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A Novel Combination Approach to Ridge Augmentation Procedure in a Severely Infected Alveolus Prior to Implant Supported Restorative Treatment: A Case Report

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Abstract

Background: Acute and chronic odontogenic infections present a significant challenge to effective ridge augmentation procedures prior to dental implant placement. Medical ozone/oxygen (MOZO) is an anti-infective therapy that has experienced a resurgence in recent years for treating a variety of medical and dental infections. Recent data has suggested that PRF can be used as a barrier membrane in regeneration procedures. This initial report aimed at investigating whether a combination approach of MOZO and PRF (platelet rich fibrin) barrier membrane and freeze dried bone allograft (FDBA) can be a viable option as an alternative approach for augmentation of severely infected alveolus resulting in a large defect.

Material & Methods: A 61-year-old female presented with a complaint of recurrent purulent infections associated with failing endodontic treatment of teeth #'s 23 and 24. MOZO was used pre and intra-operatively to eliminate the infection and subsequently, FDBA with PRF membrane acting as a barrier were used for regenerative purposes. No antibiotics were used pre-operatively for the treatment of the active infection.

Results: In one patient, MOZO was used to successfully eliminate the pre-existing infection without any antibiotics. Clinical re-entry at four months revealed successful regeneration of alveolar bone with 6mm gain in ridge width and 5mm in height, enabling the placement of dental implants.

Conclusion: Within the limitation of this study, MOZO has the potential as an adjunct anti-infective therapy combined with the regenerative potential of PRF barrier membrane, providing a novel approach to ridge augmentation in an infected and severely resorbed alveolus.

KEY WORDS: Bone Regeneration, Dental implants, Wound Healing & Biologic Agents, Ozone Therapy, Odontogenic Infections

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Figure 1a: MOZO Generation. Medical ozone generator with water flask for producing ozonated water.

Figure 1b: Oxygen tank with pediatric regulator that can deliver oxygen flow rates down to 1/32 of a liter per minute.

Figure 1c: Control panel with syringe port and corona discharge regulator. The concentration of ozone in oxygen is controlled by adjusting the rate at which oxygen flows past a corona plasma discharge with a specific voltage being generated.

Figure 1d: Device used for delivery of ozonated water under pressure to small areas via a hand piece that can be outfitted with a disposable cannula tip.

BACKGROUND

In current times, where microbial resistance is a growing concern, responsible use of antibiotics is required by healthcare professionals. With a rise in drug resistant mutant strains of bacteria, thinking about our future direction in antibiotic therapy and alternatives to antibiotic therapy is crucial. Medical ozone/oxygen (MOZO) is an anti-infective therapy that was first described for medical surgery by Payr in

1935.[1] It is a potent oxidizing agent that (1) has bactericidal, fungicidal and virucidal properties, (2) has the potential to release autocoids and growth factors from platelets (3) and acts as a host immune modulator due to the brief generation of free radicals.[2] Ozone therapy has also been used in medicine and its healing effects have been demonstrated in chronic hepatitis, herpes infections, diabetes, cancer among others.[3] MOZO is generated by subjecting medical grade oxygen to a corona plasma discharge unit (Figures 1a-d). MOZO has a therapeutic index that is determined by the medium of delivery (gas or liquid) and the concentration of ozone in the medium. The concentration of ozone in oxygen is controlled by adjusting the rate at which oxygen flows past a corona plasma discharge with a specific voltage being generated.

A review of MOZO in the medical and dental literature over the past 100 years in treating infection has been described by Seidler et al.[4] Owing to the toxic nature of ozone at elevated levels, therapeutic standards for patient administration have been established to improve safety and efficacy.[5] In the past 10 years, the use of ozone in dental surgery has been described to reduce pain and decrease osseous infections in small scale clinical studies.[6,7] Excluding the eyes and lungs, most cells in our body have the ability to negate the effects of ozone due to the presence of anti-oxidants such as superoxide dismutase in the cell membranes. The anti-infective benefit of ozone comes from its ability to destroy the cell membranes of bacteria, fungi and viruses since these organisms lack any anti-oxidants.[4] Based on these findings and the specific circumstances of the patient's disease course, a decision was made to employ MOZO as an adjunctive anti-infective therapy.

Platelet rich fibrin (PRF) can act as a biodegradable scaffold owing to the tetra molecular structure consisting of cytokines, platelets, and stem cells.[8,9,10] PRF could be used as a resorbable membrane for guided bone regeneration procedures, enabling and allowing space for osteogenic and angiogenic cells to migrate to the wound site and preventing epithelial cells from invading the defect.[8,11,12] This case is the first to demonstrate the use of MOZO as an adjunct anti-infective therapy in addition to using platelet rich fibrin (PRF) as a barrier membrane to facilitate bone regeneration of an alveolus severely compromised by a long-standing odontogenic infection.

MATERIALS AND METHODS

Clinical Presentation

A 61-year-old Caucasian female presented to the Indiana University School of Dentistry (IUSD) for treatment of a severely infected anterior mandible due to failing endodontic treatment of teeth #'s 23 and 24. A medical consult revealed no known allergies and no current or past medications that would preclude bone regeneration procedures, with regular use of vitamin supplementation. The teeth had undergone initial endodontic treatment approximately 25 years prior. When symptoms of pain and infection arose in 2009, she had apical root resective surgery, which initially relieved her symptoms. However, her symptoms of localized pain and swelling returned.

Upon clinical examination, the soft tissue around the teeth appeared extremely inflamed and erythematous (Figure 2a). Radiographic examination revealed a large periapical defect

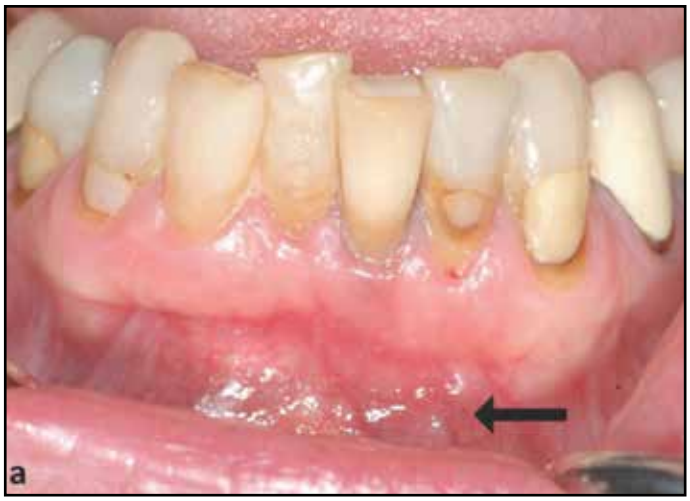

Figure 2a: Initial presentation gingival tissue in the area of #23 and #24 appears erythematous with swelling of the apical alveolar mucosa (arrow).

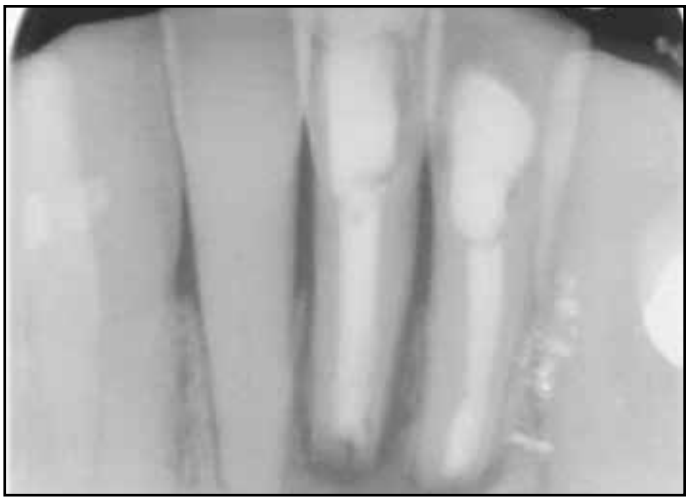

Figure 2b: Periapical radiograph showing a large periapical radiolucency of #23-#24 with probing depths ranging between 6-8mm and both teeth exhibiting Miller Class II mobility.

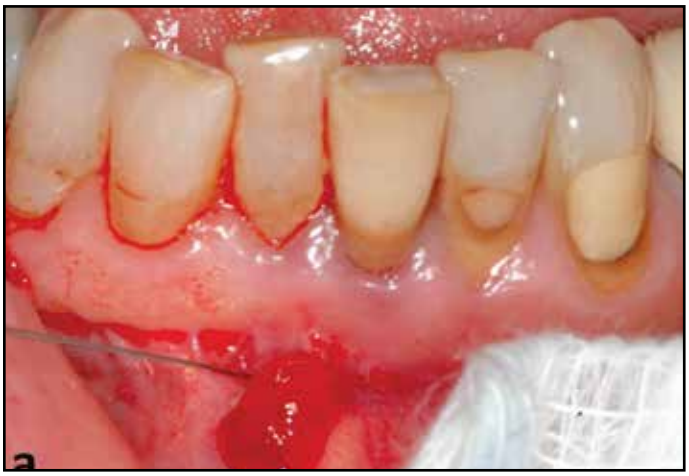

Figure 3a: MOZO Therapy, Injection of MOZO (24mcg/cc) into the apical tissue with "bubbling" occurring as the ozone reacts with the infection.

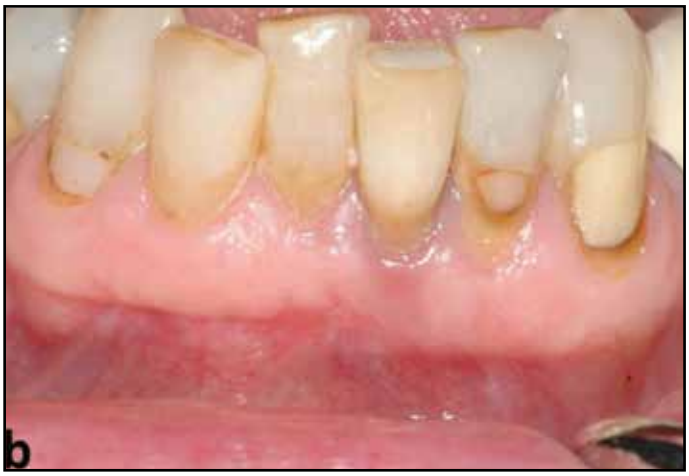

Figure 3b: Appearance of tissues following the injection. Note reduction in apical swelling of #23 and #24.

(Figure. 2b). Upon consultation with an endodontist, teeth #'s 23 and 24 were deemed hopeless and were scheduled to be extracted and ultimately, replaced with dental implants. Owing to the long standing nature of the lesion and its radiographic appearance, a significant amount of bone loss and buccal plate destruction was anticipated. To control the infection, pre- and postoperatively, antibiotic use was discussed with the patient. During this interview, the patient indicated that she desired to have as few antibiotics as possible due to

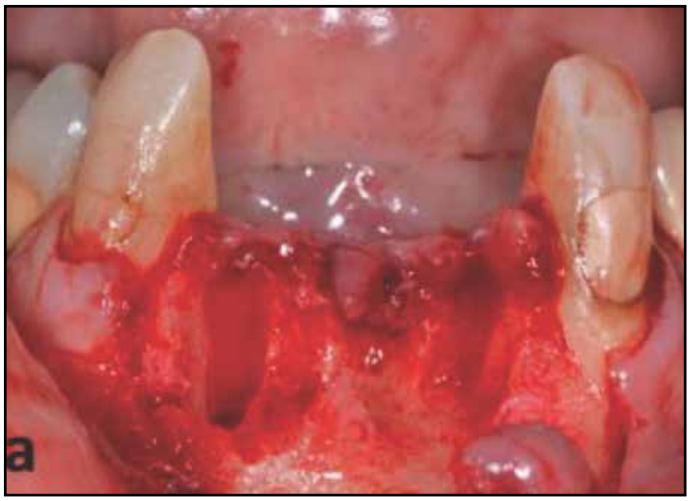

Figure 4a: Large defect with missing facial plate measuring about 18mm mesiodistally and 12mm vertically.

