedure. This loss can occur mainly because of blood supply discontinuation caused by the incisions [6]. 3 patients with no baseline facial recession showed 1 mm of recession at 6 month postoperative period. 2 patients who had facial recession at baseline showed an increase in recession at the end of 6 months.

A buccal approach was utilized in this study for ease of access because a palatal approach as employed by Beagle R^4 is difficult because of poor visibility and accessibility. The most important part of the surgical procedure was to ensure that the gingivo- papillary unit is completely mobilized for maximum coronal advancement therefore vertical incisions were used maintaining an intact blood supply from the palatal tissues. This provided adequate visibility and permitted easy handling of the partial thickness flap in the narrow zone of interdental papilla and ensured severing of all fibrous attachment at the base of gingivo-papillary unit for maximal coronal advancement.

In one of the patients there was presence of frenal fibers in the central papillary region, the tissue in this region was more resistant to coronal displacement therefore the fibers were surgically detached to allow a coronal advancement.

It was seen that interdental spaces that were long and narrow did not enable coronal advancement of gingivopapillary unit to entirely cover the black triangle.

Although the initial case reports by Shapiro in 1985 and Beagle in 1992, did not use connective tissue graft (CTG) for papillary reconstruction, most of the later approaches were based on SCTG procured either from palatal region or maxillary tuberosity.

Shapiro inflicted repeated surgical insults by means of curettage and relied upon creeping attachment for gain in the papillary height [19].

By incorporating the advantages of the pedicle graft, such as the double blood supply from the overlying flap and the periosteal – connective tissue bed, coupled with the genetic potential of the connective tissue wedge from the palate, it could be possible to maximize graft survival. The donor site being a closed wound produces less post operative discomfort [20]. Therefore these benefits of subepithelial connective tissue graft could be utilised for the reconstruction of interdental papilla [8]. Han and Takei, used palatal region as donor site where as Azzi et al. used a distal wedge incision to procure SCTG from the maxillary tuberosity region [8,21].

No specific technique is recommended so far in literature to harvest the graft from palatal region for papilla reconstruction. Since the amount of connective tissue required was minimal the palatal site which is easily accessible for SCTG was chosen for this study.

Class II Type incision (L) technique as described by Liu was used for SCTG procurement from palatal region [9].

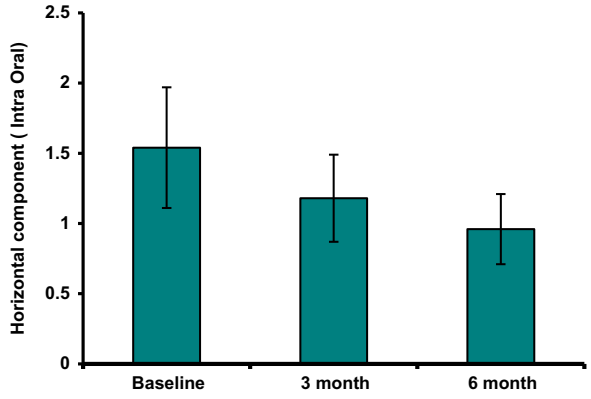


Fig. 5 – Evaluation of vertical component (mm) – INTRAORAL.

Table 6 – Horizontal component – Model { In mm}.

Clinical variables		Baseline	3 month	6 month
Horizontal component	Min-Max	1.08–2.19	0.64–1.69	0.61–1.47
	Mean ± SD	1.59 ± 0.39	1.22 ± 0.28	1.09 ± 0.24
	Δ from Baseline	–	0.370	0.494
	% change from baseline	–	23.27%	31.06%
	P value from Baseline	–	0.001**	<0.001**

- The percentage of reduction of horizontal component from baseline to 3 months was 23.27% and 31.06% from baseline to 6 months.
- The difference in the mean value from baseline to 3 months and from baseline to 6 months was strongly significant statistically.

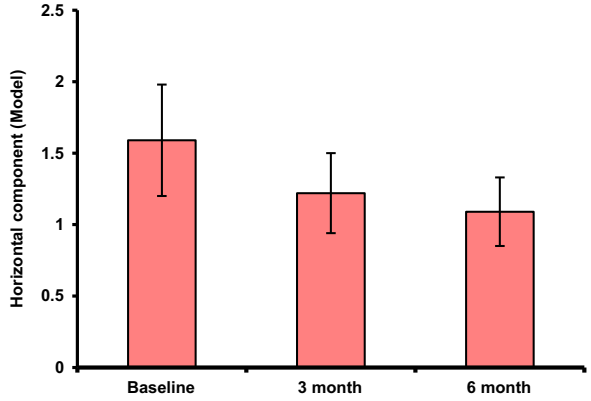


Fig. 6 – Evaluation of horizontal component (mm) – MODEL.

The palatal wound was closed by interrupted sutures using a 3–0 non-absorbable suture material. The graft was stabilized beneath the partial thickness flap with suturing of vertical incisions using 5–0 absorbable suture material and using interrupted sutures.

Table 7 – Area of black triangle - Intra-oral {In mm^2}.

Clinical variables		Baseline	3 month	6 month
Area	Min-Max	1.60–3.13	0.42–2.15	0.39–1.35
	Mean ± SD	2.29 ± 0.55	1.18 ± 0.49	0.91 ± 0.26
	Δ from Baseline	–	1.11	1.38
	% change from baseline	–	48.47%	60.26%
	P value from Baseline	–	<0.001**	<0.001**

- 48.47% reduction in the area of the black triangle was seen from baseline to 3 months similarly 60.26% from baseline to 6 months
- The difference in the mean area from baseline to 3 months and to 6 months was strongly significant statistically.

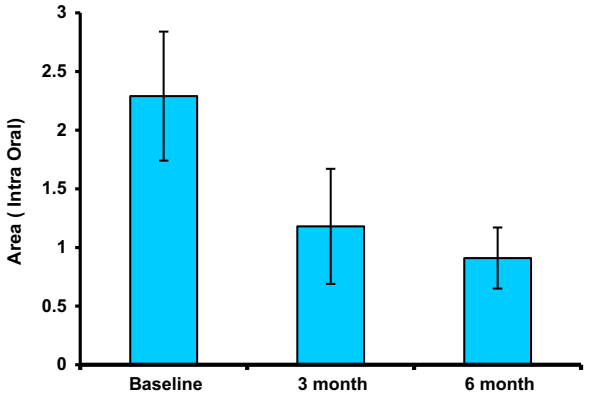


Fig. 7 – Evaluation of area of black triangle (mm^2) – INTRAORAL.

Table 8 – Area Of Black Triangle - Model {In mm ^{2}}.

Clinical variables		Baseline	3 month	6 month
Area	Min–Max	1.83–3.06	0.51–2.29	0.42–1.55
	Mean ± SD	2.53 ± 0.46	1.39 ± 0.47	1.14 ± 0.31
	Δ from Baseline	–	1.14	1.39
	% change from baseline	–	45.05%	54.9%
	P value from Baseline	–	<0.001**	<0.001**

- The percentage of reduction of the area of the black triangle from baseline to 3 months was 45.05% and from baseline to 6 months 54.9%.
- The difference in the mean value from baseline to 3 months and from baseline to 6 months was strongly statistically significant.

The surgical site was covered with a tin foil and a non-eugenol periodontal dressing {coepak™} was placed over it. The periodontal dressing was removed after one week, the surgical site was irrigated and a fresh pack was placed to be removed at the end of second week. Patients were recalled every week for the first four weeks. Healing was uneventful at both the donor and recipient sites.

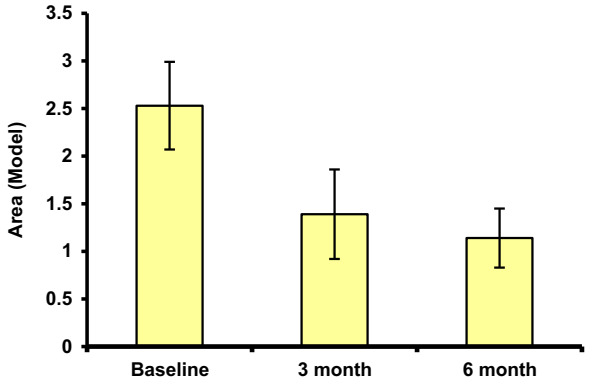


Fig. 8 – Evaluation of area of black triangle (mm^2) - MODEL.

Table 9 – Evaluation of width of keratinized gingiva.

Clinical variables		Baseline	3 month	6 month
Width of keratinized gingiva	Min–Max	3.0–6.60	4.10–7.30	4.20–7.30
	Mean ± SD	4.83 ± 1.29	6.03 ± 1.07	6.21 ± 1.09
	Δ from Baseline	–	1.19	1.37
	P value from Baseline	–	0.002**	0.001**

The difference in the mean from baseline to 3 months and from baseline to 6 months which was strongly statistically significant.

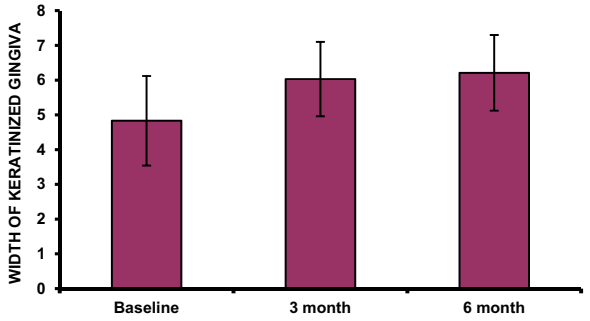


Fig. 9 – Evaluation of width of keratinized gingiva.

The main objectives of this study were to assess the stability of interdental papilla and reduction of the area of the black triangle at the end of 6 months post operative intraorally and on the model. Earlier investigators have used multiple surgeries in an attempt to reconstruct the lost papilla however, in this study only a single surgical procedure was evaluated [6,8].

The average baseline measurement of vertical component intraorally was 3.08 mm and on the model 3.28 mm which at the end of 6 months of follow up was 1.93 mm intraorally and on the model 2.08 mm. Reduction of the vertical component was 1.144 mm intraorally and 1.195 mm on the model at the end of 6 months.

The average horizontal component was 1.54 mm at base line intraorally and 1.59 mm on the model which reduced to 0.96 mm intraorally and on the model 1.09 at the end of 6 months. The horizontal component showed a reduction 0.580 mm intraorally and 0.494 mm on the model at 6 months post operative.

A significant percentage of reduction in the area of the black triangle intraorally from baseline to 3 months 48.47% and baseline to 6 months 60.26% was seen. Similarly, on the model percentage of reduction of area of the black triangle from baseline to 3 months was 45.05% and at 6 months 54.9%

A significant difference did exist between the clinical measurements and model analysis of the area of the black triangle from baseline to 6 months indicating that there could be some margin of error in the clinical recordings.

The average values of keratinized tissue at base line were 4.83 mm and at 3 months follow up 6.07 mm and at 6 months 6.21 mm. A gain of 1.37 mm was achieved at the end of the study period which was significant. Sanctis and Zucchelli, proposed a hypothesis in an attempt to explain the increase of keratinized tissue after connective tissue graft and coronal advancement of flap based on Ainamo and Karrings theory. As described by Ainamo, the mucogingival line always regains its original, "genetically determined" position. It is also known that mucogingival junction remains stationary throughout life and any attempt to coronally or apically advance the mucogingival junction shows relapse towards its original position [22]. Karring et al., 1971 and 1974, reported that the main determining factor for the nature of tissue developing at a region is genetically determined and it's the connective tissue that possess the ability to induce changes in the differentiation of the epithelium [23]. Although this was based on root coverage procedure, the flap reflection in this surgical technique is similar to the procedure followed by authors.

The difficulty in working on the papilla depends on the anatomy and morphology of this structure, which receives only a minor blood supply. Working with such a delicate structure is one of the most difficult challenges for periodontists [24].

Complete elimination of the black triangle was not possible because there could be other factors that influence the regeneration of the interdental papilla such as anatomical factors, bone loss, plaque, inflammation and also the unique functional characteristics that are due to distinct cellular and molecular properties [25].

The presented surgical technique for interproximal papilla augmentation does offer a solution to an esthetic problem with a reduction in the black triangle in one surgical attempt.

The distance from the bone crest to the contact point is positively related to the presence of an interdental papilla. When this distance is 5 mm or less, the entire papilla is always present. When the distance was 6 mm, the papilla was present 56% of the time.

As the distance increases to 7 mm or more, it is present only 27% of the time or less [17]. In the present study, only soft tissue was augmented. Therefore, long-term stability of

primarily achieved results is not guaranteed.

The limitations of the study are it does not address multiple papillary recessions, the small sample size studied and short period of follow up.

Larger long term clinical and histological follow up studies, as well as the methods that are more sensitive and better able to measure the treatment effects are necessary which address the limitations.

Conclusion

The present study attempted to reconstruct the lost interdental papilla using subepithelial connective tissue graft interposed in coronally displaced flap in 11 patients with Tarnow's class-II papillary recessions in a single surgical step. At the end of 6 months it was found that the sites demonstrated positive results as determined by percentage of reduction in the area of the black triangle both clinically (60.26%) and on the model (54.29%). However, a complete elimination of the black triangle was found to be elusive. The use of subepithelial connective graft led to statistically significant increase in width of keratinized gingiva. This was consistently observed in all patients. Use of microsurgical principles, minimal invasive and multiple surgical procedures combined with non-surgical therapeutic approaches may provide a predictable and successful solution to the long standing dilemma of correcting the black triangle.

Summary

A short term clinical study was taken up to evaluate the effectiveness of subepithelial connective tissue graft to reconstruct interdental papilla. Eleven systemically healthy patients with Tarnow's class II papillary recession participated and completed the study. Parameters such as the width of keratinized gingiva, vertical component, horizontal component and area of the black triangle were assessed at baseline. Model analysis was used to confirm clinical measurements. A single stage surgical procedure using a subepithelial connective tissue graft from the palate with coronal advancement of the gingivopapillary unit to reconstruct the lost interdental papilla was carried out. Patients were regularly followed and evaluated for a period of six months with the parameters recorded at 3 and 6 months post operative. There was a significant percentage of reduction in the area of the black triangle 60.26% intraorally, 54.9% on the model and a gain in the width of the keratinized gingiva at the end of 6 months. None of the patients recruited had any post surgical complications.

A long term study involving more number of participants is required to know for how long the soft tissue can maintain height without sufficient bone support.

Although complete regeneration of interdental papilla was not achieved, the results of this study demonstrate that a predictable and an esthetically pleasing surgical outcome can be achieved in one attempt for class II papillary recessions.

Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.sdj.2017.05.001.

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Scientific article

Disinfection of dentinal tubules with 2% Chlorhexidine gel, Calcium hydroxide and herbal intracanal medicaments against *Enterococcus faecalis*: An in-vitro study

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ARTICLE INFO

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ABSTRACT

Aim: This in vitro study was conducted to evaluate the disinfection of dentinal tubules using 2% Chlorhexidine gel, Honey, Aloe vera gel, *Curcuma longa*, Propolis gel and Calcium hydroxide against *Enterococcus faecalis*.

Materials and method: Two hundred and ten human mandibular first premolars were infected with *Enterococcus faecalis* for 21 days. Samples were divided into 7 groups. Group I- Saline (negative control), Group II- 2% Chlorhexidine gel(CHX), Group III- honey, Group IV- Aloe vera gel, Group V- 20% *Curcuma longa* gel, Group VI- Propolis gel and Group VII -Calcium hydroxide (CH). At the end of 1, 3 and 5 days, the antimicrobial efficacy of medicaments against *E.faecalis* was assessed at the depths of 200 μm and 400 μm.

Results: 2% Chlorhexidine gel was most effective followed by Propolis and *Curcuma longa*.

Conclusion: 2% Chlorhexidine gel gave the best results. Among the herbal extracts Propolis and *Curcuma longa* hold a promising future but to implement their use as sole intracanal medicaments clinically, further in vivo and long term studies are warranted.

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0377-5291/

Introduction

The aim of non-surgical endodontic therapy is to remove pathogenic microorganisms from the root canal system, shape the canal system appropriately and obturate it with a suitable material [1]. Complete disinfection however is not always achievable through instrumentation alone due to the anatomical complexities of the root canal [2]. Retention of microorganisms in dentinal tubules leads to persistent endodontic infection. Thus, the use of intracanal medicaments are required to remove the remaining microbes and to provide an environment conducive for periapical tissue repair [3].

Enteroccocus faecalis is a persistent organism that plays a major role in the etiology of periradicular lesions after root canal treatment. It is found in 22–77% of endodontic failure cases and is able to survive in the root canal as a single organism or as a major component of the flora [4]. *E.faecalis* can survive harsh conditions due to its ability at biofilm formation and making them more resistant to phagocytosis, antibodies and antimicrobial agents [5].

Calcium hydroxide (CH) has been widely used as an intracanal medicament because of its bactericidal properties. Its high pH of about 12.5 has a destructive effect on cell membranes and protein structures [6]. Despite the success of CH as an intracanal medicament, several microbial species, including *Enterococcus faecalis*, are reported to be resistant to its effects [7].

Chlorhexidine (CHX) is a bis-biguanide which has a broad spectrum antimicrobial activity and is active against both gram positive and gram negative microbes. 2% CHX has been used as an intracanal medicament and has shown potent results against common endodontic pathogens especially *E. faecalis* [8].

Natural products are sometimes deemed useful and attractive as replacements of medicaments as they are thought to have fewer side effects and less costly [5].

Honey has a potent broad spectrum antimicrobial activity due to the presence of flavanoid pinocembrim [9].

Aloe barbadensis miller (Aloe leaves) possesses anti-inflammatory,antimicrobial, moisturizing, wound healing and pain relief properties [10]. The antimicrobial effects of aloe vera are due to anthraquinones [11].

Curcuma longa, commonly called as turmeric, contains curcumin (diferuloylmethane) as the main yellow bioactive component and has been shown to have a wide spectrum of actions like anti-inflammatory, antioxidant and antimicrobial activities [12].

Propolis is a resinous material that honeybees collect from various plant species and mix with wax and other substances and it exhibits a wide range of biologic activities, including antimicrobial, anti-inflammatory, antioxidant, anesthetic and cytotoxic properties. It is believed that flavonoids account for much of the biological activities in propolis [13]. In dentistry, propolis has been used in various applications [14].

To date, there is no reported dental literature on the dentinal tubule disinfection by *Curcuma longa* and Aloe vera against *E.faecalis*, therefore an attempt was made to evaluate their disinfecting properties compared with other intracanal medicaments with reported success in dentinal tubule disinfection.

Materials and methods

Preparation of dentine specimens

The model proposed by Haapasalo and Ørstavik (1987) was modified [7]. Two hundred and ten single-rooted human mandibular premolar teeth freshly extracted for orthodontic reasons were selected for the study.

