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Case Report

Implant-Supported Removable Partial Denture: An Approach to Rehabilitate Maxillary Kennedy Class I

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ABSTRACT

Patients with maxillary Kennedy Class I are frequent visitors to the dental office, the missing of posterior teeth makes the control of the movement of removable partial dentures difficult due to the axis of rotation and the different resiliencies between the supporting structures. The use of implants in association to the conventional metal frame denture provides favorable long-term stability and retention, good clinical outcomes in terms of occurrence of complications and maintenance. In this clinical case, a patient with a maxillary Kennedy Class I was rehabilitated using a 3 implants to support metallic removable partial denture. A three dimensional (3D) surgical guide was used for the well-placement of the strategic implants and ball attachments were tightened as connectors between implant and denture. The patient was satisfied after 4-years of follow-up and reported good occlusal stability, esthetic and functional satisfaction.

Keywords
Dental implant; Distal extension removable partial denture; Kennedy Class I; Attachment denture.

INTRODUCTION

The different resiliencies between the supporting structures of a distal extension removable partial denture (RPD) can lead to horizontal and vertical forces that may have adverse effects during functional and para functional activities.[1] The continue resorption of the underlying residual alveolar ridges affect the retention, support and stability which induce changes in the occlusal condition, leading to overload of the anterior teeth.[2]

However, the most difficult problem to solve would be the anterior retention induced by the low periodontal value of the incisors as well as the visibility of the vestibular arm of the clasp, which is unsightly in the anterior region.[3]

Thanks to implantology, it is possible to improve the performance and the biomechanical behavior of the free end saddle. Placingim plant in well-studied sites prevents bone resorption, increase the retention and the stability of the RPD, reduce the stress and the number of retainer on the anterior teeth, in addition to be more comfortable and more accepted by patients.[4]

Kuboki et al[5] evaluated the impact of implants on the quality of life of three groups of patients with distal extension edentulous ridge, rehabilitated with a fixed prosthesis on implants, acrylic removable partial dentures and without rehabilitation. They have shown that the quality of life was better for patients rehabilitated with the fixed prosthesis compared to patients rehabilitated with RPD, which was the same as for those without any rehabilitation.

According to this study, the advent of dental implants made possible to substitute the missing teeth with fixed implant-supported dentures as the first choice treatment to overcome inconveniences of RPD. However, this indication may not be suitable for all patients due to financial, anatomical or systemic health conditions. Nevertheless it is possible to improve free extension RPD by using fewer implants, especially in the posterior edentu-

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lous ridge to achieve biological, biomechanical, physiological and social benefits.

In fact, various clinical studies reported the benefits of implant-supported partial dentures as anchors to promote greater retention, stability and comfort.

The current clinical case describes and discusses a new approach toward the rehabilitation of Kennedy Class I with combination between implant and metal cast RPD.

CASE REPORT

A healthy 53-year-old woman came to the Department of Prosthodontics with aesthetic and functional chief complaint. Oral examination showed fair oral hygiene, maxillary Kennedy Class1 with large extent, and a unilateral partially edentulous mandibular arch (Figures 1 and 2).

Figure 1. *Left and Right Lateral View of the Intial Condation*

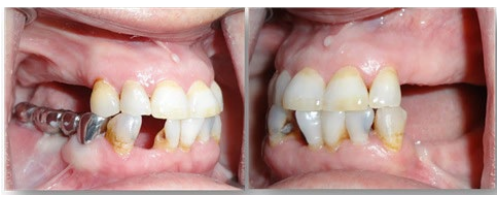
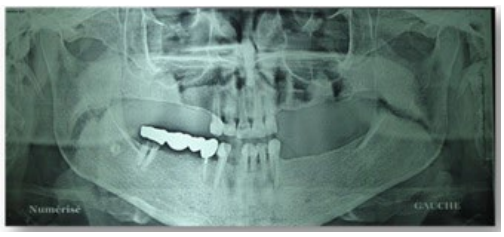
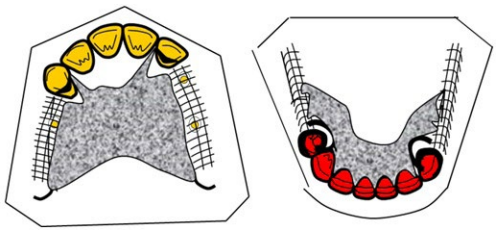


Figure 2. *Pretreatment Panoramic Radiograph*



In order to rehabilitate the maxillary arch, three treatment options were discussed with the patient, but for financial constraints, she chose removable partial denture retained by three implants. The prosthetic project is materialized by a prospective outline of the metal frame (Figure 3).

Figure 3. *Prospective Outline of the Metal Frame RPD*



- For the maxillary: a metal frame RPD associated to 3 strategic implants
- For the mandible: a metal frame associated to a metal-ceramic bridge

This layout which was dictated by the design principles to ensure the balance of the RPD, guided the position of the implants.