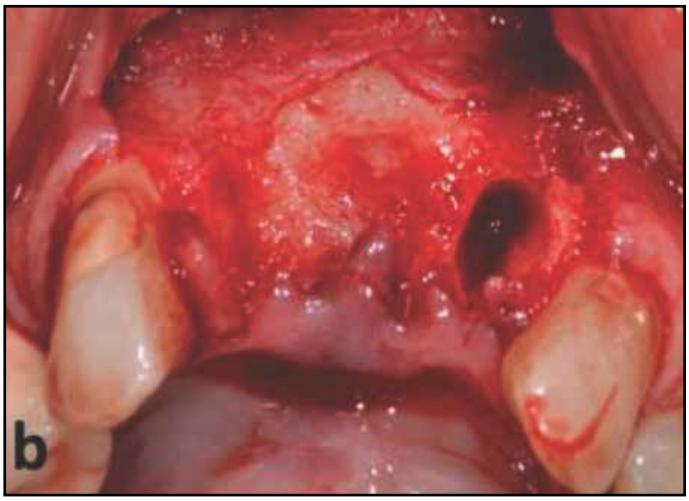

Figure 4b: Large defect with missing facial plate measuring about 18mm mesiodistally and 12mm vertically.

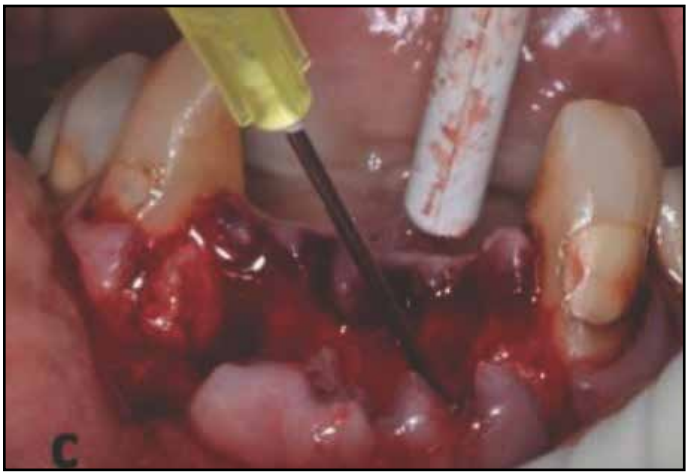

Figure 4c: Intraoperative irrigation with ozonated water.

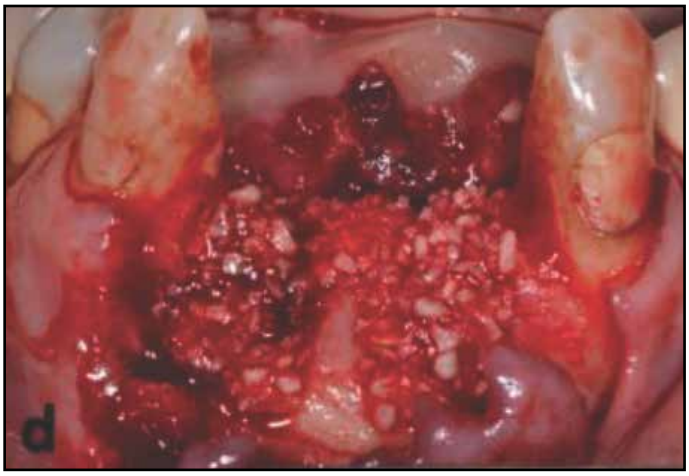

Figure 4d: FDBA placed in the defect.

their extensive use during her previous treatments. Hence, MOZO was discussed as a treatment option to reduce the use of antibiotics. The patient's esthetic demands and location of the defect were other significant concerns.

Case Management

Patient underwent three ozone therapy sessions about three days apart prior to surgery, which involved injection of medical grade ozone gas (24 mcg/cc) locally into the infected tissues of the lower anterior region under local anesthesia (Figure 3a). After the ozone therapy, a dramatic reduction in the swelling apical to #'s 23-24 was noted (Figure 3b) and no antibiotics were prescribed at this time. Intraoperative procedure: Due to crowding and for restorative purposes, the patient then underwent extrac-

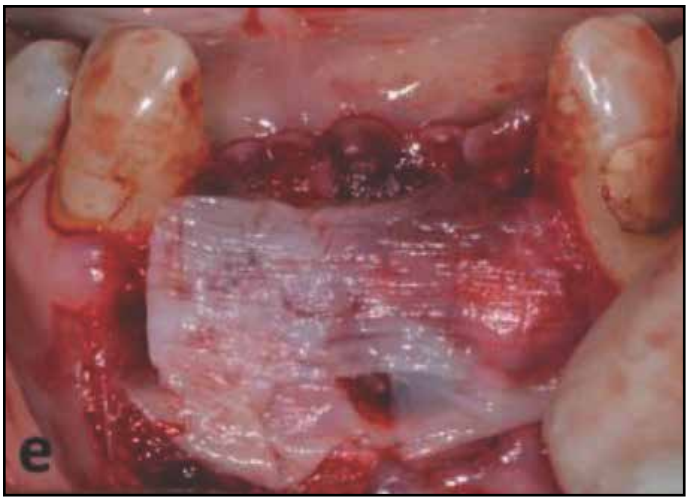

Figure 4e: PRF placed over the allograft in lieu of a membrane.

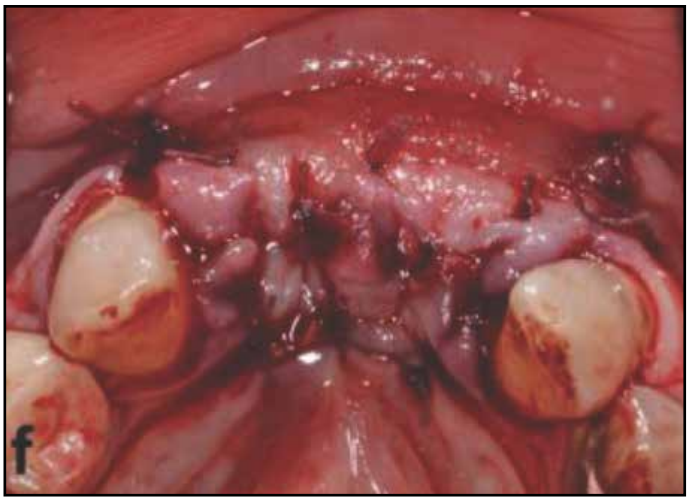

Figure 4f: Primary closure achieved using mattress and interrupted 4.0 Vicryl sutures.

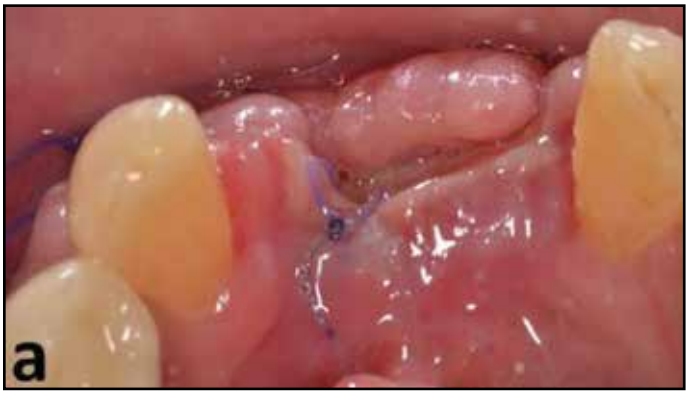

Figure 5a: Postoperative pictures, wound dehiscence at 1 week post-operatively.

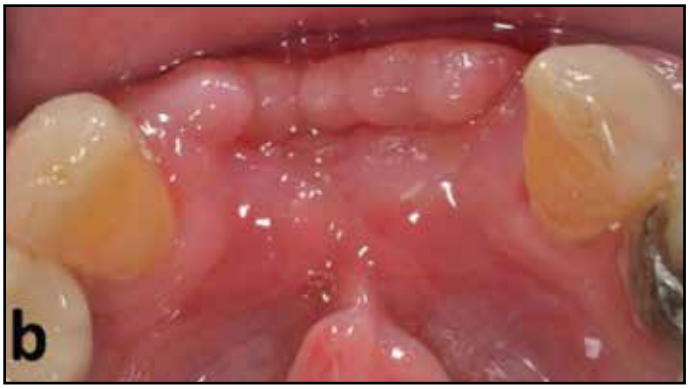

Figure 5b: Appearance of the site after 2 weeks of healing.

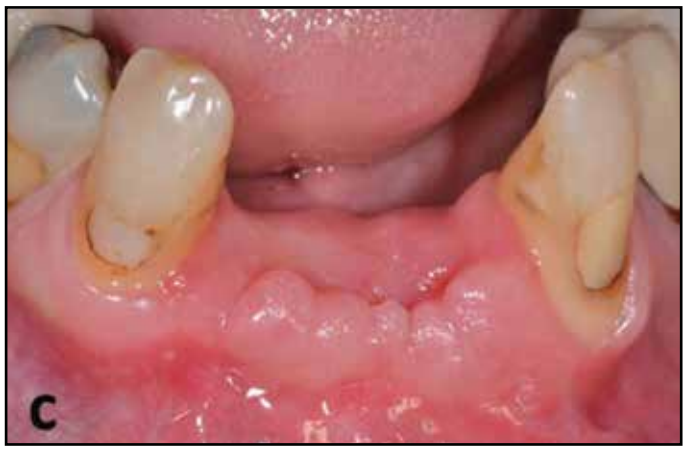

Figure 5c: Appearance of the site after 4 weeks of healing.

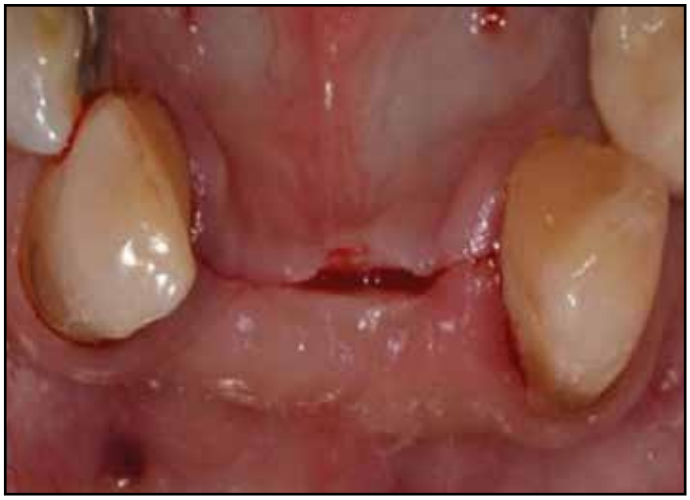

Figure 6a: Surgical re-entry for implant placement at 4 months; Soft tissue appearance at the time of implant surgery.

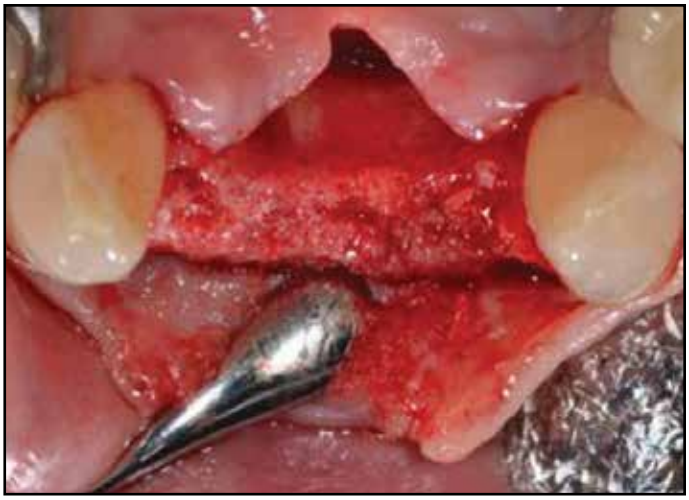

Figure 6b: Regenerated bone measuring 6mm buccolingually and 5-6mm vertically.