A rotary diamond disc was used to decoronate the teeth below the cementoenamel junction and the apical part of the root to obtain 6 mm of the middle third of the root. Cementum was removed from the root surface. Gates Glidden drills no. 3 (Mani Inc., Japan) in a slow-speed handpiece (NSK, Tokyo,Japan)were used to standardize the internal diameter of the root canals. The specimens were placed in an ultrasonic bath of 17% ethylene diamine tetra acetic acid (Dent Wash;Prime Dental Products PVT. Ltd) for 5 min followed by 3% NaOCl.for 5 min to remove organic and inorganic debris. The traces of chemicals used were removed by immersing the dentine specimens in an ultrasonic bath containing distilled water for 5 min. All the specimens were sterilized in an autoclave for two cycles. The first cycle at 121 °C and the second with the specimens immersed in 1 mL of tryptone soya (TS) broth in individual microcentrifuge tubes.

Contamination of the specimens

The test organism used for this study was *E. faecalis*, which is a gram-positive facultative anaerobic bacterium that is common in root filled teeth with post treatment infection. *E. faecalis* (ATCC 29212) ((Himedia, Mumbai) was grown in tryptone soya agar ((Himedia, Mumbai) for 24 h. The culture was suspended in 5 mL of TS brothand incubated for 4 h at 37 °C and its turbidity adjusted to 0.5 McFarland standard. Each dentine block was placed in pre-sterilized microcentrifuge tubes containing 1 mL of the TS broth. Fifty microlitres of the inoculums containing the *E. faecalis* were transferred into each of the microcentrifuge tubes. At the end of 24 h, the dentine specimens were transferred into fresh broth containing *E. faecalis* in a laminar flow chamber. Purity of the culture was checked by subculturing 5 μL of the broth from the incubated dentine specimens in TS broth on tryptone soya agar plates. Contamination of the dentine specimens was carried out for a period of 21 days.

Antimicrobial assessment

At the end of 21 days, the specimens were irrigated with 5 mL of sterile saline to remove the incubation broth. They were assigned into 7 groups (n=30 dentine blocks).

Group I-Saline (negative control),

Group II:2% CHX gel: 2% solution was made and then gel was prepared with methycellulose as a thickening agent.

Group III: Honey was used at 100% concentration in the available form.(Dabur,India).

Group IV: Aloe vera gel was prepared by taking 100% raw aloe vera powder (RYM exports,Mumbai,India) and methylcellulose as the vehicle.

Group V:*Curcuma longa* (RYM exports,Mumbai,India)was prepared by using 100% *C.longa* powder and by adding sterile distilled water to the required concentration of 20% [15]. This was then prepared into gel by adding methylcellulose as a thickening agent.

Group VI: Propolis gel was prepared by taking Propolis (Herbal Biosolutions, Delhi) which was prepared by diluting a 33% commercially available alcoholic extract using warm saline in a ratio 2:1, to form an 11% alcoholic extract [16]. Then, it was made into gel using methylcellulose.

Group VII: Calcium hydroxide mixed with saline in the ratio of 1.5:1 (wt/v) to obtain a paste like consistency [17].

The medicaments were placed inside the canals and sealed at both ends with paraffin wax. They were incubated in an aerobic environment for 37 °C. At the end of 1, 3, and 5 days an assessment of microbial cells was carried out with 10 specimens at each time interval. Harvesting of dentine was carried out at two depths (200 and 400 μm) with Gates Glidden drills (Mani Inc., Japan) no 4 and 5, respectively. The collected dentine shavings were transferred into 1 mL of sterile TS broth and incubated in an aerobic environment at 37 °C for 24 h. After 24 h, the contents of each tube was serially diluted, 100 μL of the broth in 100 μL of sterile saline five times. Fifty microlitres of the dilution were then plated on TS agar plates and incubated for 24 h. Colonies were counted and readings tabulated.

Statistical analysis

The results were statistically analysed by ANOVA and post hoc tukey test.

Results

All the intracanal medicaments tested in the study exhibited antibacterial activity. Table 1 shows the antibacterial activity, measured at 2 depths (200 and 400 μm) and at 3 time intervals (1, 3, and 5 days). 2% Chlorhexidine gel exhibited the maximum antibacterial activity followed by Propolis and *C.longa* (gel preparations) with no statistically significant difference between them whereas all the other groups had significant differences($p < 0.05$).(Graph 1). The inhibition of growth of *E. faecalis* at 200 μm and 400 μm was uniform with no statistical difference. On the basis of above analysis, the following order of microbial efficacy of different medicaments was observed.

2%CHX > Propolis~*Curcuma longa*> Honey > Calcium Hydroxide > *Aloe barbadensis miller* > Saline.

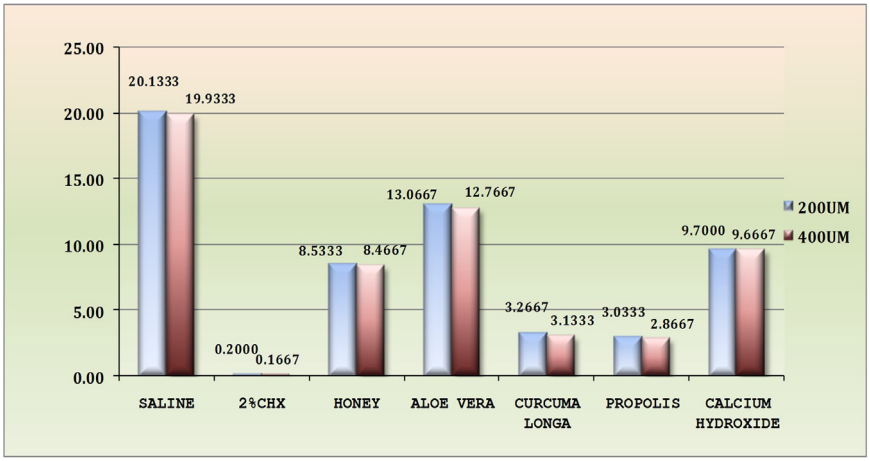
Discussion

To assess the efficacy of endodontic medicaments in the disinfection of dentinal tubules, the in vitro model developed by Haapasalo and Ørstavik (1987) [7] was modified.Human permanent mandibular first premolars were used instead of the bovine teeth as suggested by Basrani et al. [18] simulating the clinical scenario better.The presence of cementum affected the ability of *E.faecalis* cells to infect the dentinal tubules, therefore, cementum was removed from the specimens [19].

Since apical dentine is mostly sclerotic, mid root dentin blocks in the study. Invasion of coronal and mid-root dentin occurs more readily while the extent and depth of invasion are significantly less in apical dentin, because of less patent dentinal tubules [20]. The samples were tested at two depths, 200 μm and 400 μm, because Calcium hydroxide is known to

Table 1 – Mean and Standard deviation of colony counts for different intracanal medicaments at 200 and 400 μm depths at different time intervals.

Treatment		DAY1		DAY3		DAY5	
		200 μM	400 μM	200 μM	400 μM	200 μM	400 μM
Saline	AVG	19.6000	19.6000	20.2000	19.9000	20.6000	20.3000
	SD	0.69921	0.84327	0.91894	0.87560	0.51640	0.48305
2%CHX	AVG	0.2000	0.2000	0.2000	0.2000	0.2000	0.1000
	SD	0.42164	0.42164	0.42164	0.42164	0.42164	0.31623
Honey	AVG	8.8000	8.5000	8.5000	8.5000	8.3000	8.4000
	SD	0.91894	0.70711	1.08012	1.08012	0.94868	0.84327
Aloe vera	AVG	13.3000	12.9000	13.1000	12.5000	12.8000	12.9000
	SD	0.82327	0.87560	0.87560	0.70711	1.03280	0.73786
Curcuma longa	AVG	3.5000	3.4000	3.6000	2.9000	2.7000	3.1000
	SD	0.52705	0.69921	0.51640	0.73786	0.67495	0.56765
Propolis	AVG	3.4000	3.0000	3.1000	2.8000	2.6000	2.8000
	SD	0.69921	0.81650	0.73786	0.63246	0.69921	0.63246
Calcium Hydroxide	AVG	9.9000	10.2000	9.9000	9.5000	9.3000	9.3000
	SD	0.87560	0.63246	0.73786	0.52705	0.48305	1.05935



Graph 1 – Comparison of mean values of colony counts of the different intracanal medicaments at 200 and 400 μm depths.

penetrate only upto 200–300 μm [21]. Three time periods were taken to assess the disinfection because the effective antimicrobial action of the tested intracanal medicaments decreases after 48 hours [22]. Therefore, time periods chosen to evaluate the antimicrobial assessment included the first and third day. Beltes et al. [23].have shown that a 5-day period is adequate for Calcium hydroxide(CH) pastes to release the OH- ions, so an additional time period of 5 days was also taken.

E. faecalis can invade dentinal tubules, and it is therefore probable that cells within dentinal tubules surviving chemomechanical instrumentation and intracanal medication could colonize the tubules and reinfect the obturated root canal.It possesses serine protease, gelatinase, and collagen-binding protein (Ace), which help it bind to dentin. It has the capacity to endure prolonged periods of starvation until an adequate nutritional supply becomes available [24].

In our study, 2% Chlorhexidine (CHX) has shown the maximum microbial inhibition at depths of 200 and 400 μm from day 1 to 5. Since it is a positively charged hydrophobic and lipophilic molecule, it interacts with negatively charged phospholipids and lipopolysaccharides on the cell membrane of microorganism and enters the cell through some type of active or passive transport mechanism, which alters the osmotic equilibrium of the cells. This increases the permeability of the cell wall, allowing the CHX molecule to penetrate into the micro-organism, followed by leakage of intracellular constituents, particularly phosphate entities such as adenosine triphosphate and nucleic acids. It binds to hydroxyapatite and soft tissues, changing their electrical field to compete with microbial binding, thus decreasing microbial adherence. The result of the present study was similar to that of, Gomes et al. [8], Krithikadatta et al. [17], Basrani et al. [18] and Vaghela et al. [19] which showed that 2% Chlorhexidine gel produced a better antimicrobial action as compared to 0.2% Chlorhexidine gel or Calcium hydroxide mixed with 0.2% chlorhexidine.

Propolis exhibits antimicrobial, anti-inflammatory, healing, anesthetic and cariostatic properties [5,25]. Some components present in propolis extract, like flavonoids (quercetin, galangin, pinocembrin) and caffeic acid, benzoic acid, cinnamic acid, probably act on the microbial membrane or cell wall site, causing functional and structural damages [26]. Oncag et al. [13] observed that propolis had good in vitro antimicrobial activity against *E. faecalis* in the root canals of extracted teeth, suggesting that it could be used as an alternative intracanal medicament. The results of this study is in support with the study by Kandaswamy et al. [27], where 2% chlorhexidine performed better than Propolis. In this study, Propolis showed the second highest efficacy along with *Curcuma longa* in disinfecting the dentinal tubules against *E.faecalis*.

Curcuma longa belongs to the family, Zingiberaceae and is commonly known as Turmeric. Curcumin (diferuloylmethane) is the main yellow bioactive component of turmeric and has been shown to have a wide spectrum of actions like anti-inflammatory, antioxidant and antimicrobial activities [12]. A recent report suggested that curcumin in aqueous preparations exhibits phototoxic effect against gram positive and gram negative bacteria. In a study by Hemanshi Kumar [15], 20% *C. longa* showed promising results in elimination of *E.faecalis* and the author concluded that *C.longa* can be used as an intacanal medicament. Thus, 20% *Curcuma longa* was taken in our study. To standardize all the test groups, gel form was prepared by using methyl cellulose as a thickening agent as it is an inert material. *Curcuma longa* was equally effective as Propolis and has shown the second highest efficacy in disinfecting the dentinal tubules against *E.faecalis*. The results are in accordance with study by Singh et al. [28], which showed that *C.longa* with distilled water showed 60% reduction in cell count of *E.faecalis* over a period of seven days.

Honey has a potent broad-spectrum antibacterial activity against aerobic, anaerobic Gram-positive and Gram-negative bacteria, and a variety of fungi [29]. There has been no study so far of dentinal tubule disinfection with honey, this probably is the first study of its kind.In this study honey has shown moderate activity in disinfecting the dentinal tubules, the action being more as compared to Calcium hydroxide and Aloe vera. Several mechanisms have been suggested to explain the antimicrobial actions of honey. Presence of

"Inhibine" (hydrogen peroxide) [8] makes it a good antimicrobial agent. Honey also contains an enzyme lysozyme, which is a well-known antibacterial agent [28]. Raied T ahe-Al-Naama reported that 100% honey concentration showed higher zone of microbial inhibition when compared to that of 50% honey concentration [30], because of this reason we had taken pure form (100%) of honey.In a study conducted by Litik Mittal et al. [31], 100% honey had significant antimicrobial action against broad spectrum of bacteria. In this study honey exhibited moderate antibacterial action which was significantly less in efficacy as compared to that of Propolis,*Curcuma longa* and 2% Chlorhexidine. This may be due to the different test groups evaluated in our study.

Calcium hydroxide, the gold standard of intracanal medicaments was also taken as a test group. The release of hydroxyl ions in an aqueous environment is responsible for the antimicrobial activity of Calcium hydroxide. Their lethal effects on bacterial cells are probably caused by the mechanisms such as damage to the bacterial cytoplasmic membrane, protein denaturation, and damage to DNA. The endodontic literature provides discouraging information on the antibacterial effectiveness of Calcium hydroxide against *E. faecalis* because of the buffering action of dentin [32]. In our study also the dentinal tubule disinfection with Calcium hydroxide was lower when compared with other medicaments. Evans et al. [33] demonstrated that the proton pump activity of *E. faecalis* offers resistance to high pH of Calcium hydroxide. The ability of *E.faecalis* to penetrate deep into the tubules is attributed to Ace, a bacterial adhesion factor [20]. The results of our study are in accordance with the studies by Krithikkadatta et al. [17], Kandaswamy et al. [27], and Singh et al. [28].

Aloe vera (*Aloe barbadenesis miller*) has been used from time immemorial for the treatment of a multitude of ailments. The antimicrobial effects of Aloe vera have been attributed to the plant's natural anthraquinones. It has a well established antimicrobial activity ascribed to compounds that are now specifically identified as p-coumaric acid, ascorbic acid, pyrocatechol and cinamic acid. Aloe vera has shown antimicrobial effect against resistant microorganisms found in pulp space [34]. In this study among all the study groups, Aloe vera gel has shown the least potential in disinfecting the dentinal tubules. These results are consistent with those reported by Bazvand et al. [35], in which the antibacterial effect of Aloe vera on *E.faecalis* in deep dentin was less than Propolis and 0.2% Chlorhexidine gel. However, in a study by Bhardwaj et al. [36]. Aloe vera and Calcium hydroxide inhibited bacterial growth by 78.9% and 64.3% respectively. Among the natural intracanal medicaments Aloe vera did not show adequate inhibition. The results of this study are in contradiction to our study and the differences might be due to the different preparations of Aloe vera used in both the studies.

The inhibition of growth of *E.faecalis* at 200 μm and 400 μm was uniform with no statistical difference.This was in accordance with study by Krithikadatta et al. [17]., Vaghela et al. [19]., and Kandaswamy et al. [27]. Saline was taken as a negative control which as expected has shown the least antibacterial efficacy.

Conclusion

Under the limitations of the study, it can be concluded that:

- 2% Chlorhexidine gel is the most effective intracanal medicament against *E.faecalis*.
- Propolis and *Curcuma longa* (gel preparations) as intracanal medicaments showed good efficacy against *E.faecalis* and thus can be used as effective intracanal medicaments.

Among the herbal extracts, Propolis and *Curcuma longa* hold a promising future as intracanal medicaments but further in vivo and long term studies are warranted in this regard.

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Scientific article

Factors associated with faculty participation in research activities in dental schools

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ABSTRACT

Background: To quantify participation in dental research activities in Malaysia, and investigate its association with socio-demographic and professional characteristics, and perceptions of research and development (R&D) culture.

Materials and methods: Dental academics in Malaysian dental schools were invited to complete a questionnaire by email and post. The survey comprised questions on research activities in the past 12 months, socio-demographic and professional characteristics, and the R&D Culture Index. Principal components factor analysis was carried out to confirm the factor structure of the R&D Culture Index. Chi-square test was used to identify association of research activities with R&D culture, and socio-demographic and professional characteristics. Binary logistic regression was carried to identify predicators of research activities.

Results: Of 256 potential participants contacted, 128 (50%) useable responses were returned. Three R&D Culture factors accounting for 57.4% of variance were extracted. More positive perception of R&D Support was associated with Malaysians (0.025) and those employed in Government schools (0.017). R&D Skills and Aptitude were associated with older respondents (0.050), PhD qualification (0.014) and more years in academia (0.014). R&D Intention was associated with any of the socio-demographic characteristics. Thirty (23.4%) respondents reported a peer-review research publication in the past 12 months, which was associated with having a PhD (OR 12.79, CI 1.28–127.96), after adjustment in regression analyses.

Discussion: Postgraduate research training should be encouraged to promote participation in research activities. R&D culture did not appear to impact on research productivity. Other factors such as individual attitudinal interests should be studied.

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Introduction

Building and strengthening research capacity is recommended by the WHO for effective control of diseases and the socioeconomic development of any given country [1]. As knowledge is a major vehicle for improving the health of the poor in particular, the WHO Oral Health Programme focuses on stimulating oral health research in the developed and developing world to reduce risk factors and the burden of oral diseases. Greater investment in research capacity building in developing countries has the greatest potential of securing dynamic knowledge systems [2,3] that can deliver better health and equity. To improve the health of populations globally, it has been argued that biomedical research should occur in both developed and developing countries [4]. However, the imbalance between developed and developing countries in terms of biomedical research is significant. For example, dental research productivity for Asia, in terms of number of documents per million inhabitants has been reported to be 1.25, compared to 12.02 for Europe and 24.72 for North America [5], although in some disciplines a reversal in trends is observed [6].

There has been considerable interest around the world to monitor and understand the research productivity of individual institutions [7], countries [8–10] and specialties [11,12]. Research has also focussed on identifying factors that promote and barriers that hinder research activity [13], and the dynamic interplay of individual and institutional characteristics, supplemented with effective leadership [7,14]. Perceptions of values held on research and development have also been proposed as determinants of research productivity [15], and a measure of Research and Development (R&D) Culture Index has been developed for this purpose [16]. Brodin, Bennett and Appleton et al. [17] concluded that research productivity depends on individuals trained and educated to conduct independent research, time to spend on research activities, appropriate space and equipment, an on-going and appropriate budget, and an appropriate climate that encourages and rewards research achievement.