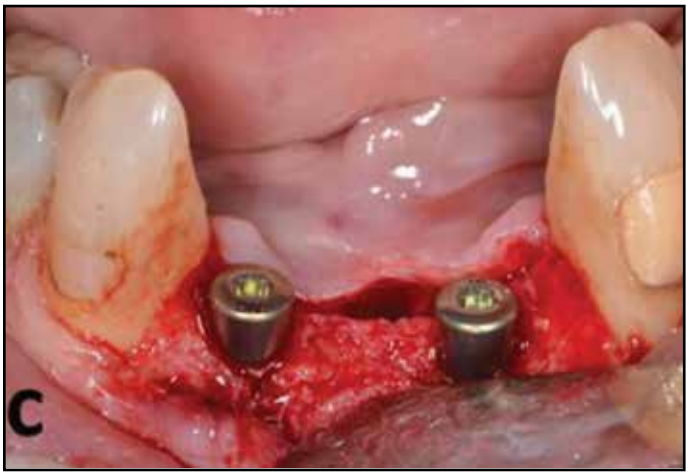

Figure 6c: Bone level dental implants (3.3 X 10mm) placed at sites #23 and #26.

tion of all four lower incisors, which left a large defect (Figures 4a & b). The defect was thoroughly debrided and irrigated with ozonated water (approx. 20 mcg ozone/ml) (Figure 4c). The rationale for the intraoperative use was to eliminate any residual infection at the surgical site. PRF and freeze dried bone allograft (FDBA) (Straumann® freeze dried bone allograft, LifeNet Health® Virginia Beach, VA) were used for the ridge augmentation procedure. No additional absorbable or non-absorbable membranes were used.

Preparation of PRF: Three test tubes (10ml) of patient's blood were drawn and spun in a centrifuge at 3300 RPM for 5 minutes. This resulted in three distinct layers of acellular plasma (PPP), fibrin clot (PRF), and a red corpuscles base. The fibrin clot was drawn from each tube and placed in a PRF box to drain out the excess fluid, which resulted in a pliable fibrin membrane. FDBA was placed in the defect and covered with three 'PRF membranes' (Figures 4d & e). A blunt dissection of the periosteum of the buccal flap was made in order to allow it to be advanced. Mattress and interrupted 4.0 Vicryl sutures were used to achieve primary closure. (Figure 4f). The patient was given Clindamycin 250mg for ten days and Ibuprofen 600mg every 4-6hrs post-operatively as a part of IUSD Periodontics Department protocol and instructed to return in one week for a postoperative evaluation.

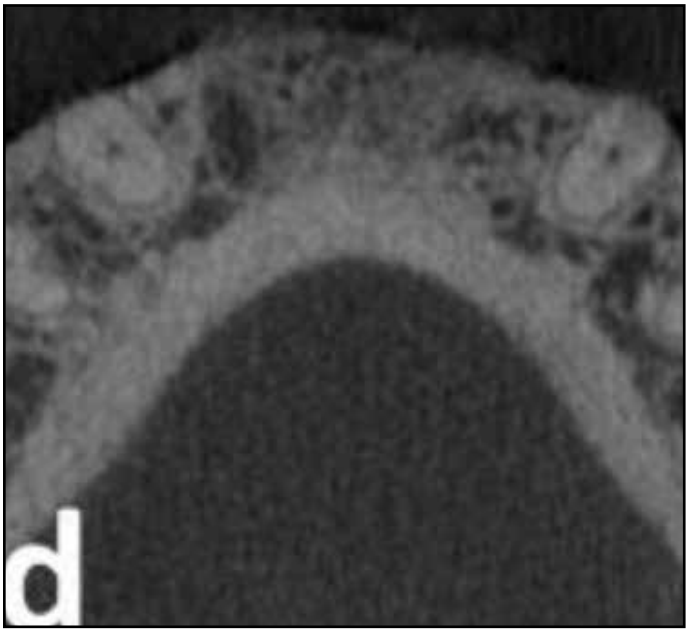

Figure 6d: CBCT slices of the anterior mandible at 4 months.

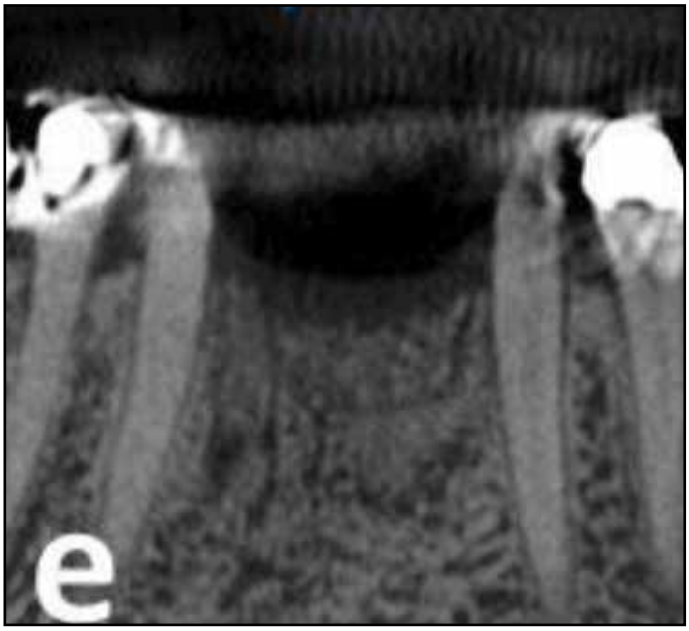

Figure 6e: CBCT slices of the anterior mandible at 4 months.

RESULTS

The soft tissue flap opening was noted after one week but the site continued to heal by secondary intention (Figures 5a-c). After four months, CBCT images revealed sufficient quantity of bone (Figures 6d & e). The surgical re-entry confirmed the radiographic findings (Figures 6a & b). The bone quality was good ranging between D2 and D3 bone,[13] two 3.3 X 10mm bone level implants (Straumann® Bone Level Implants, Massachusetts, USA) were placed at sites #23 and #26 (Figure 6c). The implants were provisionalized the same day and patient received a temporary prosthesis. Enameloplasty was performed on #22 and #27 for good esthetic outcome and the final restoration was delivered three months after the implant surgery (Figures 7a & b). The periapical radiograph at three months, post loading of the implants showed no periimplant bone loss and good bone height (Figure 7c). A clinically functional and esthetic result was achieved that was acceptable to the patient. Three years post operatively, the implants are stable with no bleeding on probing, and no clinical signs of infection or inflammation were noted (Figure 7d).

DISCUSSION

Regenerative therapy, including guided tissue and bone regeneration has been extensively researched and is ever evolving. This is partly because of complex defect morphologies that have proven to be difficult and unpredictable in term of regenerative potential. This, superimposed with infection adds to the challenge. Such difficult circumstances often require multiple approaches to address all the issues for a positive outcome. The favorable result achieved in this case can be attributed to the

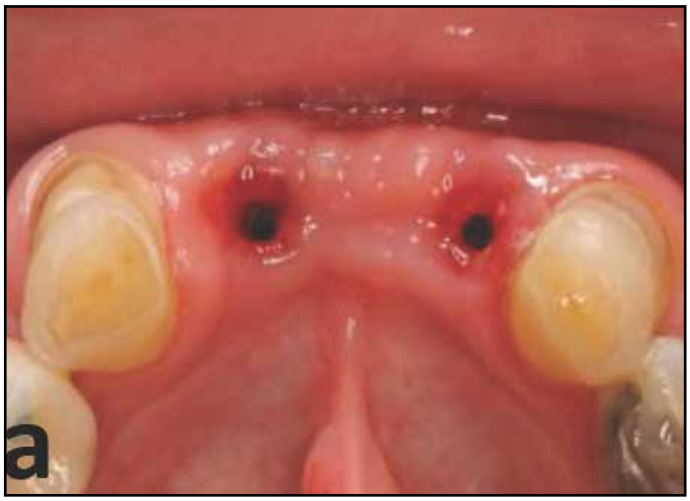

Figure 7a: Three months post implant surgery; Appearance of the ridge at 3 months.

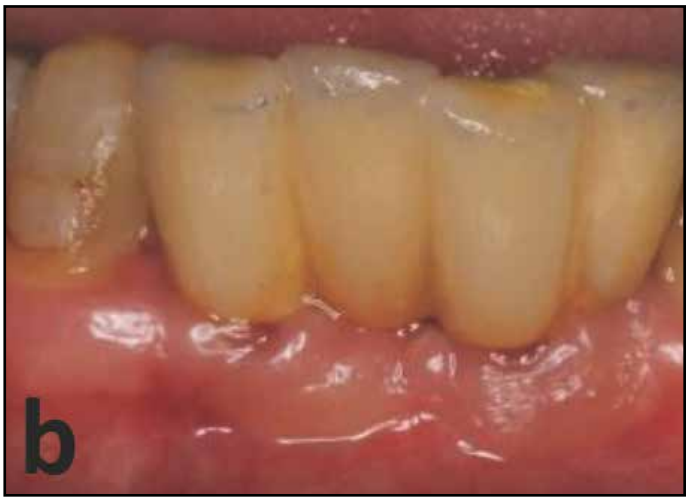

Figure 7b: Final prosthesis with enameloplasty of the canines.

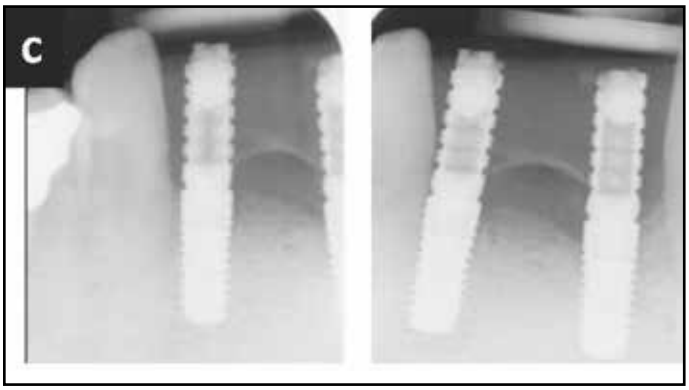

Figure 7c: Radiographic image of the implants at 3 months post-loading prior to final restoration.

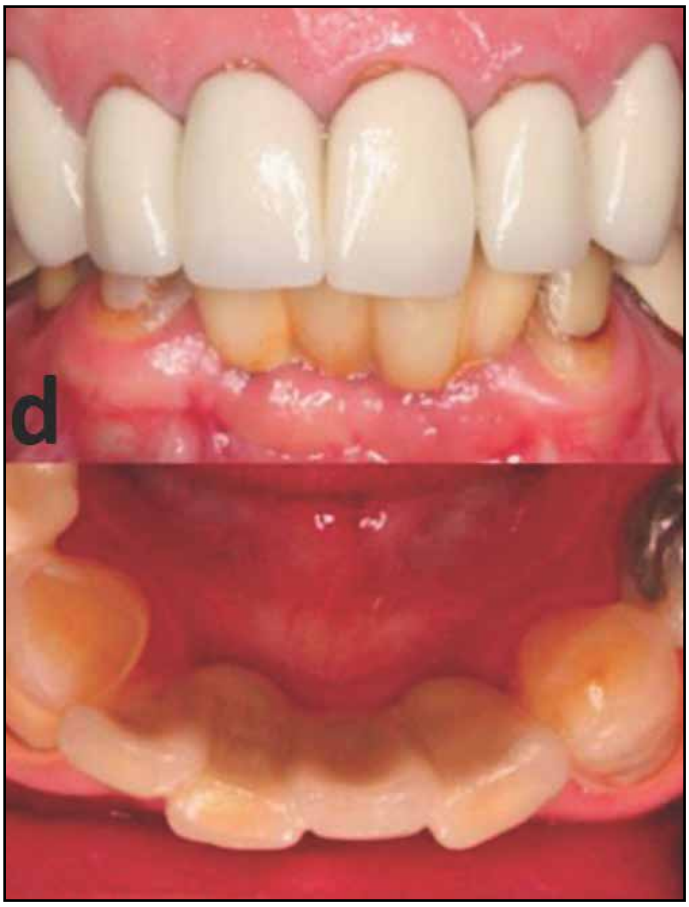

Figure 7d: Three years after implant placement.

combined effect of the antibacterial properties of MOZO and the regenerative potential of PRF. The application of MOZO pre-operatively helped in achieving healthy soft and hard tissues prior to surgery by eliminating the infection which is paramount to achieve a desired surgical outcome. The protective function of the overlying soft tissue during ridge augmentation procedures is of key importance to get a favorable outcome. In our case, it is likely that insufficient dissection of the periosteum

resulted in an opening of the wound margin. Despite this complication, an acceptable result was achieved. This could be attributed to the angiogenic and anti-inflammatory properties of PRF membranes.[4] Bone regeneration with FDBA and PRF alone can be a viable option for accelerated and improved soft and hard tissue healing of extraction sites. However, given the known properties of medical oxygen/ozone to eliminate biofilms, stimulate the immune system and create a favorable shift in the local oxygen tension[2], its addition to the surgical protocol seemed logical in this case. Although antibiotics were prescribed post-operatively as a part of the department protocol, they were not used pre-operatively when the infection was present. Based on the results of the current case, preoperative and intraoperative treatment of infected teeth, bone and soft tissues in surgical sites with medical grade oxygen/ozone gas and ozonated water may offer a means of achieving favorable treatment outcomes. Within the limitations of this case report, a combined use of MOZO and PRF barrier membrane and FDBA could be a viable option for ridge augmentation procedures which are complicated by presence of acute/chronic infection in the surgical site

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Disclosure
The authors report no conflicts of interest with anything in this article.