Research in the context of the dental school has traditionally been focused on institutional/faculty accomplishments and generating new knowledge to benefit the profession. Dental schools are expected to act as a national resource for improving oral health through research and education. To fulfil their role, dental schools need to ensure research growth through adequate and appropriate human resources, scientists and clinicians training, infrastructure, costs and leadership [18]. Only recently have significant efforts been made to expand the overall research programming into the formal dental curriculum in order to provide students with a baseline exposure to the research and critical thinking processes, encourage evidence-based decision-making, and stimulate interest in academic/research careers [19]. Within the context of low dental research productivity in Asia [5], we aimed to quantify participation in dental research related activities in Malaysia, and investigate its association with socio-demographic and professional characteristics, and perceptions of R&D culture.

Materials and methods

The target population for this cross-sectional online and postal survey were dental academics employed in Malaysian dental schools. At the time of the survey there were 12 dental schools with at least one intake of undergraduate students. Consultation on the protocol was sought from the Dental Deans Caucus in May 2012. Four dental schools declined to participate in the survey. Applications were made to the deans of the remaining eight schools to obtain the names and email addresses of their faculty staff.

An online questionnaire survey was set up. The link to this survey was emailed to the participating deans for dissemination to their faculty. The email informed potential participants that the reason for the survey was to identify factors associated with research productivity, and any information volunteered would be treated confidentially. Participants were informed that completing the questionnaire was not compulsory and it required approximately ten minutes. Reminders were sent two and four weeks after the first email. To improve the response rate, a postal survey was next carried out. Eight weeks after the first email, all potential participants were sent a copy of the questionnaire together with a cover letter to their place of work. The cover letter informed participants of the purpose of the survey and advised them not to respond if they had done so through the online survey. A stamped addressed envelope was enclosed for responding.

The outcome variables were self-reporting of involvement in research related activity, being named on a research funding application, being an author of a peer reviewed research publication and presentation of a conference research paper in the past 12 months [20]. Independent variables included demographic (age, sex, nationality) and professionally related (highest postgraduate qualification, years in academia, funding of dental school of employment) factors. The R&D Culture Index [16] was used to measure participants' perception of personal and organizational development needs so as to inform strategy to advance faculty engagement in research. The R&D Culture Index consists of 16 items graded on a four-point Likert scale: Strongly Disagree/ Disagree/ Agree/ Strongly Agree. The items are worded such as to give a unidirectional response. Possible scores on the R&D Culture Index range from 16–64 with higher scores indicating a more positive perception of the organisation's R&D culture. Previous validation has demonstrated a Cronbach alpha coefficient of 0.92 indicating good internal consistency for the whole index.

Frequency distributions for items of the R&D Culture Index were calculated. Principal components factor analysis was carried out to confirm the factor structure of the R&D Culture Index. The scores for each factor were calculated and used to categorise respondents into those with less positive and more positive perception at the median scores. Socio-demographic and professionally-related characteristics were tested for association with perception of R&D culture in the factors generated, and also association with participation in research activities using the Chi-square test. We also assessed the

Table 1 – Perceptions of R&D culture of a sample of dental academics in some Malaysian dental schools (n=128).

Item	Strongly disagree	Disagree	Agree	Strongly agree
I would like to learn about research activity during the next twelve months	0 (0.0)	2 (1.6)	69 (53.9)	57 (44.5)
I would like more opportunities to share practice development ideas/research/ information across the Faculty	0 (0.0)	3 (2.3)	71 (55.5)	54 (42.2)
I am very keen to use research in practice	1 (0.8)	2 (1.6)	71 (55.5)	54 (42.2)
Development of evidence-based practice is valued as part of my job	2 (1.6)	3 (2.3)	64 (50.0)	59 (46.1)
I know how practice is influenced by research	0 (0.0)	6 (4.7)	75 (58.6)	47 (36.7)
I feel confident about using research in my practice	1 (0.8)	9 (7.0)	79 (61.7)	39 (30.5)
I have the skills to use the library and learning facilities within the University/Faculty	1 (0.8)	13 (10.2)	75 (58.6)	39 (30.5)
I understand research terminology	0 (0.0)	7 (5.5)	87 (68.0)	34 (26.6)
There is opportunity to develop practice in my area	3 (2.3)	15 (11.7)	87 (68.0)	23 (18.0)
The development work that I do links with the Faculty's plans	1 (0.8)	15 (11.7)	94 (73.4)	18 (14.1)
There is strong professional leadership	1 (0.8)	22 (17.2)	90 (70.3)	15 (11.7)
There are people around to help and support me to change/develop practice	1 (0.8)	17 (13.3)	98 (76.6)	12 (9.4)
My discipline here works as equal partners with other disciplines in order to change or develop practice	3 (2.3)	24 (18.8)	89 (69.5)	12 (9.4)
There are opportunities to reflect on my practice	3 (2.3)	25 (19.5)	92 (71.9)	8 (6.3)
I have access to training and development opportunities which give me the skills to question and investigate practice	2 (1.6)	32 (25.0)	84 (65.6)	10 (7.8)
There are regular staff meetings to explore ideas	6 (4.7)	47 (36.7)	67 (52.3)	8 (6.3)

Table 2 – Factor structure matrix of the R&D Culture Index.

	Factor loading		
R&D Support			
1. There are people around to help and support me to change/develop practice	0.760		
2. There are opportunities to reflect on my practice	0.758		
3. There is opportunity to develop practice in my area	0.721		
4. There is strong professional leadership	0.721		
5. My discipline here works as equal partners with other disciplines in order to change or develop practice	0.618		
6. There are regular staff meetings to explore ideas	0.609		
7. I have access to training and development opportunities which give me the skills to question and investigate practice	0.591		
8. The development work that I do links with the Faculty's plans	0.570		
9. Development of evidence-based practice is valued as part of my job	0.411		
R&D Skills and Aptitude			
10. I feel confident about using research in my practice		-0.857	
11. I know how practice is influenced by research		-0.819	
12. I understand research terminology		-0.799	
13. I have the skills to use the library and learning facilities within the University/Faculty		-0.682	
R&D Intention			
14. I would like more opportunities to share practice development ideas/research/information across the Faculty			0.817
15. I would like to learn about research activity during the next twelve months			0.739
16. I am very keen to use research in practice			0.652

association between perception of R&D culture and participation in research activities using the Chi-square test.

Results

Of 256 respondents who were sent questionnaires, 172 (67%) were returned, and 128 (50%) were useable. Responses to items in the R&D Culture Index are presented in Table 1. The items that were most positively rated were "I would like to learn about research activity during the next twelve months", "I would like more opportunities to share practice development ideas/research/information across the Faculty", and "I am very keen to use research in practice", whereas the items that were least positively rated were "There are opportunities to reflect on my practice", "I have access to training and development opportunities which give me the skills to question and investigate practice", and "There are regular staff meetings to explore ideas".

The Kaiser–Meyer–Olkin coefficient for this dataset was 0.815 and the Bartlett's Test of Sphericity was statistically significant ($P < 0.001$) indicating that the data were suitable for factor analysis. Using confirmatory Principal Components Analysis, three factors accounting for 57.4% of the variance were identified. The first factor, labelled R&D Support and comprised nine items, described the perception of support for research and development activities within the working environment (Table 2), such

Table 3 – Sample socio-demographic characteristics and association with perception of R&D Culture.

		n (%)	R&D Intention			R&D Skills and Aptitude			R&D Support		
			Less positive	More positive	p-value	Less positive	More positive	p-value	Less positive	More positive	p-value
Sex	Male	49 (38.3)	24 (49.0)	25 (51.0)	0.307	23 (46.9)	26 (53.1)	0.165	32 (65.3)	17 (34.7)	0.952
	Female	79 (61.7)	46 (58.2)	33 (41.8)		47 (59.5)	32 (40.5)		52 (65.8)	27 (34.2)	
Age in years	26–35	44 (34.4)	26 (59.1)	18 (40.9)	0.449	30 (68.2)	14 (31.8)	0.050	31 (70.5)	13 (29.5)	0.645
	36–40	35 (27.3)	16 (45.7)	19 (54.3)		19 (54.3)	16 (45.7)		23 (65.7)	12 (34.3)	
	41+	49 (38.3)	28 (57.1)	21 (42.9)		21 (42.9)	28 (57.1)		30 (61.2)	19 (38.8)	
Nationality	Malaysian	79 (61.7)	41 (51.9)	38 (48.1)	0.421	41 (51.9)	38 (48.1)	0.421	46 (58.2)	33 (41.8)	0.025
	Non-Malaysian	49 (38.3)	29 (59.2)	20 (40.8)		29 (59.2)	20 (40.8)		38 (77.6)	11 (22.4)	
Highest postgraduate qualification	None	19 (14.8)	11 (57.9)	8 (42.1)	0.839	15 (78.9)	4 (21.1)	0.014	13 (68.4)	6 (31.6)	0.904
	MSc	81 (63.3)	45 (55.6)	36 (44,4)		45 (55.6)	36 (44.4)		52 (64.2)	29 (35.8)	
	PhD	28 (21.9)	14 (50.0)	14 (50.0)		10 (35.7)	18 (64.3)		19 (67.9)	9 (32.1)	
Years in Academia	Up to 5	65 (50.8)	36 (55.4)	29 (44.6)	0.416	43 (66.2)	22 (33.8)	0.014	43 (66.2)	22 (33.8)	0.946
	6–10	27 (21.1)	12 (44.4)	15 (55.6)		14 (51.9)	13 (48.1)		17 (63.0)	10 (37.0)	
	11+	36 (28.1)	22 (61.1)	14 (38.9)		13 (36.1)	23 (63.9)		24 (66.7)	12 (33.3)	
Dental school funding	Government	94 (73.4)	49 (52.1)	45 (47.9)	0.333	48 (51.1)	46 (48.9)	0.171	56 (59.6)	38 (40.4)	0.017
	Private	34 (26.6)	21 (61.8)	13 (38.2)		22 (64.7)	12 (35.3)		28 (82.4)	6 (17.6)	
	N (%)	128 (100.0)	70 (54.7)	58 (45.3)		70 (54.7)	58 (45.3)		70 (54.7)	58 (45.3)	

Table 4 – Association between socio-demographic characteristics and distribution of research activities.

		Have you been involved in research-related activity in past 12 months?			Have you been named on a research funding application in the past 12 months			Have you been an author of a peer reviewed research publication in the past 12 months			Have you presented a conference research paper in the past 12 months		
		No	Yes	p-value	No	Yes	p-value	No	Yes	p-value	No	Yes	p-value
Sex	Male	34 (69.4)	15 (30.6)	0.978	38 (77.6)	11 (22.4)	0.067	33 (67.3)	16 (32.7)	0.053	29 (59.2)	20 (40.8)	0.365
	Female	55 (69.6)	24 (30.4)		49 (62.0)	30 (38.0)		65 (82.3)	14 (17.7)		53 (67.1)	26 (32.9)	
Age in years	26–35	26 (59.1)	18 (40.9)	0.099	36 (81.8)	8 (18.2)	0.030	35 (79.5)	9 (20.5)	0.840	28 (63.6)	16 (36.4)	0.971
	36–40	24 (68.6)	11 (31.4)		19 (54.3)	16 (45.7)		26 (74.3)	9 (25.7)		23 (65.7)	12 (34.3)	
	41+	39 (79.6)	10 (20.4)		32 (65.3)	17 (34.7)		37 (75.5)	12 (24.5)		31 (63.3)	12 (34.3)	
Nationality	Malaysian	64 (81.0)	15 (19.0)	0.001	55 (69.6)	24 (30.4)	0.611	68 (86.1)	11 (13.9)	0.001	60 (75.9)	19 (24.1)	0.001
	Non-Malaysian	25 (51.0)	24 (49.0)		32 (65.3)	17 (34.7)		30 (61.2)	19 (38.8)		22 (44.9)	27 (55.1)	
Highest postgraduate qualification	None	15 (78.9)	4 (21.1)	0.400	15 (78.9)	4 (21.1)	0.421	18 (94.7)	1 (5.3)	0.024	14 (73.7)	5 (26.3)	0.510
	MSc	53 (65.4)	28 (34.6)		55 (67.9)	26 (32.1)		63 (77.8)	18 (22.2)		52 (64.2)	29 (35.8)	
	PhD	21 (75.0)	7 (25.0)		17 (60.7)	11 (39.3)		17 (60.7)	11 (39.3)		16 (57.1)	12 (42.9)	
Years in Academia	Up to 5	42 (64.6)	23 (35.4)	0.135	45 (69.2)	20 (30.8)	0.250	54 (83.1)	11 (16.9)	0.166	43 (66.2)	22 (33.8)	0.193
	6–10	23 (85.2)	4 (14.8)		21 (77.8)	6 (22.2)		20 (74.1)	7 (25.9)		20 (74.1)	7 (25.9)	
	11+	24 (66.7)	12 (33.3)		21 (58.3)	15 (41.7)		24 (66.7)	12 (33.3)		19 (52.8)	17 (47.2)	
Dental school funding	Government	72 (76.6)	22 (23.4)	0.004	62 (66.0)	32 (34.0)	0.417	78 (83.0)	16 (17.0)	0.004	67 (71.3)	27 (28.7)	0.005
	Private	17 (50.0)	17 (50.0)		25 (73.5)	9 (26.5)		20 (58.8)	14 (41.2)		15 (44.1)	19 (55.9)	
Total		89 (69.5)	39 (30.5)		87 (68.0)	41 (32.0)		98 (76.6)	30 (23.4)		82 (64.1)	46 (35.9)	

Table 5 – Association between perceptions R&D culture and distribution of research activities.

	Have you been involved in research-related activity in past 12 months?			Have you been named on a research funding application in the past 12 months?			Have you been an author of a peer reviewed research publication in the past 12 months?			Have you presented a conference research paper in the past 12 months?		
	No	Yes	p-value	No	Yes	p-value	No	Yes	p-value	No	Yes	p-value
R&D Intention												
Less positive	48 (68.6)	22 (31.4)	0.795	48 (68.6)	22 (31.4)	0.872	55 (78.6)	15 (21.4)	0.556	44 (62.9)	26 (37.1)	0.755
More positive	41 (70.7)	17 (29.3)		39 (67.2)	19 (32.8)		43 (74.1)	15 (25.9)		38 (65.5)	20 (34.5)	
R&D Skills and Aptitude												
Less positive	45 (64.3)	25 (35.7)	0.157	46 (65.7)	24 (34.3)	0.548	55 (78.6)	15 (21.4)	0.556	45 (64.3)	25 (35.7)	0.954
More positive	44 (75.9)	14 (24.1)		41 (70.7)	17 (29.3)		43 (74.1)	15 (25.9)		37 (63.8)	21 (36.2)	
R&D Support												
Less positive	54 (64.3)	30 (35.7)	0.075	55 (65.5)	29 (34.5)	0.404	62 (73.8)	22 (26.2)	0.310	48 (57.1)	36 (42.9)	0.024
More positive	35 (79.5)	9 (20.5)		32 (72.7)	12 (27.3)		36 (81.8)	8 (18.2)		34 (77.3)	10 (22.7)	

as professional leadership, practice development as a valued activity, and value of professional equity in interdisciplinary working. This factor accounted for 29.8% of the total variance and had an Eigenvalue of 4.9. The Cronbach's alpha coefficient for this factor was 0.825. The second factor, labelled R&D Skills and Aptitude and comprised four items, described the perception of the individual's ability with R&D activity, such as confidence in using research in practice, familiarity with R&D terminology, and knowledge about how practice is influenced by research. This factor accounted for 18.1% of the total variance and had an Eigenvalue of 2.9. The Cronbach's alpha coefficient was 0.867. The third factor, labelled R&D Intention and comprised three items, described the perception of willingness to engage in R&D activity, such as the wish to learn more about research, share practice development ideas across their organization, and use research in their practice. This factor accounted for 9.5% the variance and had an Eigenvalue of 1.5. The Cronbach's alpha coefficient was 0.808.

The sample's socio-demographic characteristics are presented in Table 3. There were more females (61.7%), Malaysians (61.7%), and those employed in Government-funded dental schools (73.4%). The sample was fairly equally distributed in the 26–35 (34.4%), 36–40 (27.3) and 41+ (38.3%) age groups. Most respondents possessed an MSc (63.3%) as their highest postgraduate qualification, whereas the PhD (21.9%) was possessed by just over a fifth of the sample. Just over half (50.8%) of the sample had spent up to five years in academia, with the remaining fairly equally distributed in the 6–10 (21.1%) and 11+ (28.1) intervals.

R&D Intention was not statistically significantly associated with any of the socio-demographic characteristics (Table 3), whereas more positive perception of R&D Skills and Aptitude were statistically significantly associated with older respondents (0.050), PhD holders (0.014) and those with more years in academia (0.014). Perception of more positive R&D Support was statistically significantly associated with Malaysians (0.025) and those employed in Government-funded schools (0.017).

Thirty nine (30.5%) respondents reported involvement in research-related activity in the past 12 months (Table 4), and this was statistically significantly associated with being a non-Malaysian (0.001) and employed in a Privately-funded dental school (0.004). Forty one (32.0%) respondents reported being named in a research funding application in the past 12 months, and this was statistically significantly to being in the older age groups (0.030). Thirty (23.4%) respondents reported being an author of a peer-review research publication, and this was statistically significantly associated with being a non-Malaysian (0.001), PhD holder (0.024), and employed in a Privately-funded dental school (0.004). Forty six (35.9%) respondents reported presenting a conference research paper in the past 12 months, and this was statistically significantly associated with being a non-Malaysian (0.001) and employed in a Privately-funded dental school (0.005). (Tables 5 and 6).

Perceptions of R&D culture were not statistically significantly associated with research activities except for perception of R&D Support. Those who perceived R&D Support less positively (42.9%) were more likely than those who perceived more positively (22.7%) to have presented a conference research paper in the past 12 months (0.024).

Table 6 – Prevalence and odds ratios of a research publication in the past 12 months for socio-demographic and professional characteristics.

Have you been an author of a peer reviewed research publication in the past 12 months?			Crude		Adjusted	
		Yes	OR (95% CI)	p-value	OR (95% CI)	p-value
Sex	Male	16 (32.7)	1		1	
	Female	14 (17.7)	0.44 (0.19–1.02)	0.056	0.91 (0.33–2.47)	0.905
Age in years	26–35	9 (20.5)	1			
	36–40	9 (25.7)	1.35(0.47–3.86)	0.582		
	41+	12 (24.5)	1.26 (0.47–3.36)	0.643		
Nationality	Malaysian	11 (13.9)	1		1	
	Non-Malaysian	19 (38.8)	3.92 (1.66–9.23)	0.002	2.42 (0.85–6.88)	0.096
Highest postgraduate qualification	None	1 (5.3)	1		1	
	MSc	18 (22.2)	5.14 (0.64–41.2)	0.123	5.10 (0.60–43.4)	0.136
	PhD	11 (39.3)	11.65 (1.35–100.16)	0.025	12.79 (1.28–127.96)	0.030
Years in Academia	Up to 5	11 (16.9)	1		1	
	6–10	7 (25.9)	1.72 (0.59–5.05)	0.325	1.46 (0.44–4.88)	0.535
	11+	12 (33.3)	2.46 (0.95–6.34)	0.064	1.66 (0.54–5.05)	0.374
Dental school funding	Government	16 (17.0)	1		1	
	Private	14 (41.2)	3.41 (1.43–8.14)	0.006	2.94 (0.99–8.74)	0.052
Total		30 (23.4)				

Logistic regression analyses with unadjusted odds ratios showed that being an author of a peer reviewed research publication in the past 12 months was significantly associated with being a non-Malaysia, having a PhD, and employment in a privately-funded dental school. After adjustment, significant association remained with having a PhD (OR 12.79, CI 1.28–127.96).

Discussion

This survey was carried out to quantify participation in research activities among dental academics in Malaysian dental schools. The key findings were that just over a fifth to a third of the sample had participated in some form of research activity in the past 12 months. Participation was associated with being a non-Malaysian, employment in a privately-funded dental school, and PhD training, but not usually with perception of R&D culture.

Almost all the respondents reported positive intentions towards R&D ("I would like to learn about research activity during the next twelve months", "I would like more opportunities to share practice development ideas/research/information across the Faculty", and "I am very keen to use research in practice"). However, perceptions of organisational support ("I have access to training and development opportunities which give me the skills to question and investigate practice") and an enabling research working environment ("There are opportunities to reflect on my practice" and "There are regular staff meetings to explore ideas") were less positively reported. This would appear to be consistent with findings reported for primary health care professionals in the UK [20]. The importance of an enabling research culture as indicated by positive collegial relationships, inclusivity, non-competitiveness, and effective research processes and training, has been previously highlighted [21], and indeed, specific strategies such as weekly research and journal club meetings, with an emphasis on team activities, have been reported to promote research productivity [22]. Additionally, individualized training and continuous intensive mentorship in research knowledge, skills and experience to support development of skills and aptitude [23], the training of dentists who possess a genuine interest in science should be viewed as one of the most important factors contributing to high quality research [18].

Confirmatory PCA identified three factors as previously reported by Watson et al. [16]. These were labelled R&D Intention, R&D Skills and Aptitude, and R&D Support, suggesting that R&D culture is characterised by organisational support to promote research, and individual ability to conduct independent research and motivation to participate in research [14,17]. In the present study organisational support was more positively perceived by Malaysians and those employed in government-funded dental schools. This finding reflects current faculty profiles in Malaysia, in which faculty in government-funded schools are more likely to be Malaysians. It also reflects current research funding practices, in which internal or institutional funding is more likely to be

available in government-funded schools. In terms of perception of R&D skills and aptitude, those with PhD as the highest postgraduate qualification and those who had spent longer time in academia were more likely to report a positive perception, whereas perception of R&D intentions was not associated with socio-demographic or professional characteristics. Unlike previous reports of female academics perceiving research culture less positively [24], gender was not found to be associated with perception of R&D culture in the present study.

Presentation at a research conference was the most commonly reported activity whereas authoring a peer-reviewed publication was reported by less than a quarter of the sample. This would appear to be somewhat high compared to less than 10% reported in the literature, albeit for non-academic primary care practitioners and primary care doctors [20,25,26]. Male academics [27–30] and those who spend more time in research [31] have been reported to be more likely to be research productive. Although men are reported to have higher overall research productivity, women tend to produce less research output earlier in their careers, but at senior levels they equal or exceed the research productivity of men [32]. Results of the present study also suggest that male academics are more likely to be productive in terms of publications and research funding applications although this was not statistically significant. Consistent with previous reports [33–35], results from the present study showed that respondents with a PhD were more likely to have published compared to those without. It is suggested that the additional training to obtain a PhD over a Masters degree significantly nurtures academics to hone research skills within a supervised environment and should be encouraged for research-inclined academics [33].

Although it has been proposed that a more positive perception of R&D culture is more likely to lead to research activity [20], our results indicated that perceptions of R&D Culture were not associated with participation in research activities, except for positive perception of R&D Support and presentation of a research conference paper in the past 12 months. Other studies have reported that organizational characteristics, such as staff-students ratio and library facilities [36], and attitudinal factors associated with individual faculty [24] are associated with research productivity. In addition, a mentoring system [37] and a reward scheme that awards points for research efforts for each progressive step along the research path from project design to acceptance for publication has also been proposed [38] have been proposed as supportive of intentions to participate in research activities.

Findings of the present study should be considered within its limitations. Firstly, four dental schools did not agree to participate, therefore a significant minority of potential participants were excluded. However, a mixture of private and government schools were represented in our sample, which gives our study some degree of external validity. Secondly, data were self-reported, and therefore subjected to some degree of recall bias, which may explain the over-estimation of participation in research activities compared to previous studies. Thirdly, useable responses represented 50% of the sampled respondents, with consequent limitation on its external validity. As characteristics of the source population could not be established, there is therefore no evidence that our sample is representative of dental academics in Malaysia. However, our response rate is comparable to other studies using the R&D Culture Index [20].

The factors affecting research capacity development are numerous and likely to be complex, and it is not something that should only be considered at the departmental level, but require national consideration as well as factors dependent upon the individual [39]. The amount of variability in R&D Culture Index score did not explain participation in research activities, suggesting that other important factors that determine research activity were not measured. Within the context of the present study's limitations, training to the PhD level was the only factor shown to be associated with participation in research activities. Opportunities for PhD training, especially for clinician dentists, in low to middle income countries like Malaysia are somewhat limited because of lack of expertise and resources. However, they have to be created if research capacity is to be built and strengthened for effective control of diseases and socioeconomic development. Less challenging than creating structured research training opportunities such as the MSc or Phd may perhaps be the promotion of research in the primary care dental practices setting. In countries where postgraduate training opportunities are scarce, most dentists are employed in the general practice sector, which is a rich resource for supporting the development of a research culture. The use of dental practices as research networks has been active in the UK [40] and the United States [41] for the last 10–15 years, and more recently in Japan [42]. This is perhaps a path that Asian dental research can travel in order to begin to promote a culture of research in dentistry.

Competing interests

The authors have no competing interests.

Authors' contributions

AP conceived and designed the study, and contributed to data analysis and interpretation, as well as manuscript drafting. SAK contributed to the design of the study, and contributed to the data analysis and interpretation. HAO contributed to the design of the study and the data collection. AJ led on the data collection. LLS contributed to the design of the study and manuscript drafting. CGT contributed to the design of the study and manuscript drafting.

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Research paper

Does periodontal inflammation affect glycosylated haemoglobin level in otherwise systemically healthy individuals? – A hospital based study

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ABSTRACT

Background and objectives: Microbial biofilm and host susceptibility play an important role in the initiation and progression of periodontitis. Periodontitis is considered the sixth complication of diabetes mellitus and a bidirectional relationship exists between diabetes and periodontitis. This cross-sectional observational study was undertaken to evaluate the glycosylated haemoglobin (HbA1c) level in chronic periodontitis.

Methods: The study involved 100 subjects. The case group consisted of 50 subjects with chronic periodontitis and the control group consisted of 50 periodontally healthy subjects. Periodontal parameters including plaque index, oral hygiene index, modified gingival index, probing pocket depth, and clinical attachment level were measured and recorded. Systemic parameters like Body Mass Index (BMI), Waist Hip Ratio (WHR), C- Reactive Protein (CRP), Glycosylated haemoglobin (HbA1c), lipid profile, fasting blood sugar, post prandial blood sugar and serum albumin were assessed in all subjects.

Results: The mean HbA1C for the case group was 6.27 ± 1.5 and for the control was 5.36 ± 0.4 and the difference was statistically significant ($p = 0.001$). The mean FBS, PPBS, LDL, WHR, CRP was statistically significant between groups ($p \leq 0.05$). Periodontal parameters like PI, OHI, MGI, PD and CAL were significantly higher in the case group than the control group (p value ≤ 0.05). The multivariate linear regression model with the dependent variable HbA1c showed chronic periodontitis was significantly associated with HbA1c level.

Conclusion: In chronic periodontitis patients (otherwise systemically healthy) the presence of periodontal inflammation affected the glycosylated haemoglobin level and they were in prediabetes stage. Therefore, it is plausible that the prediabetes stage might be reduced via appropriate periodontal therapy.

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Introduction

Periodontal disease is a common, chronic, immunoinflammatory disease characterized by the destruction and loss of connective tissue attachment. Mounting evidences suggest that microbial biofilm and host susceptibility play an important role in the initiation and progression of periodontitis [1]. Recent studies have demonstrated that chronic periodontitis is a potential risk factor for systemic diseases like coronary heart diseases/atherosclerosis and worsening of glycemic control in diabetes mellitus [2,3].

The Expert Committee on the Diagnosis and Classification of Diabetes Mellitus identified a group of individuals whose glucose level were higher than normal but not high enough to be classified as diabetic. This intermediate group of individuals was defined as having impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) and they were at high risk for the future development of diabetes. In 2009, International Expert Committee recommended HbA1C test as one of the available tests to diagnose diabetes and those at high risk of developing diabetes in the future. According to "American Diabetic Association" (ADA), the term pre-diabetes may be applied to individuals whose HbA1C fall within the range of 5.7–6.4% and considered at high risk for the future development of diabetes [4].

Periodontal disease has now been recognized as the sixth complication of diabetes [5]. Evidences in recent literature support the existence of bidirectional link between chronic periodontitis and diabetes mellitus [6,7]. The association between periodontitis and impaired glucose metabolism has not been completely revealed at the molecular and cellular level. Once the inflammatory mediators produced by periodontal pathogen gain access into systemic circulation, it could lead to a low-grade inflammatory burden and eventually insulin resistance [8]. Although many studies reported the association between periodontitis and diabetes mellitus, the impact of periodontitis on prediabetes is unclear. Very few studies are available in current literature addressing the impaired fasting glucose level in periodontitis [9,10]. These existing studies suggest that periodontitis may affect glucose metabolism in the general population, albeit to a lesser extent than in adults with diabetes.

So it was hypothesized that patients with periodontitis have higher HbA1c levels than healthy patients. This study aimed to assess glycosylated haemoglobin levels in otherwise systemically healthy individuals with chronic periodontitis. The secondary objective of this study was to correlate the levels of HbA1c, inflammatory markers like serum albumin and CRP with periodontal parameters.

Materials and methods

This cross- sectional study was conducted in the Department of Periodontics, Govt. Dental College, Calicut, in collaboration with Department of Biochemistry, Govt. Medical College, Calicut.

It was calculated that a sample of 50 cases and 50 controls provided the study with 90% power to detect a 0.4% difference between groups when alpha was set at 0.05 and with an estimated sample standard deviation of 0.6%. The expected difference between groups was based on the weighted value reported in a meta-analysis of HbA1c changes after periodontal treatment in patients with diabetes [11].

The duration of the study was 14 months from June 2012 to August 2013. The study was approved by the Institutional Ethics Committee, Govt. Dental College, Calicut, and informed consent was obtained from the study subjects. A total of 105 subjects were selected, 100 subjects agreed to participate in the study; five subjects (2-controls and 3-cases) were not willing to participate in the study and were excluded.

The case group consisted of 50 otherwise systemically healthy subjects with chronic periodontitis comprising of eight moderate chronic periodontitis and forty-two severe chronic periodontitis subjects. Patients with chronic periodontitis were recruited from the out-patient wing of Department of Periodontics, Govt. Dental College, Calicut, after clinical diagnosis of chronic periodontitis. The diagnostic criterion for periodontitis was based on American Academy of Periodontology's criteria 1999, and clinical case definitions proposed by the CDC working group for use in population-based surveillance of periodontitis by the Division of Oral Health (DOH), and Centres for Disease Control and Prevention (CDC), in collaboration with the American Academy of Periodontology definitions [12].

The control group consisted of 50 periodontally healthy subjects and/or those with mild periodontitis and were selected from faculty and other staff of Government Dental College, Calicut.

Inclusion criteria for case group were, chronic periodontitis patients with age between 25 to 55, minimum of 20 teeth, and no family history of diabetes. The control group was selected on the basis of same inclusion criteria as that of case group, but without moderate or severe chronic periodontitis (CDC criteria).Exclusion criteria included patients with known systemic diseases and conditions such as CVD, renal disease, rheumatoid arthritis, diabetes mellitus, liver and pancreatic diseases, nutritional deficiencies, pregnant and lactating mother, haemolytic anemia and subjects who received systemic antibiotic therapy within the preceeding 6 months and periodontal therapy within the last one year.

Subjects were evaluated using a detailed questionnaire regarding their medical and social history, age, family income, education, diet, occupation, eating habit, smoking habit, oral hygiene practice habit, family and individual history of diabetes, hypertension, and previous drug allergy. Oral and periodontal examination included bleeding from gum, pus discharge from gum, abscess, mobility of teeth, caries exposure, plaque index, simplified oral hygiene index (OHI-s), modified gingival index (MGI), probing pocket depth (PPD) and clinical attachment level(CAL).Systemic and biochemical parameters like height, weight, body mass index (BMI), waist hip ratio (WHR), C-reactive protein (CRP), glycosylated haemoglobin(HbA1c), total cholesterol (TCHO), triglycerides (TG), high density lipoprotein (HDL), low density

Table 1 – Distribution of patient characteristics.

Characteristic	Case N=50	Control N=50	P Value
Age			
Mean ± SD	42.86±7.435	38.44±7.435	0.003
Gender			
Male %	48%	44%	
Female%	52%	56%	0.841
Family income			
APL (above poverty line) (% within group)	60%	64%	
BPL (below poverty line) (% within group)	40%	36%	0.418
Distribution of diet			
Non veg (% within group)	46%	96%	
Veg (% within group)	54%	4%	0.001
Smoking habit			
Present (% within group)	10%	18%	
Absent (% within group)	90%	82%	0.388
Education status			
High school and below high school (% within group)	66%	44%	
Pre-university course (% within group)	16%	0%	0.001
Degree (% within group)	14%	4%	
Post graduate (% within group)	4%	52%	
Occupation	62%		
Unemployed		36%	
Student	2%	32%	
Worker	20%	0%	0.001
Professional	16%	32%	

lipoprotein (LDL), very low density lipoprotein (VLDL), TCHO / HDL ratio, fasting blood sugar, post prandial blood sugar and serum albumin were also assessed.

HbA1c was used as a measure of glycemic status. The assay used was Bio-Rad D-10 Dual Program. It was based on chromatographic separation of the analytes by ion exchange high performance liquid chromatography (HPLC).Total duration of assay was 6.5 minutes per sample. CRP -turbilatex quantitative turbidimetric test was used for the measurement of C- reactive protein (CRP) in all the subjects.

Table 2 – Distribution of patient according to disease severity.

Group			Disease severity (%)
Case	% within group	Moderate periodontitis	16
		Severe periodontitis	84
Control	% within group	No periodontitis	94
		Mild periodontitis	6

Statistical analysis

Mean levels of HbA1c and all other systemic and periodontal parameters were calculated for each group. All data were analysed using statistical software (SPSS 16.0 for Windows, SPSS South Asia (P) Limited, Bangalore, India). Unpaired t test was used to compare quantitative variables between case and controls, $\times^2$ test was done for qualitative variables and Mann-Whitney U test were done for non parametric variables. The effect of CAL on HbA1c, CRP and serum albumin was assessed by Pearson coefficient correlation. The effect of PI, OHI, MGI on HbA1c as determined by Spearman coefficient correlation. Multivariate linear regression analysis was also done to know the association between chronic periodontitis and HbA1c. The α value was set at 0.05 and confidence interval set at 95%.

Results

The mean age for the case group was 42.86 years and for the control group was 38.44 years, and this difference was statistically significant ($p = 0.003$). Gender distribution, family income and smoking habits were similar between the groups ($p > 0.05$).The distribution of percentages of person for educational status and occupation was significantly different between the two groups ($p = 0.001$) (Table 1). The case group comprised of 16% moderate periodontitis subjects and 84%

Table 3 – Comparision of periodontal and systemic parameters between cases and control.

Parameters	Case (n=50) Mean ±Std. Deviation	Control (n=50) Mean ±Std. Deviation	p value
Periodontal parameters			
MGI	2.60±0.4	1.00±0.01	0.001
OHI-S	2.96±0.1	1.52±0.5	0.001
PI	3.96±.1	1.84±0.6	0.001
PD	5.38±1.3	2.88±0.5	0.001
CAL	5.50±1.6	1.84±0.5	0.001
Systemic parameters			
BMI(kg/m^2)	24.90±4.1	24.48± 2.9	0.560
WHR (cm)	92.96±12.0	85.84±14.0	0.008
CRP	2.74±3.6	1.41±1.0	0.014
TCHO	203.32±37.9	192.26±32.0	0.118
HDL	45.32±4.2	43.98±4.3	0.124
LDL	136.32±29.5	124.32±24.9	0.031
VLDL	21.72±8.8	21.46±9.1	0.886
TG	109.06±44.3	109.54±48.2	0.959
TCHO/HDL Ratio	4.44±0.4	4.31±0.4	0.177
FBS	105.68±40.9	86.06±13.4	0.002
PPBS	130.98±69.4	94.82±29.1	0.001
S.Albumin	3.81±0.36	3.79±0.3	0.742
Glycosylated hemoglobin	6.27±1.561	5.36±0.409	0.001

Table 4 – Linear regression analysis of hba1c and chronic periodontitis, demographic parameters and systemic parameters.

Variables in Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.750	1.594		1.725	.088
	Chronic periodontitis	.578	.231	.239	2.501	.014
	Age	.022	.015	.136	1.471	.145
	Gender	.353	.213	.145	1.658	.101
	BMI	.052	.032	.152	1.640	.104
	CRP	.047	.042	.106	1.136	.259
	Albumin	-.572	.327	-.156	-1.746	.084
	LDL	.012	.004	.276	3.087	.003

(*) Dependent Variable: HbA1C

with severe periodontitis and the control group consisted of 6% subjects with mild periodontitis (Table 2).

Periodontal parameters (MGI,OHI-S,PI,PPD and CAL) showed statistically significant difference between the case and control groups (p =0.001) (Table 3). The mean difference in BMI,TCHO, HDL,VLDL, TG and ratio of TCHO/HDL for case and control groups were not statistically significant (p>0.05). The mean difference in CRP and LDL was statistically significant between groups (p<0.05) (Table 3).