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Assessment of Risk Indicators of Peri-implant Diseases Among a Group of Sudanese Subjects Attending Khartoum Dental Teaching Hospital: A Hospital Based Cross-sectional Study

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Abstract

Background: Data indicate that complications of dental implant occur in about 50% of patients after 5 years of function. Peri-implant disease following successful integration of an endosseous implant consider as biological complication of dental implant. Peri-implant diseases may affect the peri-implant mucosa only (peri-implant mucositis) or also involve the supporting bone (peri-implantitis). This study aimed to evaluate the prevalence of peri implant diseases in Khartoum Dental Teaching Hospital (KDTH) and to assess implants/patients characteristics as possible risk indicators for peri-implant diseases.

Methods: A Sample of 49 patients (15 males/34 females) with a total of 151 implants was examined. Implants had been inserted at KDTH and the mean time of implants in function was 3.08years (±3.2). The mean age of the subjects was (40.76 ± 11.01). General health information were recorded as well as habits regarding smoking, maintenance visits and oral hygiene. Full mouth clinical parameters (PI, BOP, PPD) were assessed and radiographs taken to determine the periodontal status and implants diagnosis.

Results: The prevalence of peri implant mucositis and peri implantitis in KDTH amounted to 47.7% and 17.2%, respectively. Among different risk indicators under the study, three were showed statistically significant relation to peri implant diseases. They were as follow: poor oral hygiene, implant surface and time of implant placement.

Conclusion: poor oral hygiene, implant surface and time of implant placement are important risk factors for periimplant inflammation in partially edentulous patients. Consequently, patients with such characteristics should be informed before implant placement and frequently re-called after for maintenance visits.

KEY WORDS: Periimplant mucositis, peri-implantitis, risk indicators

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INTRODUCTION

During the last years, dental implantology has become a reliable and predictable solution to replace missing teeth.[1] In the past two decades, there has been a paradigm shift in periodontics from the thinking of saving teeth at all costs (although compromised) to one of extracting compromised teeth and replacing them with dental implants for a better and more predictable long-term outcome.[2]

Since the discovery of osseointegration, the application of dental implants has progressed from being the support of a fixed prosthesis for an edentulous mandible to the refined use of dental implants in the replacement of single or multiple missing teeth in partially-edentulous dentitions. Recently, immediate implant placement following tooth extraction had been advocated by some practitioners as a practicable and predictable clinical technique.[3]

The success rates and benefits of dental implant therapy have been documented extensively in the literature.[4,5] Implants have a high success rate in general, and results may be maintained over many years. It is estimated that over 10 million implants are installed all over the world annually.[6] Success of dental implants is highly dependent on the integration between the implant and peri-implant tissues.

It is known that peri-implant diseases are infectious in nature[5] and they are result of an imbalance between bacterial load and host defense. During the 6th European Workshop on Periodontology in 2008, it was proposed that the term ''peri-implant disease'' is a ''collective term for inflammatory reactions in the tissues surrounding an implant'' and that peri-implant mucositis will be used to describe ''the presence of inflammation in the mucosa at an implant with no signs of loss of supporting bone.''[7] Moreover, it was proposed that the term peri implantitis is an ''inflammatory process around an implant, characterized by soft tissue inflammation and loss of supporting bone.[7]

Peri-implant mucositis as well as peri-implantitis have been categorized as biological complications in implant therapy. From a clinical point of view, the determination of signs that conclude the presence of peri-implant mucositis include erythema and swelling, generally associated with probing depths ≥4 mm.[5] However, the essential parameter for diagnosis is still bleeding on gentle probing.[8] On the other hand, peri-implantitis has been recognized as a progressive and irreversible infectious pathological condition associated with changes in the level of crestal bone, the presence of bleeding on probing (BOP), and/or suppuration with or without deepening of the peri-implant pockets around an osseointegrated implant in function.[9] In spite of the high success rates of dental implants, it is clear that osseointegrated implants are susceptible to diseases that may ultimately lead to dental implant loss.[10] The prevalence of peri-implant diseases have been reported in the literature.[7,11] But, considerable variations between these studies are noted and this is mainly due to methodological variability, different implant designs and different definitions for peri-implant disease.[12] Previous studies have indicated some potential risk variables, such as, medical status of the patient, smoking, bone quality, parafunctions, operator experience, degree of surgical trauma, bacterial contamination, lack of preoperative antibiotics, immediate loading, non-submerged procedure, number of implants supporting a prosthesis, poor plaque index, lack

of preventive maintenance as well as implant surface characteristics and design, are associated with peri-implant disease and implant loss.[13-16] As more providers start placing and restoring dental implants in Sudan, there is a need to determine the prevalence and risk indicators for peri-implant diseases, since understanding of these factors around the implants tissue may be important in the treatment and prevention of peri-implant diseases. The aim of the present study was to identify the prevalence of peri-implant disease in subjects treated with osseointegrated implants, using clinical parameters, and to evaluate the possible disease association with demographic, behavioural, and biological risk variables.

MATERIAL AND METHODS

Study Design and Participants

This study was a cross-sectional, clinical study approved by the Research Ethics Committee, Faculty of Dentistry University of Khartoum, Khartoum, Sudan. All patients who received dental implants at the Implantology Department at Khartoum Dental Teaching Hospital since its establishment in (2006) and up to (2010) were included in the study. All participants were requested to participate voluntarily in the study after full explanation of the research and only those who gave their consent were included in the study. The consent was obtained in accordance with policies established by Medical and Health Studies Board University of Khartoum. Patients were informed about their situation and treated in their follow up clinic. A retrospective chart and radiograph review was collected for the patients with dental implants that were placed during the calendar years of 2006 to 2010. Those patients were recalled back in their follow-up clinic for periodontal evaluation. All patients who were treated with implant therapy with one of two commercially available smooth/rough surface implant (push in-Helix) systems during this time period were included in the study. According to surgical protocol, all fixture installations were performed under local anaesthesia, and the alveolar crest was reveal via crestal incision. Systematic antibiotics and mouth wash were given after insertion of implant for all subjects. The implants were loaded 4months (mandible) to 6 months (maxilla) after insertion and they were received the same type of supra structure which was made in the hospital by one technician.

Study Variables

Peri-implant diseases, peri implant mucositis and peri implantitis were the dependent variables of the study, whereas patient demography, oral hygiene status , past and current systemic diseases, , smoking history as well as data specific for implants (implant surface, date of placement) were the independent variables.

Clinical Measurements

All patients received periodontal examination performed by one calibrated examiner (M.H) (Kappa value was > 0.9). The following clinical parameters were assessed at each implant site using a periodontal probe (Michigan"O" pattern): (1) Plaque Index (PI);[17] (2) bleeding on probing (BOP);[18] (3) probable pocket depth PPD[4] relative/probable attachment level. The measurements of PI, BOP, and PPD were performed at four aspects per implant: (mesiobuccal, distobuccal) and (mesiolingual, distolingual). Radiographic evaluation was performed using periapical radiographs, radiographs used to observe marginal bone loss between implant shoulder and interproximal bone[19]

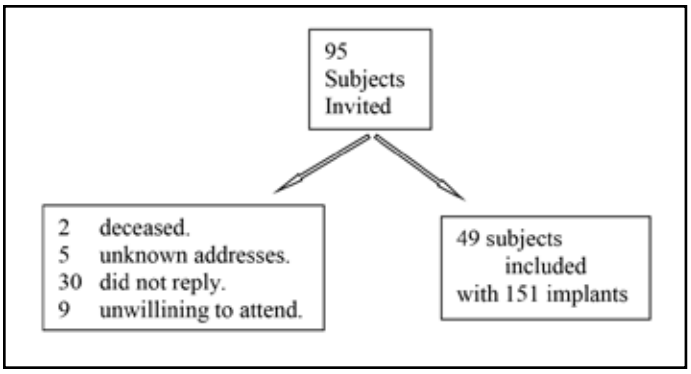

Figure 1: Subjects included in the study.

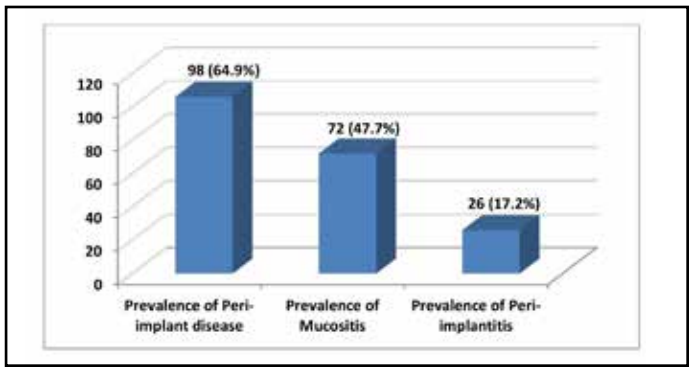

Figure 2: Prevalence of Peri-implant disease.

and it was compared to the base line radiograph.

Criteria for Diagnosis

The diagnosis of peri-implant mucositis was defined by an osseointegrated implant presenting bleeding on probing (BOP) in more than one site of the implant without radiographic signs of bone loss.[20] The presence of peri-implantitis was defined as an osseointegrated implant presenting bleeding in probing (BOP) in more than one site of the implant, Pocket depth (PD) and probable attachment loss (PAL) of ≥ 5mm and Radiographic signs of bone loss.[21]

Statistical Analysis

Data were analyzed using SPSS (Statistical Package for Social Sciences) Version 11. Descriptive analysis was performed using mean ± standard deviation for numerical variables and frequency and percentages for categorical variables. Chi-square was used to test the group differences in categorical variables while student t-test and ANOVA for 2 groups and multiple groups differences in continuous variables respectively. Correlation analysis was performed to analyze the relationship between implant related diseases and risk indicators that were investigated. For all statistical tests, two-sided type I error probability = 0.05 was considered as the level of significance.