The mean FBS was 105.68±40.9 for the case group for control was 86.06±13.4, and the difference was statistically significant (p=0.002).The mean PPBS was 94.82±29.1, 130.98±69.42 respectively for the case and control groups and it was statistically significant (p = 0.001).The mean serum albumin between groups was not statistically significant (p>0.05).The mean HbA1C for case group was 6.27±1.5 and for the control was 5.36±0.4, and the difference was statistically significant (p=0.001) (Table 3).

The multivariate linear regression model with dependent variable HbA1c showed that chronic periodontitis was significantly associated with HbA1c (beta coefficient 0.578 and p = 0.014).The LDL was also significantly associated with HbA1c (beta coefficient 0.012 and p = 0.003), whereas age, gender, BMI, CRP, serum albumin were not significantly associated with HbA1c (Table 4).There was a moderate positive correlation between HbA1C and CAL and PI {(r = 0.492), (r=0.427)}.CRP showed moderate positive correlation with CAL(r=0.306) and the serum albumin showed negative correlation with CAL(r = -0.061) (Fig. 1).

Discussion

Inflammation is linked to pathophysiology of several systemic diseases and conditions. Chronic gram-negative infection of periodontal origin may be considered a potential focus of infection for systemic diseases. Chronic low grade

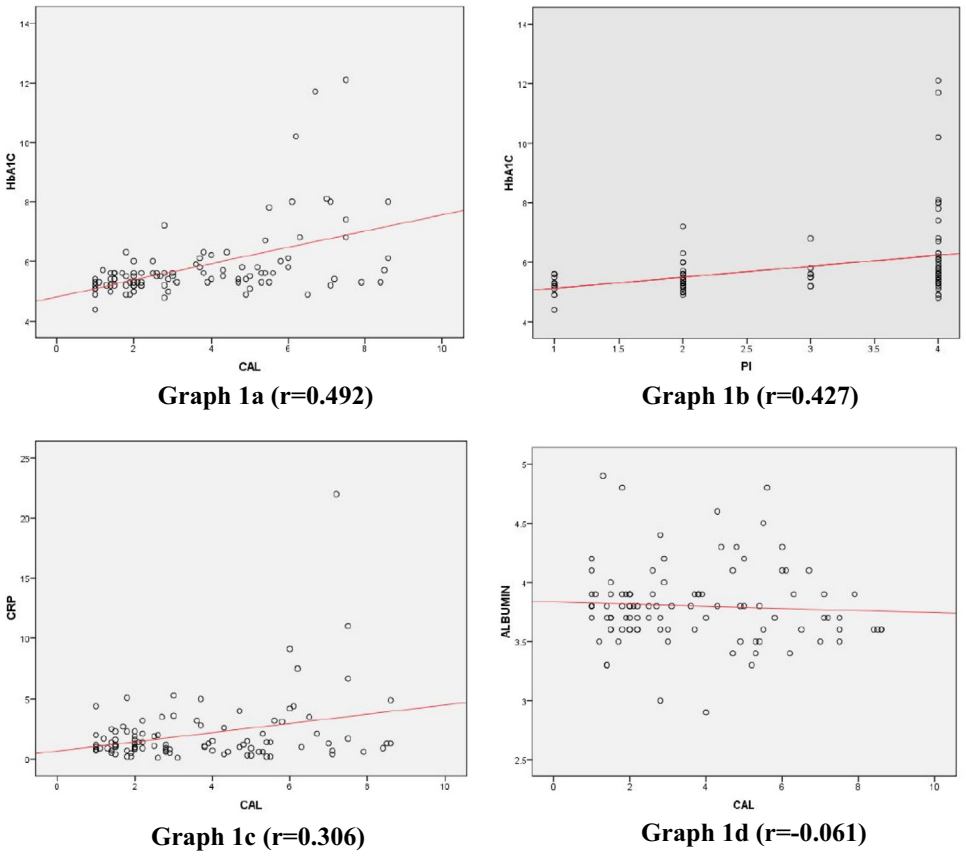

Fig. 1 – Graph depicting correlation of systemic parameters with periodontal parameters. Graph 1a-Correlationof HBA1c with CAL. Graph 1b-Correlationof HBA1c with PI. Graph 1c- Correlation of CRP with CAL. Graph 1d- Correlation of serum albumin with CAL.

inflammation produces pro-inflammatory cytokine such as IL-1β, TNF-α and IL-6 which may lead to insulin resistance [13–15]. Periodontitis is an immunoinflammatory disease and that could have a negative effect on glycaemic control.

Our study participants were not age matched (p value < 0.05). Wienerin1998 reported that age did not influence levels of HbA1c in normal subjects [16]. Nuttall et al. reported that there was an age-related increase in percentage of HbA1c [17]. However, the increase was only modest and had only a minor effect on a determined reference range in adults. In this study, the multivariate linear regression model showed that age had no relation with HbA1c levels.

In this study the control group was more educated than the case group (chronic periodontitis group). This is consistent with the systematic review and meta-analysis of Boillot et al. and concluded that low educational attainment was associated with an increased risk of periodontitis [18].

Obesity is associated with high plasma levels of TNF-α and its soluble receptors, which in turn may lead to a hyper-inflammatory state, increasing the risk for periodontal disease and also accounting in part for insulin resistance. In this study the BMI showed no statistically significant difference between the cases and controls which was consistent with previous literature [19].

Among the various metabolic parameters studied, the mean level of LDL and total cholesterol (TCHO) was higher in the case group and this finding confirms previous literature [20,21]. Chronic infectious diseases are now thought to have an impact on plasma lipid level and periodontal pathogens such as Porphyromonas gingivalis are capable of stimulating a continuous release of pro-inflammatory cytokines such as IL-1, IL-6 and TNF-α [22]. These cytokines are believed to have direct or indirect effects, resulting in enhanced hepatic lipogenesis, reduced elimination of LDL and increased tissue lipolysis. Cytokines, such as TNF-α, IL-1β may be responsible for insulin resistance and subsequent poor glycaemic control in periodontitis patients [23,24]. Contradictory to this, Machado et al. 2005 opined that there was no significant relationship between periodontal disease and blood serum lipid levels [25].

An interesting finding in this study was that the mean FBS and PPBS level was significantly higher in the case group and showed a tendency towards pre-diabetes with impaired fasting glucose and was consistent with previous studies [9,10]. This observation supports the fact that gram negative bacteria in periodontitis (immunoinflammatory disease) may deteriorate glycaemic control and may induce a state of prediabetes.

Glycosylated haemoglobin level (HbA1c) was taken to assess the level of glycemic status. HbA1c is a reliable measure of chronic glycemic levels, which captures the degree of glucose exposure over time.It serves as a better

biochemical marker of diabetes and should be considered a diagnostic tool [26]. According to the "International Expert Committee" and ADA, HbA1c is a more stable biological index than FPG, in the diagnosis of diabetes. FPG is known to fluctuate within and between days [4].

In this study, the mean HbA1c for the case group showed a tendency towards prediabetes. Our result was consistent with the previous report by Rajan et al. [27]. They reported that HbA1c was slightly higher and statistically significant in chronic periodontitis cases than in healthy controls. The mean Glycosylated hemoglobin (HbA1C) level obtained in our case group was also in accordance with the result of the previous study [10,28]. In a pilot study, Ruchika et al. 2013 suggested a possible link between periodontitis and glycemic control in non-diabetic individual in Indian population [29]. The impact of periodontitis on changes in HbA1c was assessed in a prospective 5- year study in non-diabetic individuals by Demmer et al. and concluded that periodontitis predicts the progression of HbA1c among diabetes-free individuals [30].

In our study, there was a moderate positive correlation between HbA1c level and CAL, MGI, PI and OHI. This result was in agreement with previous study by Ruchika et al. who found a positive correlation between HbA1c and clinical attachment loss [29]. Our result was in contrast with the report of Wolff et al. who reported that disease extension was negatively correlated with HbA1c [10]. In our study, multivariate linear regression model showed that chronic periodontitis was significantly associated with HbA1c.

One significant observation of this study was that the mean CRP for case group was higher than control group, and showed a slight positive correlation with CAL. In agreement with our study Demmer et al. reported that there was a possibility of synergy between periodontal infection and systemic inflammation, and supported the role of inflammation as both mediator and effect modifier of this association [31].

The impact of periodontal diseases on the glycemic control at the biological level is not fully elucidated till now. Hujoel et al. in 2001estimated the cumulative surface area of ulcerated pocket epithelium and it ranged from 8 to 20 cm^2 in untreated severe periodontal disease, which was approximately the size of the palm of an adult hand. Periodontitis is primarily an oral infection caused by gram-negative anaerobes [32]. The main virulence factors of periodontal microorganisms are endotoxins in the form of lipopolysaccharides (LPS) and pathogenesis is triggered by recognition of pathogen-associated molecular patterns by Toll-like receptors (TLRs), which release Reactive Oxygen Species(ROS), proinflammatory cytokines, and immuneregulatory complexes. Substantial evidences suggest that periodontal inflammation is associated with sub-clinical inflammatory state which can produce inflammatory cytokines (e.g. CRP, TNF-α and IL-6) in the local tissue, as well as elevate their level in the systemic circulation.CRP andTNF-α are an important mediators of inflammation. Nishimura et al.2005 found that chronic periodontal inflammation can result in increased level of serum TNF-α, which initiate phosphorylation of serine residues in the insulin receptor substrate-1, prompting the target cells to produce insulin resistance (IR), also acting on the liver to increase CRP synthesis [33]. TNF-α and other inflammatory mediators may activate the intracellular pathways, such as the I-kappa-B (IκB), I-kappa-B kinase-β (IKKβ), nuclear factor-kappa B (NF-κβ) and the protein c-Jun N-terminal kinase (JNK) axes. They may amplify and aggravate low-grade inflammation. These processes may become self-perpetuating through a positive feedback loop created by the proinflammatory cytokines, and lead to insulin resistance(IR) [34].

From the above discussion it is evident that in chronic periodontitis patients (otherwise systemically healthy), the presence of periodontal inflammation affects the glycosylated haemoglobin level and resulting them in being a prediabetes stage. Multi- centric study with a large sample size is required to study HbA1c in chronic periodontitis patients. Since this is a hospital- based observational study, interventional studies are needed to establish whether periodontal therapy can improve pre- diabetic state in periodontitis.

Conclusion

This observational study showed increased level of HbA1c, FBS, and PPBS in otherwise systemically healthy individuals with chronic periodontitis. In periodontitis the presence of subgingival pathogens elicits a local inflammatory response and their end-products also trigger a systemic host response which in turn may lead to a hyper inflammatory state, increasing the risk for prediabetes or future development of diabetes. Therefore, it is plausible that the prediabetes stage may be reduced via appropriate periodontal therapy. Closer collaboration between physicians and periodontists could reduce the risk for prediabetes or future development of diabetes.

Conflict of interest statement

All the authors in the study have contributed significantly and by keeping the latest guidelines by international committee of medical journal editors. All authors are in agreement with the content of the manuscript and there is no conflict of interest.

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Review

The use of 3D models to improve sinus augmentation outcomes – A case report

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ABSTRACT

Sinus augmentation is a predictable procedure that is often required when restoring the posterior maxilla with dental implants. Even with high success rates, careful pre-surgical planning is crucial. A 3D model is a valuable aid for the clinician as it allows for pre-operative simulation, which can reduce surgical time, reduce the risk of intra-operative complications and decrease the potential for error. The aim of this case report is to focus on how such a model is useful when undertaking a sinus augmentation procedure with simultaneous implant placement.

Contents

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Introduction

The posterior maxilla has traditionally been seen as a challenge when it comes to successfully placing dental implants. This is due to a combination of poor bone quality, ridge atrophy and pneumatization of the sinus floor following extraction. The sinus augmentation procedure, first introduced by Boyne and James in 1980 [1], is well documented in the literature as being a safe and reliable technique with highly predictable results [2]. Owing to good surgical outcomes reported in the literature, [3–5] sinus augmentation has gained more popularity with the dental profession and, due to the growing number of clinicians now placing implants, has become increasingly performed. The conventional approach includes preparation of a lateral window through which the sinus membrane is carefully elevated and the space created then filled with a bone graft material.

Although this procedure has a high rate of success, it is surgically challenging and presents various risks and complications [6]. To date, implantology is not a specialty recognized by the ADA in the United States. Moreover, initially only oral surgeons were the specialists who placed dental implants. Today, implant surgery is performed by clinicians with various degrees of surgical experience including general dentists, periodontists, prosthodontists, and endodontists [7]. The level of training dentists receive in this surgical field can vary significantly and it is likely that lack of formal training or inadequate training could lead to higher complication rates. Before performing a sinus augmentation procedure, clinicians should have a thorough knowledge of sinus anatomy, physiology, pathology, and surgical technique in order to avoid undesirable complications that may arise.

Careful pre-surgical planning is crucial and will reduce the incidence of complications. For years, the only pre-operative imaging prior to sinus augmentation were intra-oral periapical and panoramic radiographs. These, however, have their limitations and are not very accurate in showing anatomical variations and landmarks such as lateral wall thickness, disparity/unevenness of the sinus floor, blood vessels and septa. Moreover, sinus pathology is difficult to determine on these 2 dimensional radiographs. Cone Beam Computed Tomography (CBCT) provides greater detail and has become a commonly used diagnostic tool for implant treatment planning. Yet, it can still be challenging to convert the two-dimensional cross sectional images from CBCT into the three-dimensional quadrangular pyramidal structure of the maxillary sinus. For this purpose, 3D printing technology has been introduced in dentistry as a useful and cost effective tool for education and to improve surgical preparation [8]. Stereolithographic (SLA) models, introduced by Charles W. Hull in 1988 in the field of medicine, [9] can be fabricated using digital data from CBCT. More recent advances in digital technology have made 3D printing more accessible and more economical, solidifying its place in mainstream dentistry [10].

3D-printed models can be used to gain insight and become familiar with a patient's anatomy prior to surgical procedures. Furthermore, 3D models can be used for preoperative simulation of the surgical procedure itself, which is advantageous to the surgeon who will perform the procedure. Using such models can aid in reducing surgical time, limiting the amount of soft tissue manipulation, familiarizing the surgeon with the patient's specific anatomy, reducing the risk of intra-operative complications and decreasing the potential for error [11].

The aim of this case report is to focus on how a pre-surgical 3D model can be a valuable aid for undertaking a sinus augmentation procedure with simultaneous implant placement.

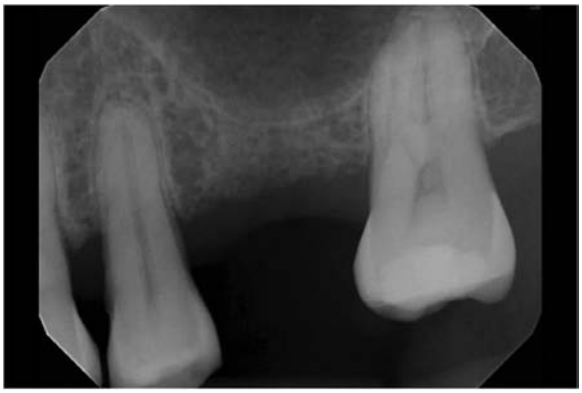

Fig. 1 – Preoperative periapical radiograph showing insufficient height for implant placement in the maxillary left first molar edentulous site.

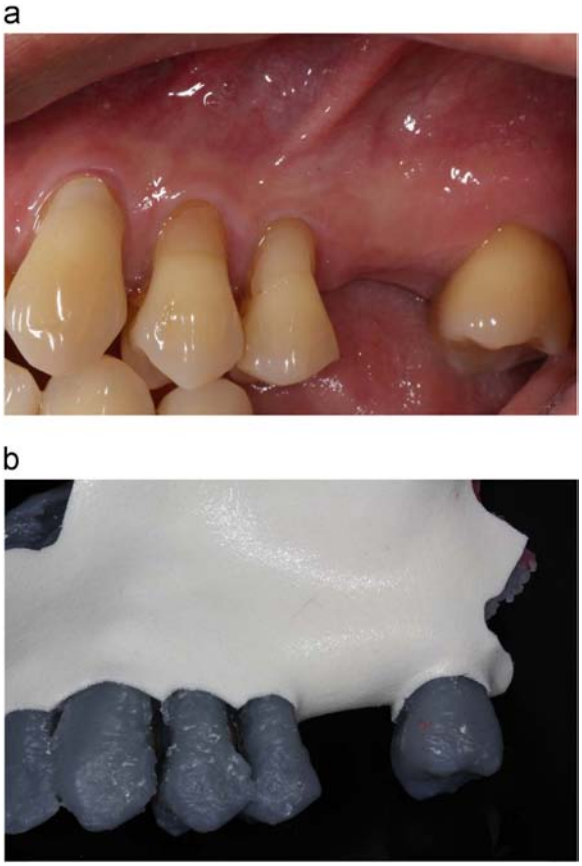

Fig. 2 – a. Preoperative lateral view of the edentulous site. b Simulated 3D model of the surgical site.

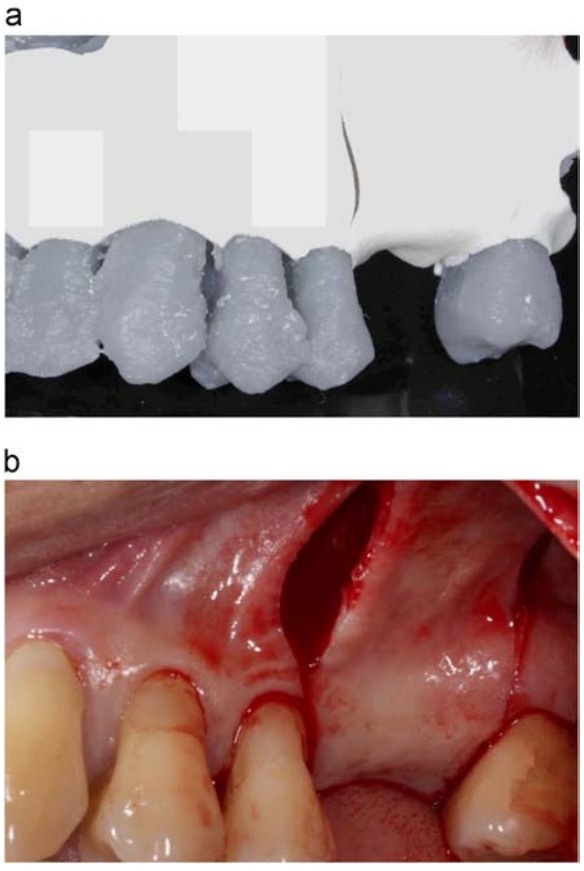

Fig. 3 – a. Midcrestal and two vertical incisions simulated on the 3D model. b. Incision design as was pre-planned on the 3D model.