RESULTS

A total of 95 subjects were invited to participate in this study. They have had 206 endosseous implants that were placed during the calendar years 2006-2010 in Khartoum dental teaching hospitals, the included subject were shows in (Figure 1). Of the 49 individuals in the final sample, 15 (30.6%) were men and 34 (69.6%) were women, with a mean age of (40.76 ± 11.01) years. About 68% of the subjects had their last dental visit before more than one year while subjects who had their last dental visit during the last year were about (14%). Moreover Subjects who had previous periodontal treatment were 19 (38.8%) while those without history of periodontal treatment were 30(61.2%). The maintenance programmed of implants (SPT) was presented with 0.00%, which means that patients with implants did not perform supporting periodontal therapy after placing their implants (Table 1). The prevalence of peri-implant mucositis and peri-implantitis for patients were 47.7%) and 17.2%, respectively (Figure 2). Only 6 (4%) of implants had good

Table 1: Distribution of the Participants According to, Last Dental Visits, Previous Periodontal Treatment and Supportive Periodontal Therapy

Description	Frequency	Percent (%)
Last dental visit		
Within the last year	**7**	**14.3**
More than one year	**42**	**85.7**
Total	**49**	**100.00**
Previous periodontal treatment		
Yes	**19**	**38.8**
No	**30**	**61.2**
Total	**49**	**100.00**
Supportive periodontal treatment	**0**	**0.0**

oral hygiene and 67 (44.4%) had poor oral hygiene while the majority of implants had fair oral hygiene. Higher total plaque scores were statistically associated with peri-implant disease, and a very poor status of oral hygiene was highly associated with peri-implantitis (Table 2). The mean loading time of the implants was 3.67 ± 1.00 years. Statistically significant differences were found in the prevalence of periimplantitis in subjects presenting with implants for more than 3 years after the assimilation of the supra-structure (Table 3). When considering the implant surface, the peri-implantitis was more prevalent among patients with rough surface implants than those with smooth surface and the difference was statistically significant (p-value 0.00). However, no significant difference was detected in the prevalence of Periimplant mucositis between rough and smooth surface implants (p-value 0.037) (Table 4). The degree of association of all independent variables was tested using multinomial logistic regression analysis, as shown in (Table 5). The model revealed that oral hygiene, implant surface, and time of implant placement were positively associated with peri-implant disease; however, time of implant placement was not associated with peri-implant mucositis. The independent variables that were not associated with periimplant diseases were age, gender, smoking and diabetes.

DISCUSSION

The present study revealed a prevalence of 47.7% for peri-implant mucositis and 17.2% for peri-implantitis respectively in the overall sample. These values can be considered high and

Table 2: Peri-implant Disease vs Oral Hygiene Cross-tabulation

	Oral Hygiene				
Description	**Poor**	**Fair**	**Good**	**Total**	**P-value**
Peri-implant disease					
Yes	**54 (80.6%)**	**44 (56.4%)**	**0 (0.0%)**	**98 (64.9%)**	
No	**13 (19.4%)**	**34 (43.6%)**	**6 (100.0%)**	**53 (35.1%)**	**0.000**
Total	**67 (100.0%)**	**78 (100.0%)**	**6 (100.0%)**	**151 (100.0%)**	
Muscositis					
Yes	**35 (52.2%)**	**37 (47.4%)**	**0 (0.0%)**	**72 (47.7%)**	
No	**32 (47.8%)**	**41 (52.6%)**	**6 (100.0%)**	**79 (52.3%)**	**0.01**
Total	**67 (100.0%)**	**78 (100.0%)**	**6 (100.0%)**	**151 (100.0%)**	
Peri-implantitis					
Yes	**19 (28.4%)**	**7 (9.0%)**	**0 (0.0%)**	**26 (17.2%)**	
No	**48 (71.6%)**	**71 (91.0%)**	**6 (100.0%)**	**125 (82.8%)**	**0.005**
Total	**67 (100.0%)**	**78 (100.0%)**	**6 (100.0%)**	**151 (100.0%)**	

this is not surprising since all individuals diagnosed with Periimplant disease did not perform preventive maintenance visits. Therefore, it is possible to consider that, the sample of this study has a high risk for susceptibility and progression of peri-implant disease. The Consensus of the Seventh European Workshop on Periodontology, revealed that mucositis results from the response of host to bacterial biofilm and it is an obvious precursor to peri-implantitis.[8] The results of the present study agree with a study conducted by Lindhe & Meyle who found that periimplant mucositis occurred within 50% of all peri-implant sites, whereas peri-implantitis was identified 43% of the sites.[5] Inadequate plaque control and poor oral hygiene has been suggested as a potential variable associated with Periimplant diseases.[22-24] Therefore patients who were rehabilitated with dental implants should perform proper oral hygiene measures. As well, the present study revealed that, the poor oral hygiene was significantly associated with the occurrence of peri-implant disease. Consequently, patient's compliance including good plaque control and dental follow-up seems to have a pivotal role to prevent the occurrence of Periimplant diseases. Roughness of the implant surface was associ-

Table 3: Peri-implant Disease vs Time of Implant Placement			
	Time of Implant Placement		
Description	Mean ± SD	S.E.	P-value
Peri-implant disease			
Yes	**2.71 ± 1.26**	**0.13**	
No	**2.49 ± 1.26**	**0.17**	**0.300**
Mucositis			
Yes	**2.51 ± 1.29**	**0.15**	
No	**2.75 ± 1.23**	**0.14**	**0.259**
Peri-implantitis			
Yes	**3.27 ± 1.00**	**0.20**	
No	**2.50 ± 1.27**	**0.11**	**0.002**
(n=151)			

ated with the occurrence of peri-implantitis in this study 91.0% of rough surface implants presented peri-implantitis, whereas 63.3% of smooth surface implants had this biological complication. This finding could be explain by that rough surface is prone to accumulation of dental plaque than the smooth surface.

These findings is supported to what has been reported in the literature relative to infectious risk of dental implants, that using a relatively smooth abutment and implant surface was necessary to prevent from biological complications.[25] Regarding risk factors related to duration of implant placement in the present study, it was found that, the proportion of patients with implants for more than 3 years in function presented a percentage of peri-implantitis much higher than the others with less duration. Regrettably, considering the fact that the more implants will be placed every year, we would likely have to deal with many peri-implantitis in the coming years.

Smoking has been identified as a potential risk factor for periimplant diseases.[26-28] However in the present study smoking was not significantly associated with the occurrence of peri-implantitis. This could be explained by the small proportion of smokers compared to non-smokers. Other possibility is that, registration of smoking habits was based on self-report and some of the patients might deny to be smokers.

As well, gender and age of patients did not show any relevance in the study. Conflicting results have been published about the influ-

Table 4: Peri-implant Disease vs Implant Surface

	Implant Surface				
Description	**Rough**	**Smooth**	**Combination**	**Total**	**P-value**
Peri-implant disease					
Yes	**44 (56.4%)**	**35 (79.5%)**	**19 (65.5%)**	**98 (64.9%)**	
No	**34 (43.6%)**	**9 (20.5%)**	**10 (34.5%)**	**53 (35.1%)**	**0.037**
Total	**78 (100.0%)**	**44 (100.0%)**	**29 (100.0%)**	**151 (100.0%)**	
Muscositis					
Yes	**37 (47.4%)**	**19 (43.2%)**	**16 (55.2%)**	**72 (47.7%)**	
No	**41 (52.6%)**	**25 (56.8%)**	**13 (44.8%)**	**79 (52.3%)**	**0.603**
Total	**78 (100.0%)**	**44 (100.0%)**	**29 (100.0%)**	**151 (100.0%)**	
Peri-implantitis					
Yes	**71 (91.0%)**	**28 (63.6%)**	**26 (89.7%)**	**125 (82.8%)**	
No	**7 (9.0%)**	**16 (36.4%)**	**3 (10.3%)**	**26 (17.2%)**	**0.000**
Total	**78 (100.0%)**	**44 (100.0%)**	**29 (100.0%)**	**151 (100.0%)**	

ence of diabetes associated with a higher risk of peri-implant disease, Some studies report a positive association[16,29] whereas others found no association.[14,30] In this study diabetes was not associated with the occurrence of peri-implant disease. This finding may well be related to the small number of diabetics in the sample.

In the present study, the lack of preventive maintenance within the overall sample was clear, without supportive maintenance therapy, peri-implant disease could be a common complication on the long-term.[31] Many studies have shown the potent effect of periodontal maintenance in maintaining periodontal health, minimizing the progression of periodontitis and reducing the possibility of tooth loss. In regard to dental implants, few studies have been carried out among individuals with and without preventive maintenance.[14,23,32] However, the benefits of preventive maintenance on implants have been underscored in previous studies.[23,28,33]

CONCLUSION

Within the limits of the present study, Poor oral hygiene seems to account for the higher risk in the development of peri-implantitis.

In this study, the lack of maintenance visits has influenced the peri-implant health status.

Table 5: Adjusted Parameter Estimates the Risk Indicators for Peri-implants Diseases in Three Different Statistical Models (*p < 0.05)

	Model 1		Model 2		Model 3	
	Odd Ratio	Correlation coefficient (P-value)	Odd Ratio	Correlation coefficient (P-value)	Odd Ratio	Correlation coefficient (P-value)
Age		-0.052 (0.527)		-0.023 (0.780)		-0.036 (0.661)
Gender	2.25	0.144 (0.078)	1.55	0.089 (0.277)	1.47	0.064 (0.435)
Smoking	2.39	0.124 (0.130)	1.11	0.018 (0.825)	2.38	0.132 (0.105)
Diabetes	2.58	0.099 (0.225)	1.35	0.039 (0.639)	1.91	0.075 (0.362)
Oral Hygiene	3.78	0.353** (0.000)	1.39	0.118 (0.149)	4.35	0.267* (0.001)
Time of Implant Placement		-0.085 (0.300)		0.092 (0.259)		-0.230* (0.005)
Implant Surface	0.33	-0.233** (0.010)	1.06	0.041 (0.654)	0.17	-0.336* (0.000)

Model 1: Peri-implant diseases. Model 2: Peri-implant mucositis. Model 3: Peri Implantitis
*** Correlation is significant at the 0.05 level (2-tailed).**
**** Correlation is significant at the 0.01 level (2-tailed).**

Along these lines, the control of oral hygiene and the periodontal status should be monitored after the placement of dental implants, so as to avoid, or at least minimize, the risk of developing peri-implant disease in subjects rehabilitated with implants. No association was found between smoking and diabetes with peri-implant disease in the present study population.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

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Efficacy of Biograft (β Tricalcium Phosphate) in Alveolar Ridge Preservation – A Randomized Controlled Clinical Study

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Abstract

Purpose: The purpose of this study is to evaluate the efficacy of biograft (β tricalcium phosphate) in alveolar ridge preservation.

Materials and Methods: Patients requiring tooth extraction except the third molars and who agreed for bone grafting were selected for the study. Randomly these were divided into two groups, one was the socket preservation group in which after extraction, bone graft () was placed in the extraction socket and protected with a collagen membrane and the other was a control group wherein no graft was placed and extraction socket was left to heal normally. Radiographic height and width was assessed, at time of extraction and 6 month postoperatively using vista scan and bone calliper.

Results: β - TCP placed at the time of grafting extraction socket was well tolerated in all sites with barrier membrane used. There was no incidence of graft rejection or infection. The reduction in the height and width of alveolar bone at the end of 6 months showed lesser reduction in Group 1(with graft) as compared to Group 2 (without graft) with a P value of < 0.001 in horizontal width measurement which is considered to be strongly significant.

Conclusion: Guided Bone Regeneration is a successful method of alveolar ridge preservation and that synthetic bone substitute (β- TCP) with a collagen membrane can be usefully utilized for this purpose.

KEY WORDS: Alveolar ridge preservation, Guided Bone Regeneration, Collagen Membrane, Synthetic bone substitute, Beta tricalcium phosphate, allograft

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INTRODUCTION

Alveolar bone seems to play a key role in providing support to the teeth. Tooth extraction leads to typical bone deficiency of ridge width and height of alveolar crest and reduces the possibility of placing screw titanium implants. The bone resorption process is initiated immediately after extraction, leading to an average 40–60% decrease in the horizontal and vertical dimensions of the alveolar ridge, during the first 2 years.[1] To restore alveolar bone loss and support efficient placement of dental implants, many different bone substitute such as autografts, allografts, xenografts, synthetic biomaterials and osteoactive agents have been proposed.[2] Morbidity of donor sites, attempts at reduction in the number of surgical sites, and limitations in amount of bone available are some objective reasons driving the search of bone substitute to replace the use of autogenous bone. Ridge preservation using the Guided Bone Regeneration (GBR) technique has been shown to improve ridge height and width dimensions when compared with tooth extraction alone.[3] The use of bone grafts in the maxillofacial region has been considered for regeneration of bone defects and to re-establish the original skeletal contour and function. According to previous studies ß TCP shows great osteoconductive potential because of its macroporosity (1 micron -1000 micron), which leads to good bone growth. Approximately 90% of this material is interconnected void spaces. ß TCP bonds directly to bone, which facilitates healing.[4] Therefore, in our study we are using Beta Tricalcium Phosphate (β-TCP) with a resorbable collagen membrane. The present study was carried out to evaluate the alveolar ridge preservation achieved following tooth extraction with or without the placement of β-TCP.

Figure 1: Placement of graft in extraction socket.

MATERIALS AND METHODS

Thirty patients aged between 18-50 years, irrespective of sex reported to the Department of Oral and Maxillofacial Surgery, M.S. Ramaiah Dental College and Hospital, Bangalore, India for the extraction of teeth were included in the study. Each was given numbers and odd and even numbers were selected. Randomly these were divided into 2 groups of 15 cases each, one was the experimental group i.e. the socket preservation group in which after extraction, bone graft (β tricalcium phosphate) was placed in the extraction socket and covered with a collagen membrane (collagen), and the other was a control group wherein no graft was placed and extraction socket was left to heal normally. All patients were followed up for a period of 6 months. Alveolar height and width of both groups was assessed at post extraction / 7th day and 6th months respectively.

Inclusion/Exclusion Criteria

Patients with ASA I (Healthy patient without any systemic disease), tooth indicated for extraction and extraction socket with four intact walls after extraction of tooth were included in study.

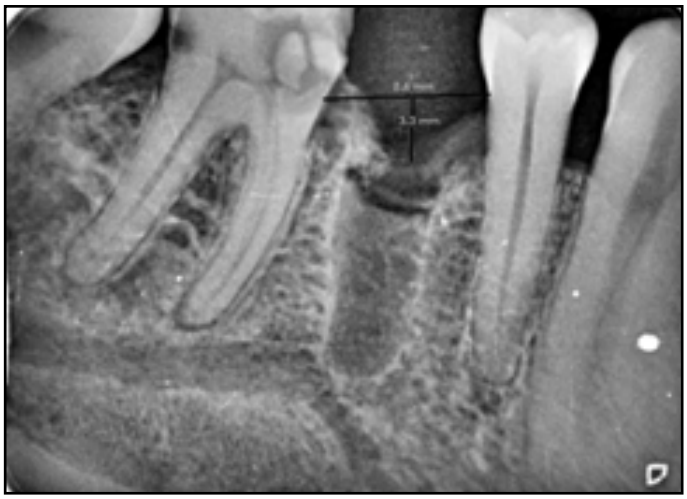


Figure 2a: Vista scan image immediately after extraction.

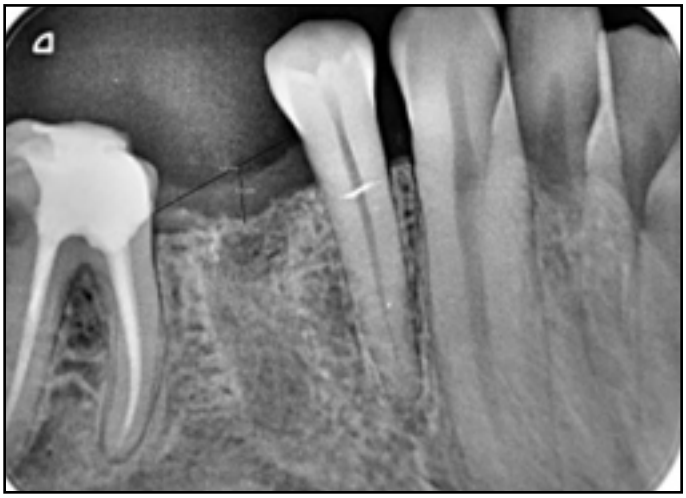


Figure 2b: Vista scan image 6 months postoperatively.

Patients with presence of any chronic systemic disease like diabetes, hypertension, bleeding disorder etc. that contraindicate surgical treatment, allergic to local anesthesia or adrenaline, undergoing chronic treatment with any medication known to affect bone turnover like heparin, cyclosporine, bisphosphonates, chemotherapeutic drugs – methotrexate etc., pregnant or lactating women and heavy smokers (a smoker with cigarettes consumption more than 20 pieces per day).

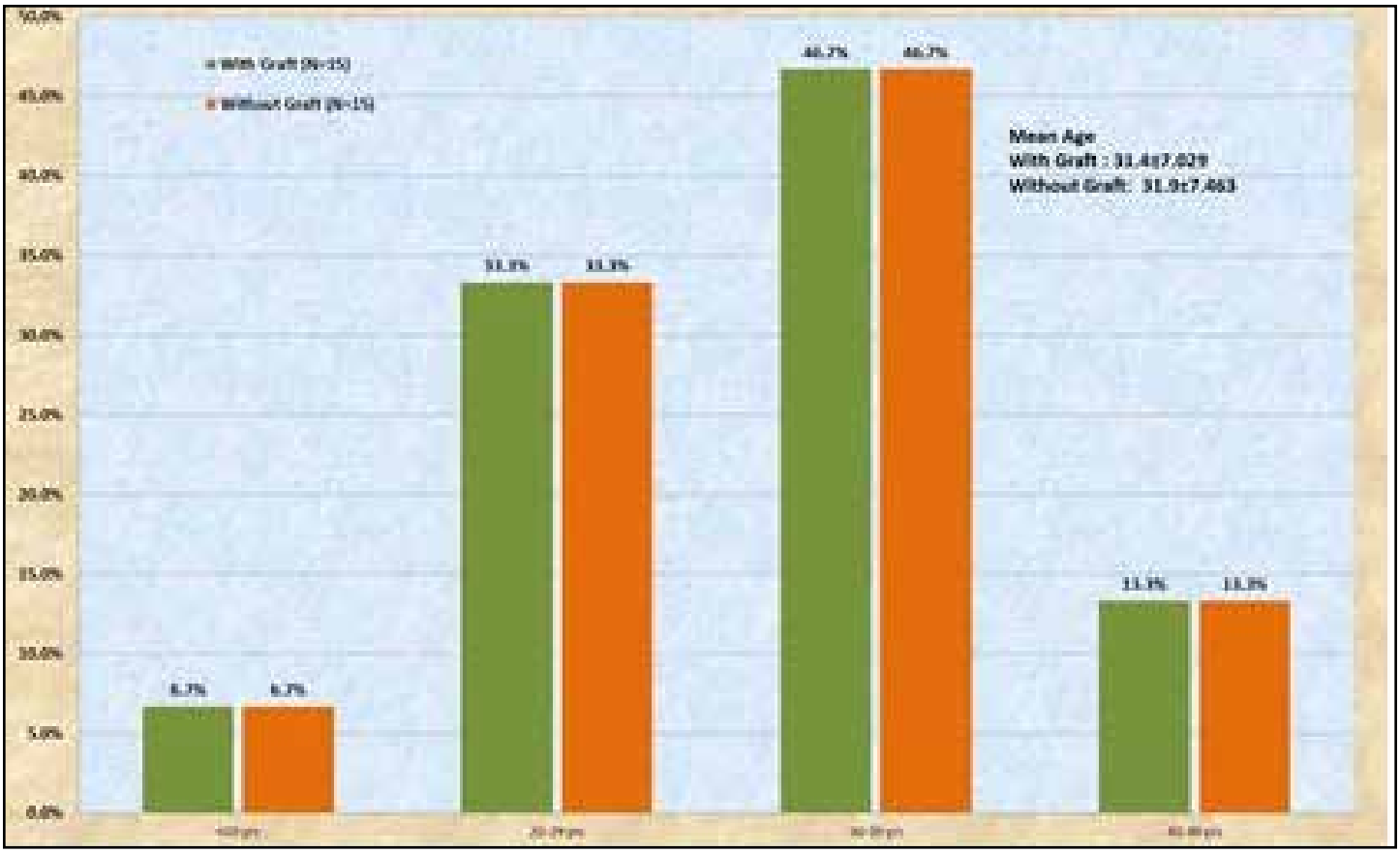
Materials Used

With granule size 250-350 microns was used as bone graft material. Collagen membrane as barrier over graft. 3-0 Black braided silk sutures were used for primary closure. Informed consent was taken prior to surgery.

Surgical Procedure

Atraumatic tooth extractions were performed using periosteal elevators and forceps under local anaesthesia (lignocaine 2% with epinephrine 1:200,000). Site preparation was accomplished with fine curettes by removing granulation tissue followed by irrigation with saline. Vista scan image of tooth was taken and horizontal (a straight line joining the CEJ of anterior tooth to the CEJ of posterior tooth adjacent to extracted socket drawn) and vertical height (a straight line joining the CEJ of anterior tooth to the CEJ of posterior tooth adjacent to extracted socket drawn, from centre of horizontal line a straight line drop to the crest of alveolar ridge) were measured. Buccolingual ridge width was measured using bone calliper (placing its tip one on buccal side and other on lingual side at upper bone level and on most central part of alveolar ridge)

The Bone graft material was dispensed from its container into a sterile stainless-steel kidney tray and placed and packed into the socket until it filled the socket space (Figure 1). Collagen membrane was placed over the grafted site and closure was done with 3-0 silk suture. Postoperative instructions were given. Postoperatively the alveolar bone height and width of both groups were assessed (using vista scan) and compared with the pre surgical values respectively (Figure 2). The reduction in the ridge dimensions were evaluated



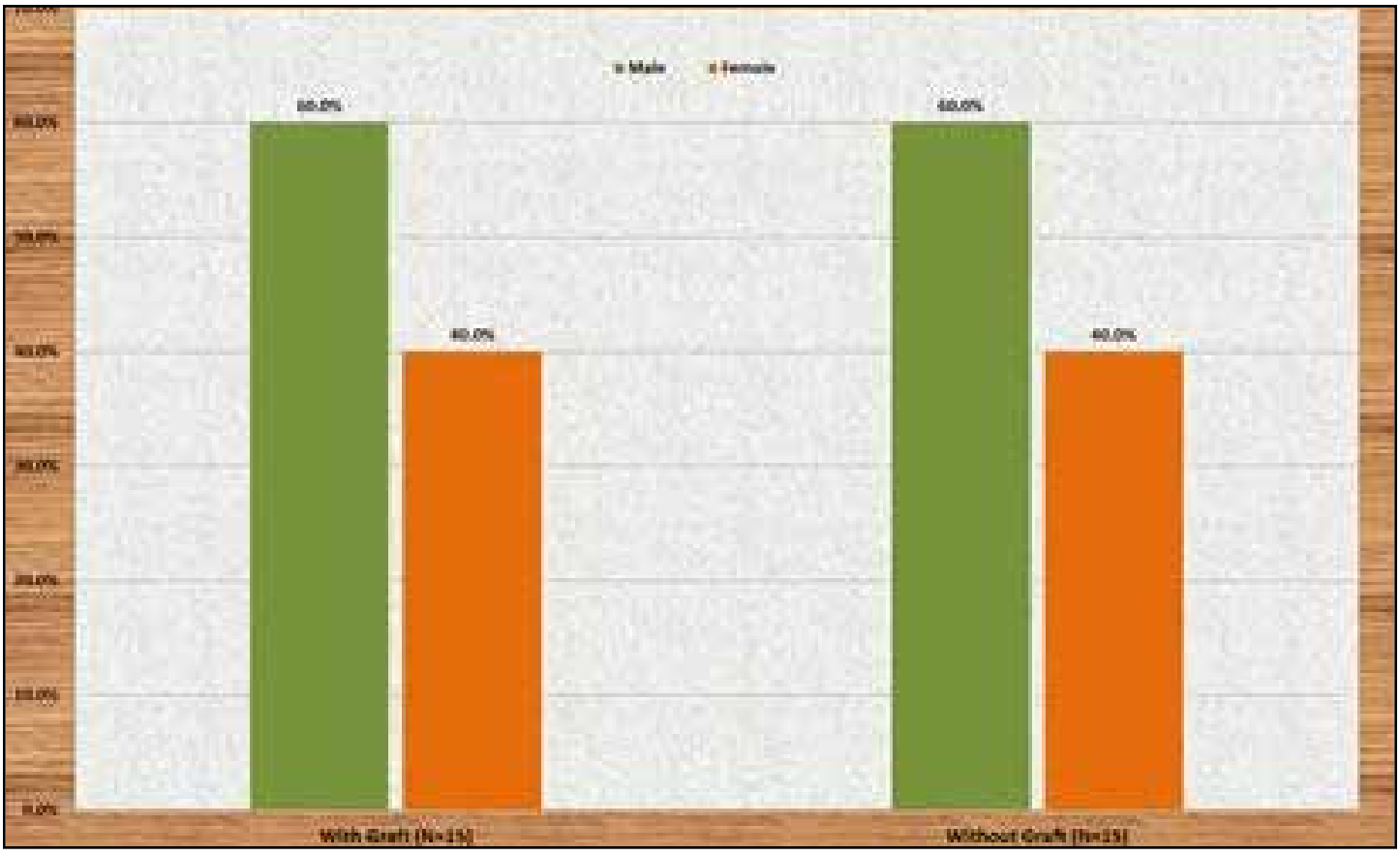
Graph 1: Age distribution in 'with' and 'without' graft groups.

and compared. Univariate analyses of the dichotomous variables encoded was performed by means of the Chi square test with Yates correction and Student "t' test was used to determine whether there was a statistical difference between male and female subjects in the parameters measured.