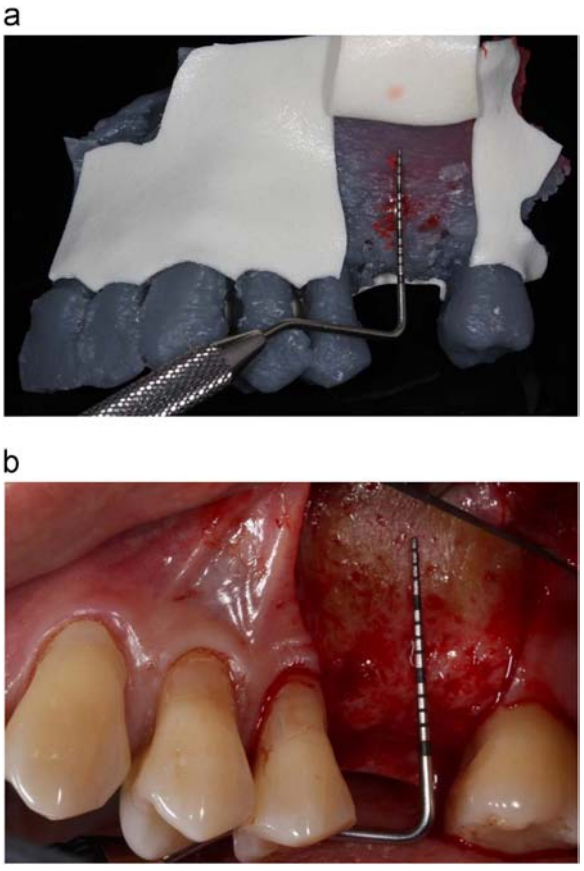

Fig. 4 – a. The soft tissue layer on the 3D model is reflected and a probe can be used to measure the distance of the anticipated antrostomy from the ridge crest. b. Full thickness mucoperiosteal flap was reflected and the lateral wall of the sinus was located.

Case presentation

A 51-year-old male patient presented with a missing maxillary left first molar. The tooth had been extracted over 2 years ago. Intraoral site evaluation and periapical radiographs, made using the paralleling cone technique, showed adequate restorative space and the presence of adequate mesio-distal bone width but lack of apico-coronal bone height for implant placement (Fig. 1).

A cone beam computerized tomography scan of the maxilla was taken to carefully evaluate bone anatomy and confirm the absence of sinus pathology. Digital Imaging and Communications in Medicine (DICOM) images from the patient's CBCT were then converted to STL files (OsiriX Lite, Geneva, Switzerland) and transferred to a 3D printer (Formlabs, USA) for production of a polymer model of the maxilla. Medical adhesive tape and liquid tape were added to the model to mimic the oral mucosa and Schneiderian membrane respectively for a more realistic simulation of the actual surgical environment (Fig. 2a,b). The sinus augmentation procedure via the lateral window approach was simulated on the 3D model prior to treating the patient.

On the day of surgery the patient received 2 g amoxicillin one hour before surgery. Following administration of local anesthesia (2% lidocaine with epinephrine 1:100,000, Septodont, CA), a crestal incision and two vertical releasing incisions on the distal aspect of the maxillary left second premolar and mesial aspect of the second molar, respectively, were made with a 15C scalpel blade (Fig. 3a,b). A full thickness mucoperiosteal flap was reflected exposing the lateral wall of the sinus (Fig. 4a,b). A high speed round diamond bur under copious irrigation was used to create the antrostomy (Fig. 5a,b). Initial elevation of the membrane was performed (Fig. 6a,b) before the final oval-shaped antrostomy was made (Fig. 7a,b). Using a sinus membrane elevator, the sinus membrane was gently separated from the sinus floor. The membrane was carefully elevated along the anterior and medial walls ensuring the instrument remained in contact with the underlying sinus bony wall throughout the procedure to avoid perforation. Following complete membrane elevation extending to the medial wall of the sinus, implant osteotomy was performed (Fig. 8a,b). Once the implant site was prepared, an organic bovine bone (Bio-Oss®, Geistlich Pharma, Princeton, NJ) was compacted into the sinus cavity

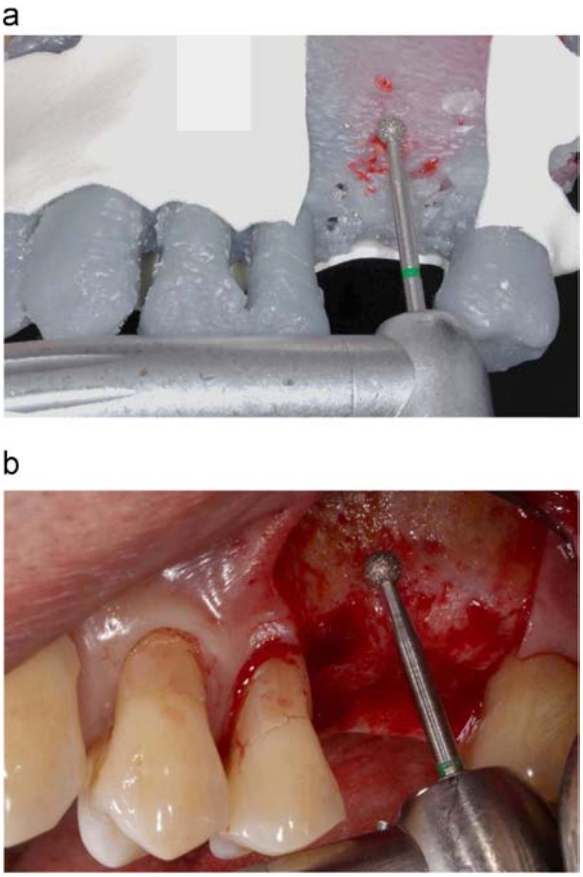

Fig. 5 – a. A round diamond bur is used to create the antrostomy on the 3D model. b. Antrostomy preparation was done using a round diamond bur.

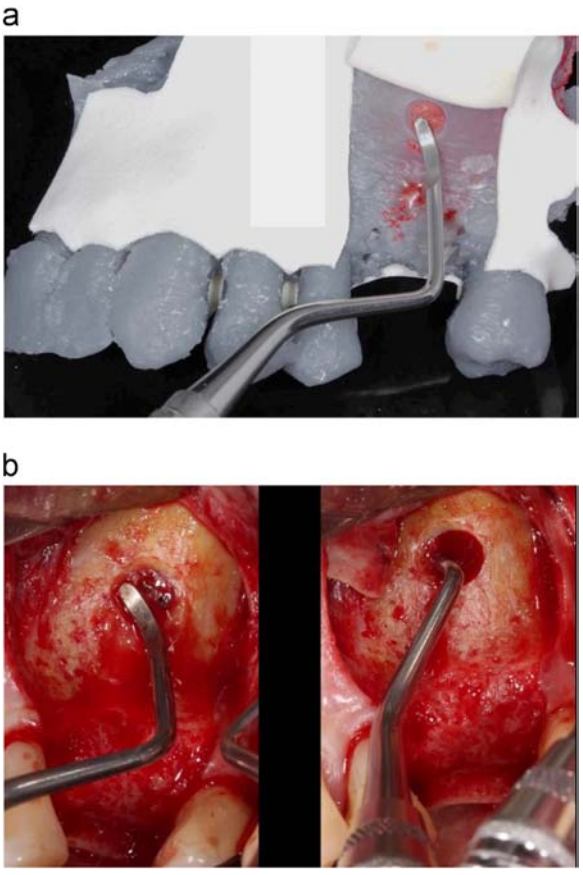

Fig. 6 – a Initial elevation of the simulated membrane is performed on the 3D model. b. Initial elevation of the Schneiderian membrane.

with a bone syringe and gently packed with hand instruments against the intact walls. A 5 × 13mm implant (Nobel Replace Select TPR TiU, Nobel Biocare ® Yorba Linda, CA) was placed and more bone was placed against the lateral and medial portion of the surgical site (Fig. 9a,b). The incisions were closed with interrupted sutures (4-0 chromic gut, Henry Schein Inc, USA) (Figs. 10a,b,11). The patient was followed up after 2 weeks and the healing was uneventful (Fig. 12).

Following successful simulation on the patient's 3D model (Fig. 13), the sinus augmentation procedure with simultaneous implant placement was performed on the patient and no complications were experienced. Second stage abutment insertion surgery was performed 4 months following the sinus augmentation procedure (Fig. 14) and the final screw-retained PFM crown was delivered 1 month later (Fig. 15a,b). Post-operative x-ray and CBCT showed a successful outcome (Figs. 16 and 17).

Discussion

Sinus augmentation is surgically challenging and effective training and education is required to ensure successful outcomes. Although considered a predictable procedure, care must be taken so as not to disturb the long-term function of the sinus and to maintain the health and well being of the patient. Simulation of the procedure on the patient's 3D model can enable seamless execution on the day of surgery leading to a more predictable result. The use of 3D-printed models for such training is also preferable to training on cadavers, since it is patient specific and availability and cost are not limitations [12].

3D-model

While a conventional CBCT does provide adequate information, 3D printed models help the clinician to physically observe the anatomy of the maxillary sinus and allows for pre-surgical simulation of the procedure. Recent articles have reported the uses and benefits of using 3D models in the field of implant dentistry [10]. In the case presented, a 3D model of the patient's own maxillary sinus was used not only for diagnosis and treatment planning, but also to simulate the sinus augmentation procedure via the lateral window with simultaneous implant placement prior to carrying out the

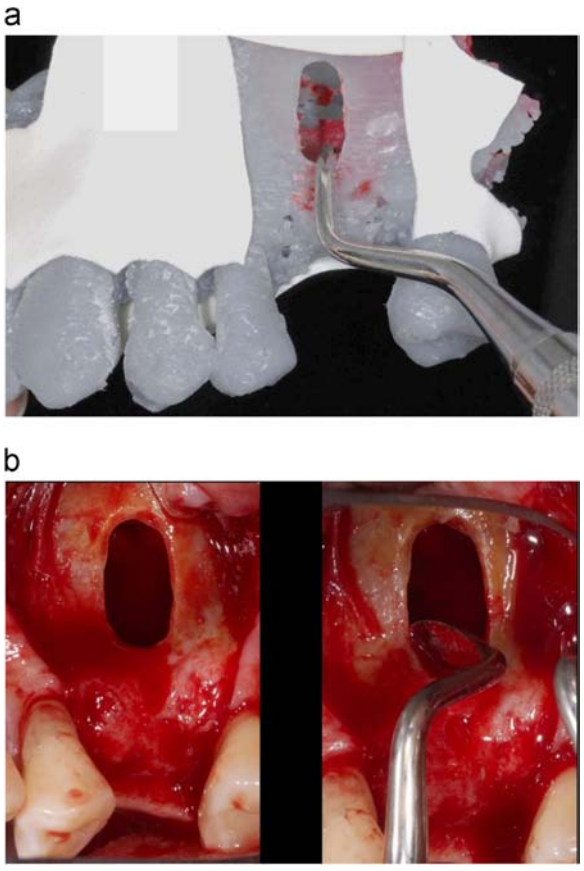

Fig. 7 – a. Final antrostomy shape which allows complete elevation of the membrane layer. b. Final antrostomy shape as was predetermined using the 3D model.

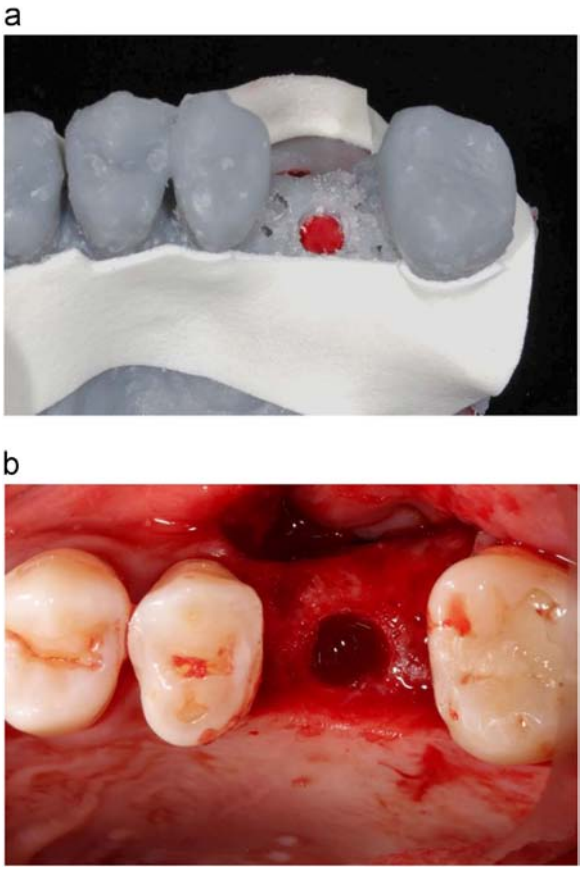

Fig. 8 – a. Implant osteotomy is performed on the 3D model to practice correct 3 dimensional positioning. b. Osteotomy preparation performed during the surgery.

surgical procedure on the patient. Hard and soft tissue can be simulated and due to the realistic nature of the 3D model, each procedural step could be performed on the model as intended on the day of surgery (Table 1).

Flap design

Flap design should be considered prior to surgery and the 3D model allows the surgeon to plan the incisions correctly so as to maximize visibility and access to the surgical site. Incision design and flap elevation, once made, are irreversible and it is crucial that primary closure without tension can be attained.

Antrostomy

The location of the lateral wall can normally be distinguished clinically, however, the shape and size of the antrostomy must allow for the instruments to reach all the walls to ensure complete elevation of the membrane. The 3D model can therefore be used to determine the nal shape of the antrostomy. Similarly, the surgeon can also bene t from the tactile sensation of using the elevators against the internal walls of the sinus and separating the layer of liquid tape simulating the membrane on the 3D model. Implant site preparation and placement, packing of the bone substitute or graft and suturing can all be simulated on the 3D model.

Posterior superior alveolar artery (PSAA)

Possible complications reported as a result of the sinus augmentation procedure include intraoperative bleeding, membrane perforation and post-operative infection [13,14]. Knowledge of sinus anatomy together with its blood supply and noting the location of the blood vessels on the CBCT are important. Marking these blood vessels on the 3D model and ensuring the extent of the vertical incisions and site of antrostomy are at a distance from these vessels and then reproducing this on the day of surgery can reduce the risk of severing the vessel. If the PSAA located in the internal sinus wall cannot be avoided, sinus augmentation via the crestal approach may be indicated.

Schneiderian membrane

Elevating the Schneiderian membrane during sinus surgery is a delicate procedure, and the risk of membrane perforation

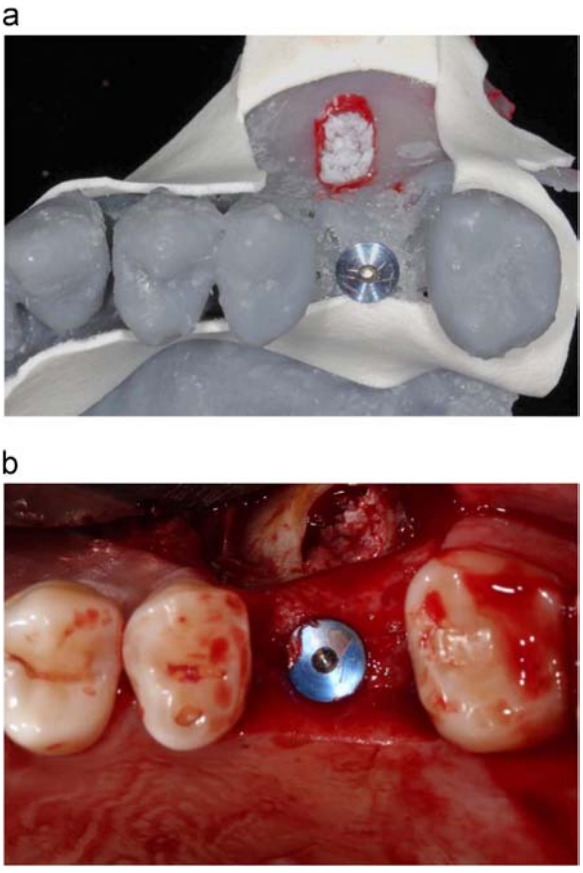

Fig. 9 – a. The implant is placed into the 3D model. Graft material is used to pack the sinus cavity. b. Correct 3 dimensional implant placement on the day of surgery. Bovine bone is packed in the sinus cavity.

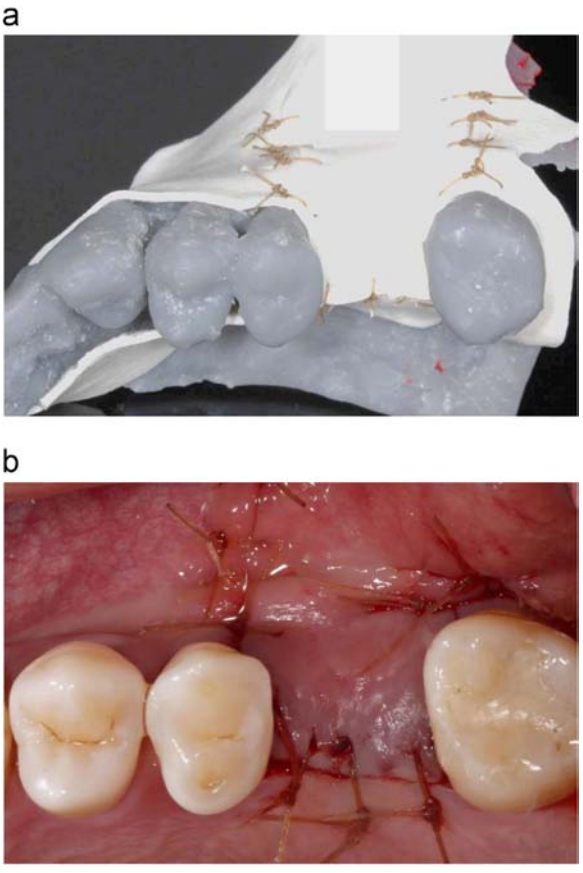

Fig. 10 – a. Closure of the soft tissue layer using 4-0 chromic gut. b. Tension-free primary closure.

has been reported to vary from 11% to 56% [15]. Perforation most often occurs during antrostomy preparation but it can also occur during membrane elevation. A CBCT can be used to assess unevenness of the sinus floor as well as the presence of septa. However, the 3D model enables the clinician to visualize and appreciate the anatomy of the internal walls and also allows the use of the sinus instruments to practice separating the simulated membrane from the bony walls, septa and adjacent teeth. Although this simulated material cannot truly represent the membrane, a deliberate perforation can be made which can allow practice of repairing/treating a perforated membrane.

Infection

The risk of infection exists as in any other surgical procedure and postoperative infection after sinus augmentation occurs in 2.3% of cases [16]. However, a positive correlation exists between the duration of operation and risk of infection [17] and an operation lasting longer than 2 h is a possible risk factor for infection [18]. Performing the procedure beforehand on the patient's 3D model results in reduced operating time and therefore reduced risk of infection.