RESULTS

Thirty patients divided into two groups - Group 1 (with graft) consisting of 15 patients and the Group 2 (without graft) consisting of 15 patients were included in study. The patients were aged between 18 and 50 years with mean age of 31.4 ± 7.029 years in group 1 and 31.87 ± 7.463 years in group 2 (Graph 1). Among the 30 patients 18 (60%) were male and 12 (40%) were females, the two groups suggesting an equal distribution of both genders in the study groups (Graph 2)

Preoperative and postoperative (after 6 months) comparison of mean value of parameters; buccolingual width pre - 9.00 mm and post – 8.30 mm, horizontal width pre - 9.25 mm and post 8.95mm and vertical height pre –1.94 mm and post -2.03mm in group 1 (with graft) showed slight decrease in alveolar ridge dimensions that were comparable to Preoperative and postoperative (after 6 months) comparison of mean value of parameters in group 2 (without graft) ; buccolingual width pre:

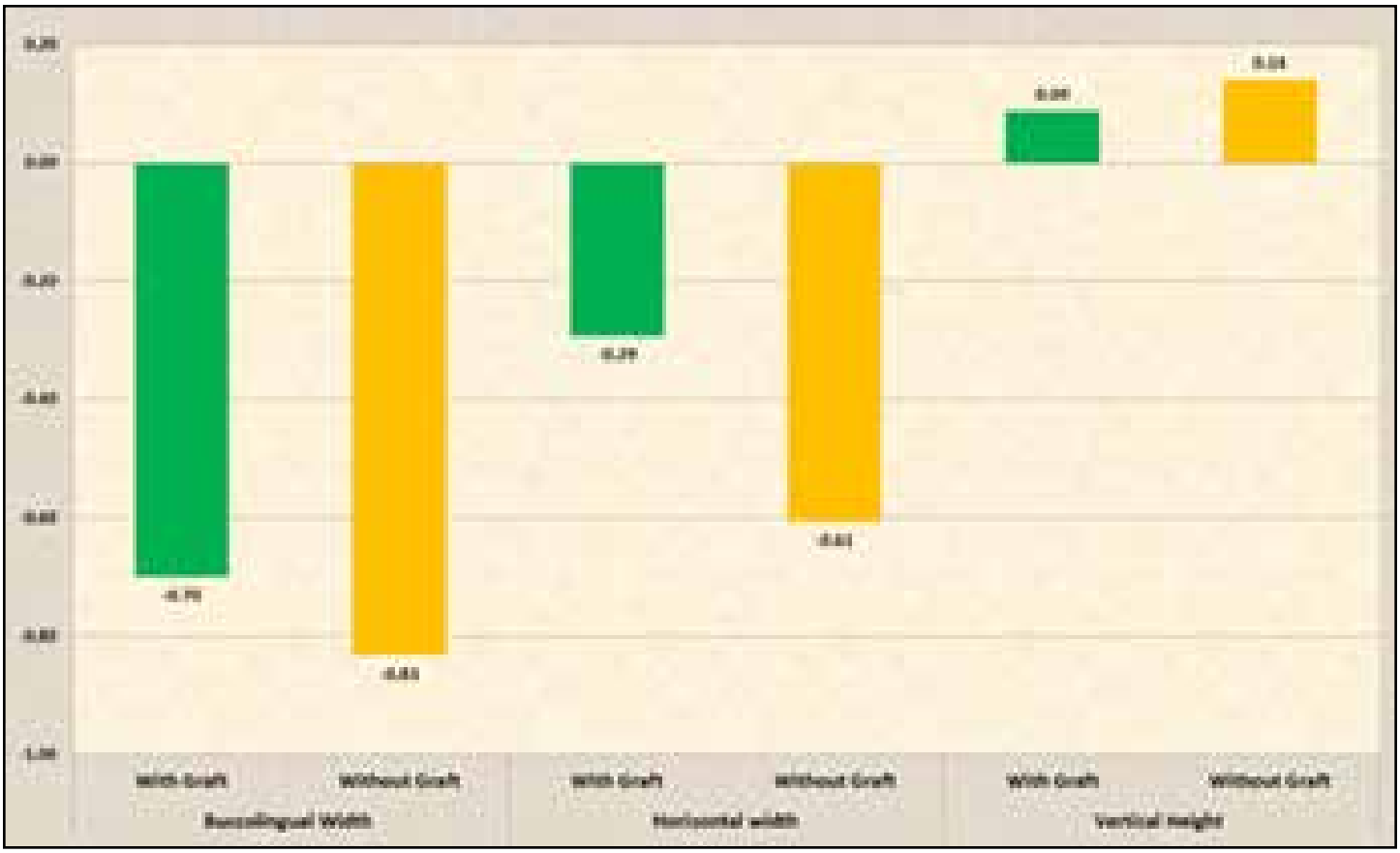


Graph 2: Gender distribution in 'with' and 'without' graft groups

10.067 mm and post: 9.233 mm, horizontal width pre: 9.600 mm and post: 8.933mm and vertical height pre: 1.540 mm and post: 1.40mm. Comparison of parameters (post-pre) in study groups with and without graft showed Buccolingual width in group 1: - 0.700 ± 0.0254 mm, Group 2: - 0.833 ± 0.748 mm P value: 0.519, Horizontal width in group 1: - 0.293 ± 0.202, Group 2: - 0.607 ± 0.179 mm P value : < 0.001, Vertical height in group 1: 0.087 ± 0.074mm Group 2: 0.140 ± 0.074 mm P value: 0.058. (Graph 3, Table 1) P value of < 0.001 in horizontal width measurement showed that use of β-tcp in alveolar ridge preservation was statistically significant. No incidence of infection or dehiscence occurred.

DISCUSSION

Characteristic of ideal bone replacement graft material include safety, efficacy and ability for the graft material to be replaced by vital alveolar bone. The β tcp graft material used in this study was purely synthetic material,[6] osteoconductive[7] in nature and has no organic components, therefore no chance of antigenicity or allergic reaction. Compared with autogenous bone grafting, this synthetic graft has unlimited availability without second



Graph 3: Comparison of mean changes (pre and post) parameter values in 'with' and 'without' graft groups.

site morbidity.[8] Contrary to GTR procedures, additional bone grafting materials for space maintenance, tend to improve GBR outcomes.[9] In this study, we used Guided bone graft augmentation (GBGA)[10] which designates a barrier membrane application to help preserve and maintain the bone graft, based on principle of osteopromotion.[11] Bone substitutes were able to preserve post extraction alveolar ridge dimensions to some extent, the quantity and the quality of the bone tissue formed in the socket have been variable and their presence often interfered with the normal healing process.[12] But in this study, quantity and quality of bone formed was good with trabecuale resembling adjacent natural bone and there were no cases of infection and dehiscence. Healing was satisfactory and uneventful. Post-extraction alveolar ridge resorption was observed in previous randomized controlled clinical trials where extraction sockets were treated with either β tcp[4], a combination of HA and β-TCP bone graft and a collagen membrane[13] or porcine xenograft and a collagen membrane.[14] Also, in a study healing of extraction sockets filled with freeze dried bone and collagen membrane was compared with the healing of "empty" untreated extraction sockets.[15] In

Table 1: Comparison of parameters (pre and post) in study groups 'with' and 'without graft'

		N	Mean	SD	Min.	Max.	't' value	'p' value
Bucco-lingual Width	With Graft	15	-0.70	0.254	-1	-0.5	0.427	0.519
	Without Graft	15	-0.83	0.748	-2	1		
Horiz-ontal Width	With Graft	15	-0.29	0.202	-0.7	0	20.24	< 0.001
	Without Graft	15	-0.61	0.179	-1	-0.3		
Vertical Height	With Graft	15	0.09	0.074	0	0.2	3.896	0.058
	Without Graft	15	0.14	0.074	0	0.3		

study, both pre and postoperative radiographic measurements on Vista scan were taken from the Cemento-enamel junction of the adjacent mesial tooth to Cemento-enamel junction of the adjacent distal tooth to the corresponding highest Alveolar bone crest level. The results clearly showed less dimensional change in horizontal width, vertical height and buccolingual width in Group 1 patients which indicate decreased bone resorption as compared to more resorption in Group 2 patients over a period of six months post operatively. Horizontal width measurement with p value < 0.001 gave statistically significant result. One of the advantages of our study is the presence of a negative control group in which unassisted socket healing was observed for a similar period of time in the patient where socket preservation procedure was carried out. The limitation of the present study was that the sample size was small consisting of 15 patients and histological evaluation was not performed for all the treated sites which would have given us a clear picture of bone formation.

CONCLUSION

β tricalcium phosphate is a bio-graft material, resorbable, osteoconductive in nature, economical, with minimal rejection and no donor site morbidity. Collagen membrane is resorbable in nature.

In the present study we used combination of β tcp and collagen membrane. It gave significant results with regard to preservation of horizontal width of the socket and also helped in preservation of buccolingual width and vertical height. Hence use of β tcp and collagen membrane is viable option after routine extraction of tooth. However the limitation of this study is small sample size, hence long term study with a larger sample size is recommended.

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Disclosure
The authors report no conflicts of interest with anything mentioned in this article.

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A New Standard Classification System for Dental Implant Drills and Role of Implant Drills in Successful Osseointegration

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Dr. Prabhdeep Kaur Sandhu[3] • Dr. Sachin Mittal[4]

Abstract

Background: Implant drills use is so common now a days and clinicians are aware about implant drills of the system which they are using. It is demand of the time that we should formulate a classification system to categories these drills for ease to remember and identification. Attempts have been made through this article to shed some light on various types of implant drills along with a simplified system of their classification. Another aspect included in this article is various factors influencing the drilling process and causing overheating in osteotomy site.

Methods: Searches performed in MEDLINE related to Dental Implant Drills and a review was carried out regarding various types of drills available and various variables during drilling process which affect the osseointegration process (Implant Success rate).

Results: Reviewed literature revealed that there are four different criteria based on which implant drills are classified in this review. Even the drilling process seems very easy but little more awareness about small looking steps can drastically improve Implant success rate. This procedural information is concluded as "guidelines of drilling process" for the betterment of clinical practice.

Conclusions: Every clinician should be well aware about the instruments which they use in daily routine and a classification system helps in categorization and easy remembrance of these similar looking mechanical tools. This review article is presenting a classification system for the dental implant drills and also discussing the points where operator's negligence is very common.

KEY WORDS: Dental implants, drills, classification

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INTRODUCTION

Dental implants have been used since mid-1960's but in recent years their use has been increased drastically as evidence from studies and clinical experience have shown that they are safe, most conservative approach for restoration, convenient to place and their results not only restoring function but aesthetics too. This success rate is determined by various factors like operator knowledge & skill, case selection, surgical technique, bone graft/augmentation procedure, implant type/design/number/angulations, loading protocol and type of overlying prosthesis.[1] However the focus of most of the studies/ research in literature is on design, surface modification, and loading conditions. It is unfortunate that the effect of surgical procedures such as the drilling protocol has been sparsely explored, and clinicians basically follow the instructions given by the manufacturers. This article is bound to discuss role of Implant Drills in healing process (osseointegration) and a system of classifying dental implant drills is also incorporated for a better understanding.

A dental implant drill is a small-high speed drill used during dental implant procedure to create a hole and to prepare implant bed for the best fit at recipient site. These drills are run by a powered hand-piece/ dental engine designed with special controlling features meant for implant placement. They can be of different shapes and designs as per their functional requirement. Unfortunately, no standard classification system is available for them. A very simplified way to categorize them is as follows:

CLASSIFICATION SYSTEM FOR IMPLANT DRILLS

Presently available implant drills can be classified on the following basis:

Based upon the drill design:[2,3]

- Twisted Implant drills (further categorized into)
- Triple twist drill with a relief angle
- Triple twist drill without a relief angle
- Double twist drills with a relief angle
- Double Twist drill without a relief angle
- Fluted drills

Based upon the method of cooling:[4-10]

- Drills with internal irrigation
- Drills with External irrigation

Based upon the usage of drills:[11,12]

- Single use/disposable drills
- Multiple use drills

Based upon the usage during osteotomy:[13]

- Mucosal punch drill [14]
- Locator drill
- Pilot drill
- Conical or cylindrical drill
- Countersink drill/profile drill
- Tap drill
- Trephine drill [5]

Role of Drills and Drilling Process in Osseointegration

Dental implant surgery involves drilling a hole in the bone, which is a friction process between the drill and bone resulting in heat generation.[15,16] The majority of generated heat is absorbed by drill but bone also absorbs a significant amount of heat. In the absence of irrigation, bone temperatures may

exceed 100^0 C. It has been documented that bone cell changes may occur when bone is heated over the critical temperature i.e. 47^0 C [16,17,18,19] (threshold temperature is 30.3^o C for 5 seconds[20] or 44-47^o C for 1 min).[7,15,18,20] The negative effect of heat on bone results in the denaturation of the enzymatic & membrane proteins, hyperemia, dehydration, desiccation, fibrosis, decreased osteoclastic & osteoblastic activity and necrosis, which may all contribute to cell death (osteonecrosis).[21-26] This may result in a failure of bone to bond to the implant, leading to early failure.[27,28]

FACTORS AFFECTING HEAT GENERATION

After a detailed literature survey, the factors[3,29] that can affect a temperature rise during the drilling process can be listed as follows:

- Drill Sharpness
- Drilling speed and pressure
- Drilling time
- Drilling status
- Drill design/ drill geometry
- Drill material and wearing/coating
- Drill diameter
- Drilling depth
- Irrigation (coolant delivery) systems
- Miscellaneous Factors (type of the recipient bone, age of the patient and experience & skill of clinician)

Drill Sharpness

The condition of drill plays a major role in regulating the temperature of bone during drilling.[30] A worn drill will thus have more heat production than a sharper drill.[23] There are many factors that reduce the sharpness of a drill like density of bone, multiple reuse of the drill, the debris released during the process, material construction & surface treatment of drill.[10] Indication for drill change are loss of shine at cutting edge and wear off along cutting blade (visual examination), clinical observation of when the drill fails to progress rapidly and after number of sites prepared as suggested by manufacturers.

Drilling Speed and Pressure

There are variable results from different studies about the optimal speed for dental implant surgery. Earlier reports have supported the slow-speed as heat generation was assumed to be less compared with high-speed[31-33] (recommended speeds were 600 rpm,[34] 125-2000 rpm[2]) and this rise in temperature was noticed up to an approximate speed of 10,000 rpm.[34] At very high speeds (27,000 rpm to 97,000 rpm) temperature rise was very less and healing was faster compared to lower speeds.[31,35.36] At this point of discussion, it is very important to understand that osteotomy procedures for implant bed preparation require a precise cutting because it should match exactly the specifications like implant diameter/length, thread shape/design for its primary stability which can't be achieved with high speed beyond 2500 rpm. Slower rotational speeds require more drilling time, which produces more frictional heat so rpm (drilling speed) is not the only factor for rise of temperature, however duration/time of drilling is more important and is major determinant than speed. This duration of drilling can be reduced by incorporating factors like torque and pressure[10,23,37-39] along with optimum speed. Eriksson has shown that using high torque and low rpm (1500-2000) are ideal to avoid temperature rise and to increase drilling accuracy.[19]

The role of pressure was studied by Brisman[40] who compared the drilling at 1,200 rpm and 2,400 rpm under loads of 1.2 kg and 2.4 kg in dry bovine femoral bone and found that less heat was generated with 2,400 rpm (or 2500 rpm[41]) under 2.4 kg of force.[40] However the pressure is a variable factor which differs from operator to operator[42] and there is no standard way to optimize it but it is interesting to know that generally clinicians use a force of approximately 2 kg during implant drilling procedure under normal clinical conditions.[3,38,42] So this factor can be assumed optimal for all operators; with its least effects on heat generation.

Drilling Time

This factor can be discussed under two criteria, i.e. drilling time and the time required for the heated part to return to its normal temperature. This can be simplified as more drilling time will cause more rise in the bone temperature which will require more time for the heated part to return to its normal temperature hence more damage can be noticed in situ. Eriksson and Albrektsson demonstrated that the long-term effect of heating bone up to 47°C for 5 minutes resulted in dominant bone resorption (about 20%) after a period of 30 days.[20] This was accompanied by an invasion of fat cells and little osteogenic activity, so less osseointegration at site.[44,45] Best way to control this variable is to remove drill gradually in between every 5 seconds for at least 10 seconds to allow the temperature of bone to return to baseline and use of copious irrigation (Intermittent Drilling).

Drilling Status

Drilling status should be discussed under two headings; Incremental versus single step drilling and intermittent versus continuous drilling:

Incremental versus single step drilling: In one step drilling, the hole is being drilled in a single step using a single drilling tool whereas in incremental or multi-step drilling the diameter is increased gradually starting from the minimum to the final diameter using a series of drilling tools. Eriksson[44] has described a single step technique while Branemark[46] and others[15,18-20,47,48] have recommended an incremental enlargement of the osteotomy site. Branemark's[46] hypothesis on the incremental drilling sequence was that each drill bit gradually enlarges the osteotomy site, which would dissipate heat better than a one-stage drill sequence. In a later study, Eriksson also found that the incremental drilling is better at reducing heat production compared to single drilling.[18]

Intermittent versus continuous drilling: Drilling into bone involves the use of irrigation, either internal or external, to reduce the heat generated. Because of the intimate contact present at the bone-drill interface, the irrigation solution has to reduce the temperature throughout the whole length of the bony walls. This mechanism could not be achieved unless the bur or drill was intermittently removed to allow the escape of bone chips and access for the irrigation fluid.[37] Whenever continuous drilling is performed, temperature will rise not only because of the inaccessibility of coolant, but also because of the clogging effect of the bone debris on the cutting edge of the drill, which will decrease its cutting efficiency and consequently increase the time required for the bone bed preparation.[10,18,47,49] In addition, it is suggested the clinicians should inter-

rupt the drilling procedure, while saline is applied to the bone. The interruption will dramatically decrease the bone temperature. Even while proceeding to next size drill in the osteotomy before allowing the bone to return to baseline temperature may eventually heat up the bone more than 10° C (47° C when baseline is body temperature). This is most important in the dense bone types.

DRILL DESIGN

The drills usually follow the morphological and the topographic skeleton of the implant. In general, twist drills and taps are used to prepare sites for screw-shaped implants, whereas fluted drills are used to prepare sites for cylindrical implants.[50] Cordioli and Majzoub compared twisted and fluted drills for heat generation and found fluted drills increase less temperature than twisted drills.[18,51] But screw implants are used more than cylindrical and fluted drills can't be used for screw implants as it will decrease primary stability so twisted drills are more in use. Twisted drills with relief angle at cutting sides[52] and point angle at apex[53] are more efficient and produce less heat than twisted drill without relief angle. Among flute geometry, the four flute drill has been considered to reduce frictional heat, although Kay et al. recommended that 3 is the maximum number of flutes that could withstand use without technical problems.[50]

Drill Material and its Coating

Most of available drills are made in stainless steel alloys however they are available with coatings also to increase cutting efficiency and to reduce wear rate (e.g. Stainless steel coated with titanium nitride). Recently oxide Zirconia based ceramic drills (80% Zirconia oxide and 20% alumina oxide) have also been studied and found that they show more hardness with less wear compared to stainless steel so have better cutting efficiency and induce less heat but further studies under different conditions are still needed.[40,54-56]

Drill Diameter

Larger diameter drills produce less heat than smaller diameter, even the time required for the temperature to return to baseline is also less.[2,10,51] Amount of bone removed by smaller diameter is less so needs more time for same osteotomy when compared with larger diameter. Therefore, time of drilling is more critical than the diameter of the drill. Correct orientation and depth of pilot drill is key to minimize temperature rise during complete osteotomy procedure.[10]

Drilling Depth

More deep drilling increases temperature rises due to increase in cutting surface area along with less irrigation at the inaccessible apical extent of the drill and also because of the clogging effect of the bone cuttings.[2,8,50] Such cases are highly indicated for intermittent drilling with adequate intervals and copious irrigation.

Irrigation Systems

Implant systems have begun to use irrigation systems with coolants for heat dissipation during osteotomy for implant placement. There are two types of cooling system: internal and external. If one does not use any coolant, then the critical bone temperature is always exceeded so irrigation is a key factor in implant osteotomy.[10] Kirschner and Meyer[9] introduced internally cooled drills to dentistry, later Huhule[57] con-

cluded several advantages of internal irrigation over external like; it prevents clogging of the drill twists/flutes by bone chips thus increasing its efficacy regardless of the depth of the cavity and causes more heat dissipation.[9,58-60] Haider et al. found external cooling better in superficial cutting whereas internal more efficient in deep drilling so he recommended that additional of external cooling along with internal system, particularly in compact bone, seemed most beneficial.[8] The low temperature (4° C) irrigation solution is better than room temperature solution.[61,62] Normal saline or distilled water can be used as irrigation solution;[51] however air-water coolant mixture should not be used as chances of air embolism formation are there.[63,64]

Miscellaneous Factors

The temperature produced also depends on many factors like density and the texture of the bone, age of the patient etc. Bone usually varies in density from person to person, bone to bone in the skeleton, and from site to site in the same bone. Compact or dense bone has less body fluid (blood, lymph, tissue fluid) for heat absorption and requires more drilling time as it poses more friction for cutting so all these factors result in more raise in local temperature.[5,10,65] Similarly, drilling in healing socket or extraction socket during immediate implant placement requires less cutting and less time so resulting in less heat production compared to healed socket.[66-69] Even bony structures in older patients tend to become denser and more fragile; the medullary cavity space enlarges faster thus resulting in a net decrease of cortical thickness and mass and also healing capability is usually impaired.[70-72]

Alternative Methods to Drilling

Ridge split technique (Pneumatic chisel and osteotome),[73-75] bone-condensing technique,[76] Er:YAG laser,[77] piezoelectric surgery,[77] peizotome;78 however ultrasonic implant site preparation is more time consuming and generates higher bone temperatures than conventional drilling.[79] These techniques are not common among clinicians due to lack of long term studies to support their reliability and superiority over conventional drill osteotomy.

CONCLUSION

Even after following all guidelines we can't totally avoid rise in temperature in osteotomy site, we can only minimize it to below critical level. According to a theory, a smaller devitalized zone next to implant surface would be beneficial in immediate loading as implants are loaded before bone remodeling is complete and this devital zone will be replaced by healthy bone during remodeling process.[84] If future implants have the ability of bone regeneration around their surface then there will be no or very less failures; till then success rate is relying on repair/healing process which is dictated by various guidelines for all determinant procedures used during implant placement, restoration and maintenance.

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Disclosure

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