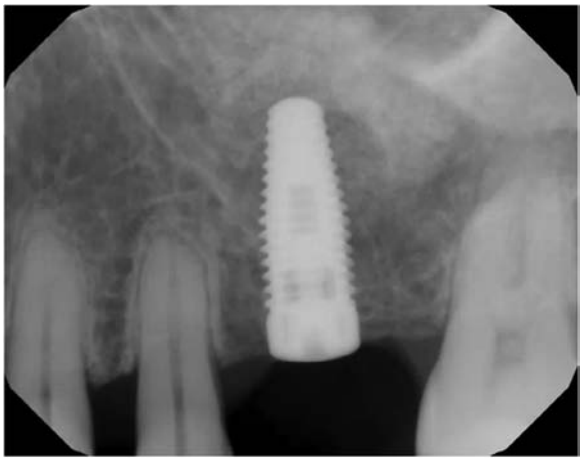

Fig. 11 – Postoperative radiograph after sinus augmentation with simultaneous implant placement.

Conclusion

The anatomical variations of the maxillary sinus make the use of 3D-printed models ideal for surgical preparation. Having an exact three dimensional model of a patient's sinus anatomy available for a clinician to study and use for simulation of the lateral window sinus augmentation procedure is a great

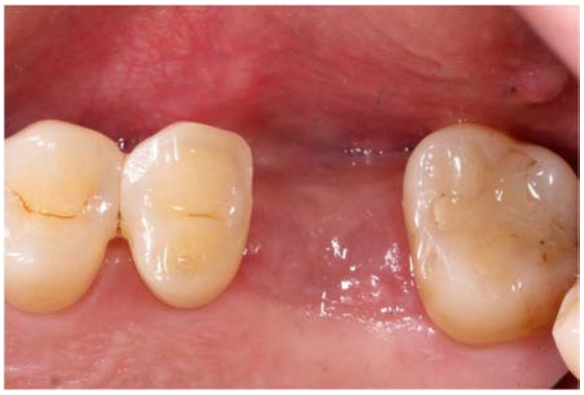

Fig. 12 – The surgical site 2 weeks post surgery.

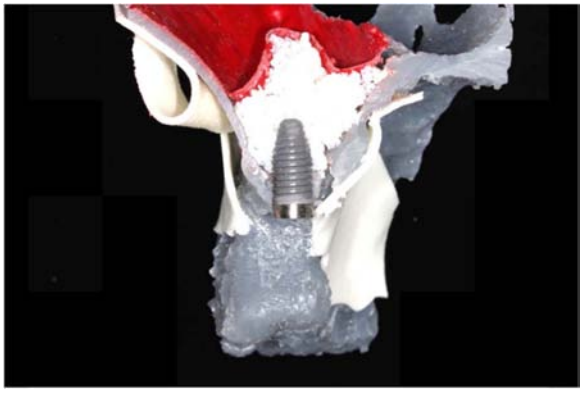

Fig. 13 – Cross-sectional image of the simulated 3D model.

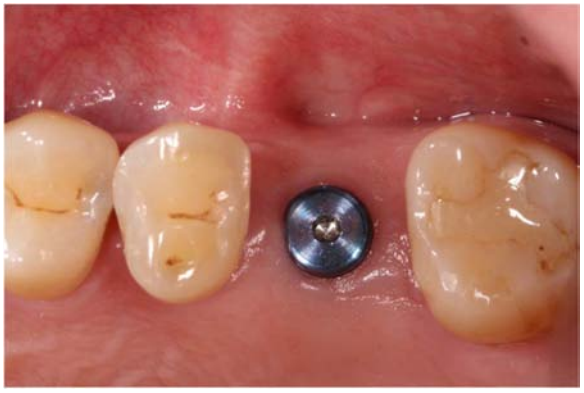

Fig. 14 – Healing abutment in place following second stage surgery.

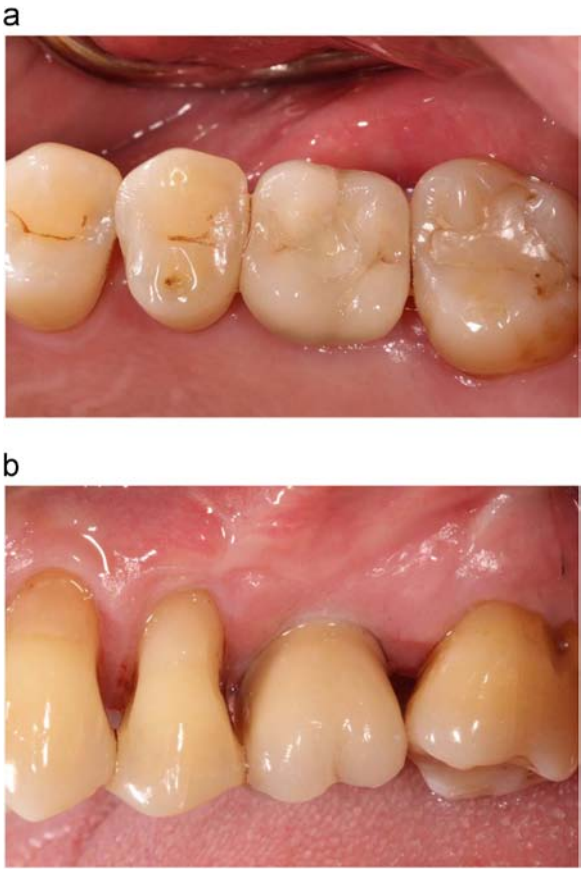

Fig. 15 – a. Occlusal view of the final crown. b. Lateral view of the final crown.

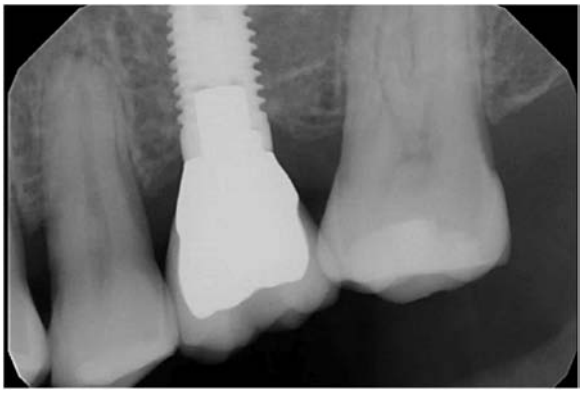

Fig. 16 – Postoperative radiograph after delivery of prosthesis.

advantage compared to relying solely on a CBCT scan which is viewed in 2D on a screen. Repetition is known to be the key to success and carrying out the step by step procedure on the patient's 3D model can help in educating and preparing the clinician for surgery. The use of a 3D printed model is a valuable and effective aid in guiding the less experienced clinician to achieving a successful surgical outcome by allowing practice prior to the actual procedure. In the hands of the experienced operator, it allows better treatment planning and locating anatomical structures.

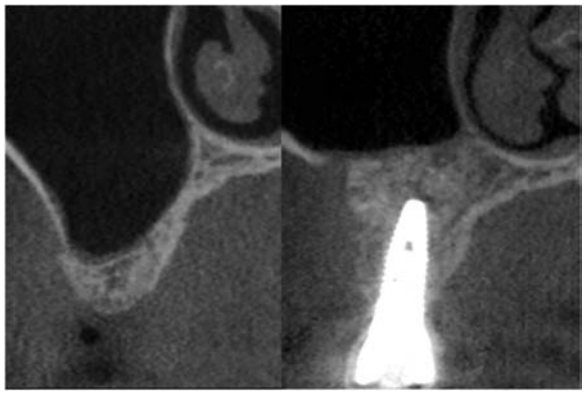

Fig. 17 – Preoperative and postoperative CBCT.

Table 1 – Procedural steps for sinus augmentation.

Procedural Step	Simulation on a 3D Model
Incision design	++
Full thickness flap elevation	+
Lateral window antrostomy	++
Sinus membrane elevation	+
Implant osteotomy	++
Graft packing	++
Implant placement	++
Flap repositioning	+
Closure	+

+ Simulation only
++ Simulation with real dimension

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Conflict of interest

The authors have not received any institutional, private, or corporate nancial support for the study reported herein. In addition, the authors do not have a nancial interest in the companies that manufacture the products used in this study.

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Research paper

Occlusal characteristics and ethnic variations in Malaysian orthodontic patients

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Introduction

Investigations to detect malocclusion and variations in ethnic groups or local populations are important from clinical orthodontic as well as health delivery systems perspectives, to be able to offer orthodontic services specific to the needs and requirements of the communities. Occlusal traits and prevalence of malocclusion may be specific to certain races like Class II problems being more prevalent in whites of northern European descent and Class III problems being more prevalent in Oriental populations [1]. The Asian races of Chinese, Malay and Indians form the three ethnic sub-groups of populations of both Malaysia and Singapore due to their common origin and history. A few studies on prevalence of malocclusion and their inter-ethnic variations have been carried out on these populations.

A study by Woon et al. [2] on 347 Malaysian high school children showed significantly higher prevalence of Class III occlusion among Chinese and Malays as compared to Indians. They also concluded that a crowded dentition was the norm for all three races, edge-to-edge incisor relationship was a norm for Chinese and Malays whereas overjet between 2–4 mm and overbite of between 1/3rd to 2/3rd was more normal for Indians. Soh [3] et al. investigated the occlusal status of 339 Singapore male army recruits and found that Class I molar relation occurred most frequently, however Chinese and Malays had higher prevalence of Class III incisor and molar relationships, whereas Class II division 1 was more common among Indians. Lew and Keng [4] who investigated 1050 Singapore Chinese school children found higher Class III, reverse overjets and open-bites, similar Class II and lower increased overjet, overbite and cross-bite prevalence in them as compared to Caucasians.

Occurrence of these traits in a population does not automatically translate into treatment need. One of the ways treatment need can be assessed is by analysing the characteristics or traits of malocclusion of the population seeking treatment, which are indicators of what patients consider to be severe or significant enough to seek orthodontic treatment. In other words, a study of the distribution of malocclusion in Orthodontic patients reflects the conditions for which patients seek treatment, which may or may not reflect the prevalence of malocclusion in the general population. Hence, we conducted this study with the objective of analyzing the distribution and variation in features of malocclusion among three ethnic sub-groups of Malaysian subjects specifically seeking Orthodontic treatment.

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Materials and methods

For this cross-sectional study, clinical database and pre-treatment study models of 273 patients who were undergoing treatment in the Department of Orthodontics at Klinik Pergigian, Melaka Manipal Medical College, Melaka, Malaysia, between November 2011 and November 2014 were assessed.

By referring to the study done by Soh et al. [3], the sample size for prevalence of occlusal traits (malocclusion, overjet, overbite, crossbite, spacing, crowding and midline shift) was calculated by using the formula:

$$n = \frac{z^2(1-\alpha/2)P(1-P)}{d^2}$$

$$z^2(1-\alpha/2) = 1.92^2$$

P = Prevalence of Occlusal Traits.
d = Precision (0.05).

From all of the calculated values, the highest number of sample size was 1137 (for total Class I molar relationship). This projected ideal sample size was too large size firstly, since we were constrained by time given for submission of the students' elective research project and secondly this time constraint meant that we could only access cases visiting the Department of Orthodontics, from November 2011 until November 2014. Hence, keeping in view the time and resource constraints, it was decided to carry out a pilot study with 30 subjects in each ethnic group, which would sum up to a total of 90 subjects. Although the original target was to investigate 90 samples, we were able to obtain 112 out of a total of 273 study models available for investigation after applying the inclusion and exclusion criteria.

Ethical approval for this study was obtained from the institutional Research Ethics Committee (Reference no: MMMC/FOD/AR/B2/E C-2014 (08)). To be included in the study the subjects had to fulfil the inclusion criteria of being Malaysian citizens and having good quality pre-treatment study models available. They were excluded if they had previous history of orthodontic treatment. Based on these criteria 112 study models were selected and on them measurements were carried out and recorded as described in Table 1 using electronic digital calipers, Insize© (Series 1108, Resolution 0.01 mm/0.0005") and metallic ruler. Each of the three examiners (AMI, JNR, MBNN) was trained in the methodology for carrying out measurements by the expert and principal investigator (MPS). Measurements on 30 study models by each of the three examiners were compared with those of the expert to assess the accuracy using Pearson's correlation coefficient. Measurements by all 3 examiners correlated highly with those of the expert at statistically significant levels ($P < 0.05$).

Three sets of readings for all parameters were recorded by the three examiners and an average of the three readings was recorded as the final reading. Out of 112 study models involved, 10 were selected at random after six weeks for the second set of measurements for intra-examiner reliability analysis. From the data collected, frequency, percentage, range, mean, standard deviations and confidence intervals were calculated. Chi-Squared test was used to test association between occlusal traits and ethnicity. All the statistical

Table 1 – Measurement method.

Occlusal features	Measurement Method
Molar relationship	According to Angle's classification as Class I, Class II, Class III for the right and left sides [5].
Canine relationship	Classified as Class I, Class II, Class III for the right and left sides [6].
Malocclusion	Overall malocclusion class was assigned as Angle's Class I, Class II and Class III after assessing molar and canine relationship on both sides.
Incisor relationship according to British Standards' Institute (BSI) [7]	Class I – Lower incisal edges occlude with or lie immediately below the cingulum plateau of the upper incisors. Class II – Lower incisal edge lies posterior to the cingulum plateau of the upper incisors. Class III – The lower incisal edges lay anterior to the cingulum plateau of the upper central incisors. The overjet is reduced or reversed.
Overjet (mm)	Measured from the mid-point of the labial surface of the most anterior lower central incisor to the mid-point of the labial surface of the most anterior upper central incisor, parallel to the occlusal plane [3]
Overbite (mm)	The vertical distance between the incisal edges of the upper and lower central incisors [3]
Cross bite [3]	Anterior crossbite – When one or more upper incisor teeth were palatal to the lower incisor teeth at maximum intercuspation. Posterior buccal crossbite – When one or more lower posterior teeth in any quadrant distal to the lateral incisor were placed buccal to the upper posterior teeth at maximum intercuspation. Posterior lingual crossbite – When one or more lower posterior teeth in any quadrant distal to the lateral incisor were lingually placed with respect to the upper posterior teeth at maximum intercuspation.
Maxillary and mandibular crowding (mm)	Linear contact point displacement between adjacent teeth of the maxillary and mandibular arches were measured and summated to give a total score [3].
Maxillary and mandibular spacing(mm)	Spaces between adjacent teeth in maxillary and mandibular arches were measured and summated to give a total score
Midlines (mm)	The displacement of the lower midline as compared to the upper midline [2]

analyses were carried out using Epi Info™ 6.0 and statistical significance was set at P<0 .05.

Results

One hundred and twelve pre-treatment study models consisting of 84 females with average age 19.77±4.86 years and 28 males with average age 20.07±4.45 years were assessed. The distribution of ethnic groups was 50 Chinese, 32 Indians and 30 Malays, malocclusion groups was 46.4% Class I, 33% Class II and 20.5% Class III (Table 2). Based on molar relationship, Class I malocclusion occurred most commonly followed by Class II and then Class III, except in the Malays. Highest percentage of Class I malocclusion occurred in the Chinese, Class II among Indians and Class III among Malays (Table 3). Overall Class II incisor relationship occurred most frequently at 37.5% followed by Class I at 35.7% and least was Class III at 26.8% among all subjects (P > 0.05) (Table 3).

Increased overjet between 3–6.5 mm occurred the highest at 35.7% followed by reduced overjet (<2 mm) in 33% subjects. More than 6.5 mm overjet, which is considered to be handicapping, was found in 13.4% of subjects. Within ethnicities, increased overjet of 3–6.5 mm was found the highest among Chinese (48%) and Indians (34.4%) and half the samples among Malays had less than 2 mm overjet, which was highest among all three ethnic groups (Fig. 1). With respect to overbite, 39% of all subjects fell in the range of 2–4 mm and 30.4% had an overbite of more than 4 mm, with similar distribution patterns among the three ethnic groups (Fig. 2). Differences for both overjet and overbite were not statistically significant (P>0.05).

Mild crowding of 1–3 mm in both maxillary (33%) and mandibular (40.2%) arches occurred most commonly. Severe crowding of more than 7 mm was seen in 20.5% maxillary arches and 15.2% mandibular arches (Table 4). Highest maxillary crowding was seen amongst Indians at 43.8% and highest mandibular crowding among Chinese subjects at 48% both in the category of mild (1–3 mm) crowding. Differences among the races was found to be not significant (P > 0.05).

Spacing in both arches was absent in majority of subjects – Maxillary −61.6% and Mandibular 76.8%. Mild spacing of 1–3 mm was seen in 32% maxillary arches and 19% mandibular arches. All ethnic groups also had highest percentage of no spacing for both arches. Malays had the most amount of mild spacing at 40% and 20% for maxillary and mandibular arches respectively however, there was no significant difference among the races (Table 4). There was no significant difference among the races for mandibular spacing as well (P > 0.05).

Midline shifts of less than 2 mm were seen in 60% Malay, 64% Chinese and 59.4% Indians (Table 5). Posterior crossbites were more common (48.2%) than anterior crossbites (30.4%), and highest percentages of both were seen in Malay subjects at 60% and 43.3% respectively. However, differences among races were not statistically significant (Fig. 3).

Table 2 – Distribution of ethnicities and malocclusion in the study sample.

Ethnicity	Class I n (%)	Class II n (%)	Class III n (%)	Total n (%)
Malay n (%)	10 (33.3)	9 (30.0)	11 (36.7)	30 (26.8)
Chinese n (%)	27 (54.0)	14 (28.0)	9 (18.0)	50 (44.6)
Indian n (%)	15 (46.9)	14 (43.8)	3 (9.4)	32 (28.6)
Total n (%)	52 (46.4)	37 (33.0)	23 (20.5)	112

Discussion

Our study investigated the distribution of features of malocclusion among Malaysian Orthodontic patients and variations among the three ethnic sub-groups. The Malaysian population consists of three mainstream ethnic groups – Malays (67.4%), Chinese (24.6%) [8] and Indians (7.3%). Malaysian peninsula was considered historically as the major crossroads of Asia, with the straits between Sumatra and the peninsula being a crucial corridor for maritime transport between the orbits of China and India for ancient trade [9]. The earliest settlers of the peninsula were the Negritos with

Table 3 – Distribution of Incisor, Right and Left Canine, Right and Left Molar relationship among ethnic groups.

Occlusal trait	Class	Malay Percentage (95% CI)	Chinese Percentage (95% CI)	Indian Percentage (95% CI)	TOTAL Percentage (95% CI)
Incisor (BSI) P=0.103 NS	I	30.0 (14.7–49.4)	36.0 (22.9–50.8)	40.6 (23.7–59.4)	35.7 (26.9–45.3)
	II	26.7 (12.3–45.9)	38.0 (24.7–52.8)	46.9 (29.1–65.3)	37.5 (28.5–47.2)
	III	43.3 (25.5–62.6)	26.0 (14.6–40.3)	12.5 (3.5–29.0)	26.8 (18.9–36.0)
Right Canine P=0.206 NS	I	36.7 (19.9–56.1)	42.0 (28.2–56.8)	56.3 (37.7–73.6)	44.6 (35.2–54.3)
	II	36.7 (19.9–56.1)	46.0 (31.8–60.7)	34.4 (18.6–53.2)	40.2 (31.0–49.9)
	III	26.7 (12.3–45.9)	12.0 (4.5–24.3)	9.4 (2.0–25.0)	15.2 (9.1–23.2)
Left Canine P=0.292 NS	I	36.7 (19.9–56.1)	46.0 (31.8–60.7)	46.9 (29.1–65.3)	43.8 (34.4–53.4)
	II	33.3 (17.3–52.8)	42.0 (28.2–56.8)	40.6 (23.7–59.4)	39.3 (30.2–49.0)
	III	30.0 (14.7–49.4)	12.0 (4.5–24.3)	12.5 (3.5–29.0)	17.0 (10.5–25.2)
Right Molar P=0.196 NS	I	36.7 (19.9–56.1)	52.0 (37.4–66.3)	59.4 (40.6–76.3)	50.0 (40.4–59.6)
	II	30.0 (14.7–49.4)	26.0 (14.6–40.3)	31.3 (16.1–50.0)	28.6 (20.4–37.9)
	III	33.3 (17.3–52.8)	22.0 (11.5–36.0)	9.4 (2.0–25.0)	21.4 (14.2–30.2)
Left Molar P=0.373 NS	I	40.0 (22.7–59.4)	50.0 (35.5–64.5)	37.5 (21.1–56.3)	43.8 (34.4–53.4)
	II	26.7 (12.3–45.9)	28.0 (16.2–42.5)	43.8 (26.34–60.3)	32.1 (23.6–41.6)
	III	33.3 (17.3–52.8)	22.0 (11.5–36.0)	18.8 (7.21–36.4)	24.1 (16.5–33.1)

NS – Not significant.

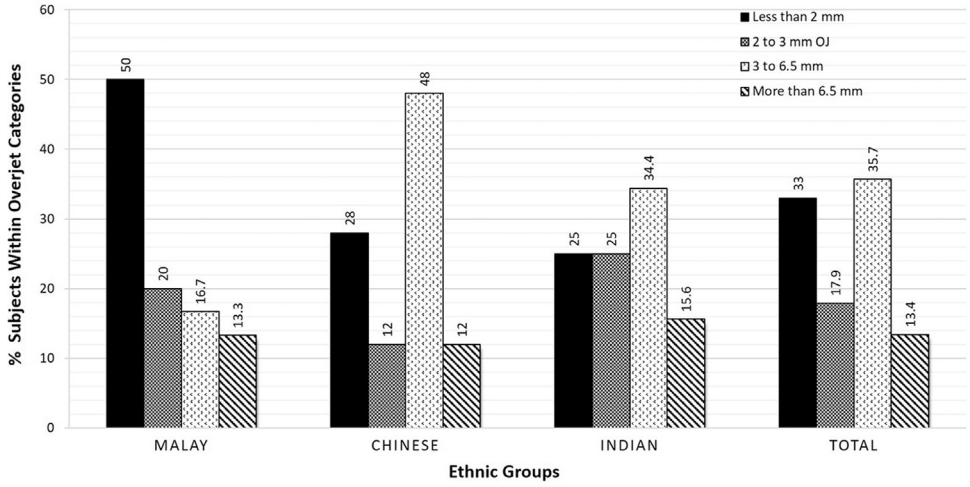

Fig. 1 – Distribution of overjet among the three ethnic groups. Differences between races not significant (P=0.09).

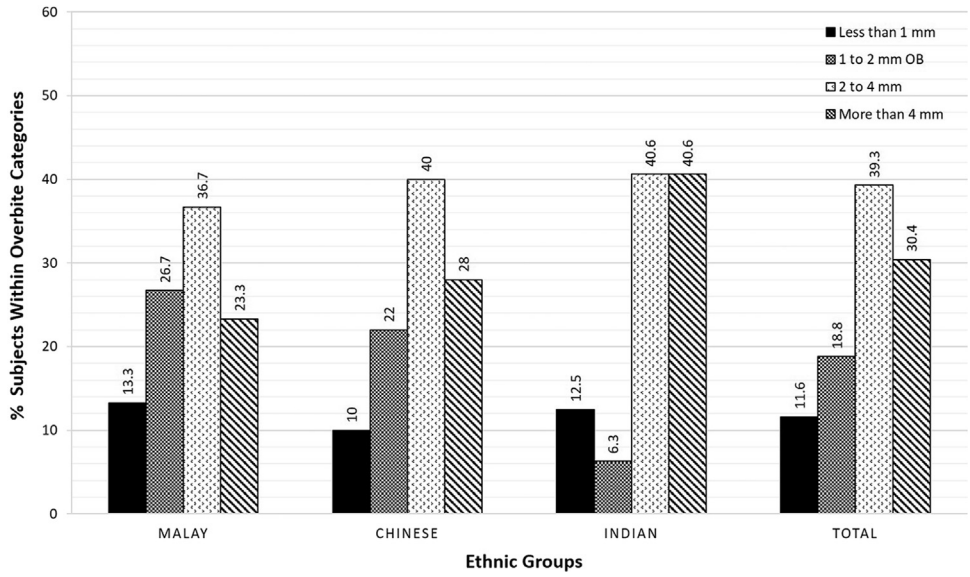

Fig. 2 – Distribution of overbite among the three ethnic groups. Differences between races not significant (P=0.43).

Australo-Malesian affinity and were followed by sea-faring Proto-Malays in 2000 BC who admixed with Siamese, Javanese, Sumatran, Indian, Thai, Arab and Chinese traders of the ancient trade routes, giving rise to present day Deutero-Malays [10]. Colonialization by the British in the 19th century led to large influx of Chinese and Indians to works as labourers in tin mines and plantation industry, to fuel the industrial revolution in the west resulting in genesis of a multi-ethnic and culturally diverse society.

Such mixed, heterogeneous societies often give rise to more malocclusions since there is mixing of inherited characteristics from parents of different genetic lineages [11]. Nevertheless, certain occlusal traits seem to have been maintained and propagated among ethnic groups, like the Malays exhibiting the highest percentage of Class III incisor, canine and molar relationship, reduced overjet and both anterior and posterior crossbites – all features of Class III malocclusion. The Class III incisor relationship and reduced overjet could be explained by the fact that the Malaysian malays were found to have more proclined lower anteriors as compared to Caucasian norms. In a study by Mohammad et al. [12] the value of lower incisor to NB in Steiner's analysis was found to be 32.3° as opposed to the Caucasian norm of 25°. The Chinese had second highest percentage of Class III malocclusion and highest percentage of Class I malocclusions, Class II canine relationship, moderately increased overjet and midline shifts. Indian ethnic group was highest in Class II malocclusion, Class II incisor and Class I canine relationship, severely increased overjet and overbite and had the least crossbites and Class III malocclusion.

These findings in our study corroborate the summary on epidemiology of malocclusion made by Proffit that Class II problems are most prevalent in whites of northern European descent, and Class III problems are most prevalent in Oriental populations [1]. Our findings also concur with the general observations made by Woon et al. [2] and Soh et al. [3] who also assessed the features of permanent dentition of the same three ethnic races in Malaysia and Singapore respectively, that the Chinese and Malays are similar in the distribution of their occlusal patterns whereas Indians are

Table 4 – Distribution of maxillary and mandibular crowding and spacing among total samples and ethnic groups.

Severity	Distribution among Ethnic groups															
	CROWDING*								SPACING[b]							
	Malay		Chinese		Indian		Total		Malay		Chinese		Indian		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Maxillary arch																
Absent	9	30.0	12	24.0	7	21.9	28	25.0	15	50.0	32	64.0	22	68.8	69	61.6
Mild (1–3 mm)	10	33.3	13	26.0	14	43.8	37	33.0	12	40.0	13	26.0	7	21.9	32	28.6
Moderate (4–6 mm)	5	16.7	12	24.0	7	21.9	24	21.4	2	6.7	3	6.0	2	6.3	7	6.3
Severe (>7 mm)	6	20.0	13	26.0	4	12.5	23	20.5	1	3.3	2	4.0	1	3.1	4	3.6
Mandibular arch																
Absent	7	23.3	8	16.0	8	25.0	23	20.5	20	66.7	41	82.0	25	78.1	86	76.8
Mild (1–3 mm)	11	36.7	24	48.0	10	31.3	45	40.2	6	20.0	7	14.0	6	18.8	19	17.0
Moderate (4–6 mm)	9	30.0	8	16.0	10	31.3	27	24.1	3	10.0	1	2.0	0	0.0	4	3.6
Severe (>7 mm)	3	10.0	10	20.0	4	12.5	17	15.2	1	3.3	1	2.0	1	3.1	3	2.7

* Comparison among ethnicities for maxillary and mandibular crowding not significant (P-value=0.607 and 0.387 respectively).
[b] Comparison among the ethnicities for maxillary and mandibular spacing not significant (P-value=0.807 and 0.403 respectively).

Table 5 – Distribution of midline shift among total samples and ethnic groups.

Midline Shift*	Ethnicity							
	Malay		Chinese		Indian		Total	
	n	%	n	%	n	%	n	%
No midline shift	8	26.7	11	22.0	8	25.0	27	24.1
Right								
Mild shift (<0.5 mm)	1	3.3	2	4.0	2	6.3	5	4.5
Moderate shift (0.5–2 mm)	9	30.0	17	34.0	5	15.6	31	27.7
Severe shift (>2 mm)	2	6.7	3	6.0	1	3.1	6	5.4
Left								
Mild shift (<0.5 mm)	1	3.3	3	6.0	0	0.0	4	3.6
Moderate shift (0.5–2 mm)	7	23.3	10	20.0	12	37.5	29	25.9
Severe shift (>2 mm)	2	6.7	4	8.0	4	12.5	10	8.9

* Differences between ethnicities not significant (P-value = 0.747).

different, thus substantiating their different genealogical ancestries that the Chinese and Malays belonged to the same "Mongoloid" race, and that the Indians had descended from the "Caucasoid" race.

In our study, highest proportion of patients were of Chinese ethnicity (44.6%) followed by Indian (28.6%) and Malay (26.8%) subjects (Table 2). Although Malays constitute the highest percentage among the general Malaysian population, they were the least in number in our study. This portrayed the utilization of private dental health services by different ethnicities. Unlike the population study of army recruits [3], our study sample consisted of orthodontic patients who had elected to undergo treatment for their malocclusions. This could be the reason why the Class II incisor relationship was found to occur at the highest frequency (37.5%) in our study, followed by Class I (35.7%) and Class III (26.8%), as opposed to 48.1% Class I, 26.3% Class II div 1, 22.4% Class III and 3.2% Class II div 2 in the Soh et al. [3] study. Malay subjects in our study showed the highest prevalence of Class III while both Chinese and Indian subjects had mostly Class II incisor relationships, whereas in the Singapore study Chinese and Malay groups displayed the highest prevalence of Class I incisor malocclusion ($P > 0.05$) while the Indians were four times more likely to have Class II/1 incisor malocclusion ($P < 0.05$), with the difference being statistically significant [3].

For both canine and molar relationship, Class I had the highest occurrence followed by Class II and then Class III relationship (Table 3). Indian subjects had highest percentage of Class I canine while Malays had the least. For molar relationship majority of Malay and Chinese subjects presented with Angle's Class I whereas amongst Indians there was higher prevalence of Angle's Class I on the right side and of Angle's Class II on the left. Soh et al. [3] found that Angle's Class I molar was the most prevalent among all ethnicities. In Woon et al. [2] study Chinese had statistically significantly less Class I than Malays and Indians, additionally the Chinese and Malays also had significantly higher Class III than Indians, for both canine and molar relationship. However, the differences in the distribution in our study were statistically insignificant ($P > 0.05$).

Soh et al. found that Indian subjects were eight times more likely to have overjet greater than 6.5 mm ($P < 0.01$) [3]. In the present study both Chinese and Indian subjects had high frequency for moderate increase in overjet (3–6.5 mm) while Malay subjects had high frequency for overjet less than normal (<2 mm). Thus, in general our subjects were found to have higher occurrence of increased overjets as compared to other populations [2,3]. Similarly more subjects in our study were found to have deeper bites as compared to that found in a study on Malaysian school children [2]. An overbite of 2–4 mm was found to occur the most frequently in all subjects and in each ethnicity in our study whereas in Woon et al.'s [2] study an overbite of 1/3rd – 2/3rd was considered as norm for

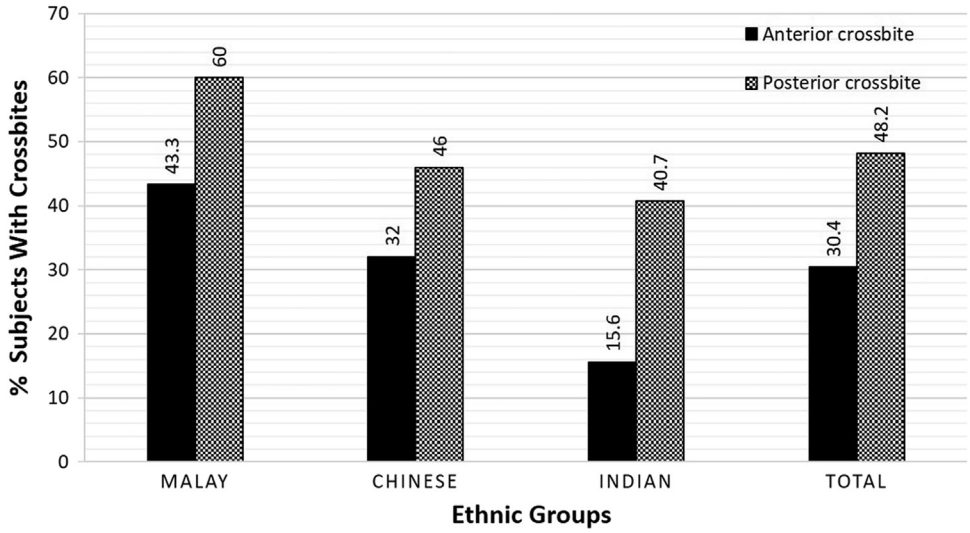

Fig. 3 – Distribution of crossbites among total sample and ethnic groups. Differences between races not significant (P=0.33).

Indians and overbite of 0–1/3rd as norm for Chinese and Malays.

Crowding and spacing are considered to be factors that compromise aesthetics and occlusal function, and these are often the main reasons for patients to seek orthodontic treatment. In our study, mild incisor crowding of 1–3 mm was the most common feature seen in all three ethnic groups. Indians had the highest percentage of maxillary crowding whilst the Chinese had the highest percentage of mandibular crowding, with differences not being statistically significant. Much higher levels of crowding and spacing were seen in our subjects at 77% and 30% as compared to 50% and 5.78% respectively in Woon et al.'s study sample [2].

The figures for posterior and anterior crossbites in our study at 48.2% and 30.4% respectively, were quite high compared to the figures of 29.8% and 14.7% respectively in the Soh et al. study [3]. Similarly, posterior crossbite for each ethnicity –Chinese - 20.5%, Malay -16%, and Indian - 11.6% was much higher than figures of 6.49%, 5.96%, and 4.76% respectively in Woon et al. study [2]. Severity of malocclusion continued to be reflected in midlines as well, where midline shifts of less than 2 mm were seen in 64% Chinese, 60% Malay, and 59.4% Indians in our study as opposed to 36.4% Chinese, 36.4% Malays, and 23.8% Indians in Woon et al. study [2]. All three races had highest occurrence of moderate shifts (0.5–2 mm).

Overall we detected that the severity of malocclusion was greater in our study subjects when compared to subjects in prevalence studies, due to the very fact that we studied patients who were seeking orthodontic treatment. The differences in malocclusion detected between ethnicities give an insight into treatment planning, prognosis and prediction for that ethnicity, hence it is of much clinical significance and value. Orthodontic treatment planning and timing of intervention depend on the type of malocclusion. The Malay and Chinese ethnic groups in our study who showed a Class III tendency may require orthopaedic appliances for early intervention growth modification whereas the Indian ethnic group with a greater Class II tendency may require functional or orthopaedic appliances for skeletal correction in children. In adults, depending on whether these anomalies are of skeletal or dental origin, the appropriate corrective, camouflage or surgical treatment can be anticipated, advised and applied.

However, these differences in characteristics of the malocclusion were not found to be statistically significant. This could be due to the fact that ours being a study on patients presenting for orthodontic treatment, the sample size was limited, thus affecting detection of statistically significant differences. Time and resource constraint did not allow us to extend our study further or wider to enable us to increase the sample size. Distribution of ethnic groups in our study also did not reflect their actual proportion in the general population, which may have led us to miss some significant differences and underreport certain findings. For ethnicity we relied only on patient report and our malocclusion categorisation was based only on the molar relationship which may have differed from the underlying skeletal malocclusion which was not taken into consideration. Future investigations may take these factors into consideration while designing further studies on the Malaysian population.

Conclusion

1. Occlusal characteristics with highest occurrence were Class I canine and molar relationship, Class II incisor relationship, moderately increased overjet and overbite, more posterior than anterior crossbites, presence of mild crowding, absence of spacing and moderate shifts in midline.
2. Malays had the highest proportion of Class III malocclusions, Class III incisor, molar and canine relationship, reduced overjet and overbite, both anterior and posterior crossbites and maxillary and mandibular crowding.
3. The Chinese had highest percentage of Class I malocclusions, Class II canine relationship, moderately increased overjet and midline shifts and second highest percentage of Class III malocclusion.

4. Indian ethnic group was highest in Class II malocclusion, Class II incisor and Class I canine relationship, severely increased overjet and overbite and had the least crossbites and Class III malocclusion.
5. Differences between ethnicities were not statistically significant ($P > 0.05$).

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1. Stevens J. *Applied Multivariate Statistics for the Social Sciences*, 3rd edition. New Jersey: Lawrence Erlbaum Associates, 1996.
2. Sapp JP, Eversole LR, Wysocki GP. Infections of Teeth and Bone. In: Sapp JP, Eversole LR, Wysocki GP. *Contemporary Oral and Maxillofacial Pathology*, 2nd edition. St Louis: Mosby, 2004:70–93.

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