For the maxillary arch: a metal frame RPD associated to 3 strategic implants:

- An implant placed at the anterior level in place of the canine to eliminate the vestibular arm of the clasp;
- 2 implants on either side of the edentulous ridge as posteriorly as possible to improve the overall retention of the frame;

For the mandible: a metal frame associated to a metal-ceramic crowns.

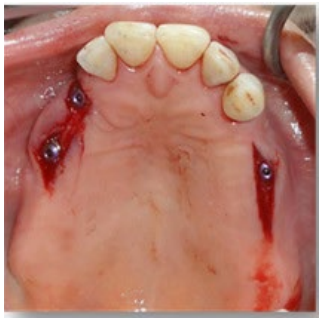
To fulfill this prosthetic project, the diagnostic wax was made to anticipate the final rehabilitation with the integration of soft and hard tissue. It was be as a reference for the realization of the provisional prosthesis and an interim acrylic resin partial denture.

After validation of this rehabilitation concept, a radiographic guide was performed, allowing the treatment to take place. A cone beam computed tomography (CBCT) was used to determine the alveolar ridge bone quantity and quality and an approximation of the implant site with the anatomic structures, as well as to plan implant angulation.

This radiographic treatment planning was transferred to surgical guide *via* three dimensional (3D) printing for proper positioning of implants.

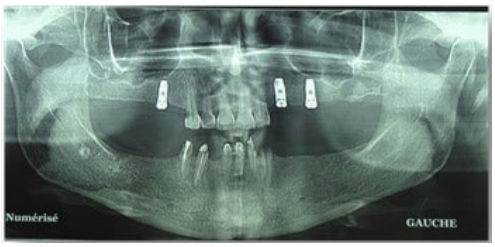
Three implants (Easy System Implant, Chavanod, France), 3.7 mm in diameter and 11.5 mm in length, were performed in the Department of Oral Surgery using a submerged surgical procedure (Figure 4). One implant was placed in the maxillar left canine region to eliminate the vestibular arm and to resolve the problem of the low value of anterior retention. The others two implants were placed symmetrically in the right and left second premolar regions because of the low quantity of bone posteriorly as shown in Figure 5.

Figure 4. *Occlusal View of Implant Positions*



- The implants in the region of the second premolar reduce the extent of the edentulous ridge.
- The implant in the region of 23 provides anterior retention and minimizes the lever effect on the lateral incisor

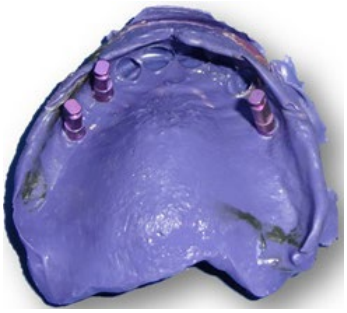
Figure 5. *Panoramic Radiograph after 6-Months of Placement*



Six months after placement of the implants, the healing abutments were placed. In this period, the selection of the proper ball abutment was done based on the prosthetic platform of the implant and tissue thickness. The abutment collar or shoulder was 1 mm higher than the tissue height to prevent soft tissue impingement at time of seating.

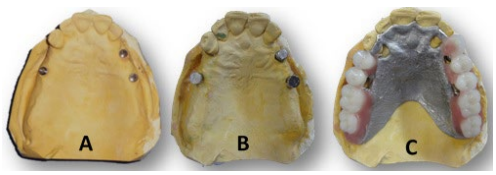
A selective-pressure impression procedure was made 2 weeks after placing the healing abutments using a custom acrylic trays and low-viscosity polyether (3M ESPE Pentamix) (Figure 6).

Figure 6. *Final Impression Done with Custom Acrylic Trays and Low-Viscosity Polyether*



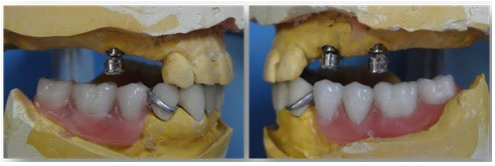
The maxillary metal framework was prepared with holes in the saddle to avoid coverage of the ball attachment, and allow the capture of the o-ring by acrylic resin (Figure 7). The maxillary master cast with three attachments analogues, were mounted on a semi adjustable articulator, using a facebow and a centric relation record, allowing the assessment of the vertical prosthetic space in relation to the opposing teeth and consequently tooth arrangement (Figure 8).

Figure 7. *Laboratory Steps for the Evaluation of the Space Between the Attachment Housing and the Artificial Teeth*



***A**: the ball attachment in place, **B**: Positioning the metallic cap, **C**: the metallic RPD with artificial teeth mounted in wax must completely seat over the plaster cast without contact with the attachment*

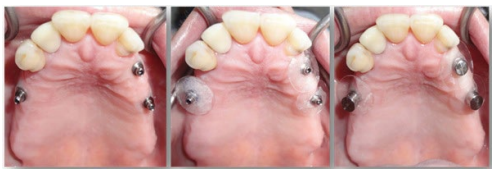
Figure 8. *Evaluation of the Vertical Prosthetic Space: It Should be More Than 11 mm for the Ball Attachment*



After the clinical validation of the artificial teeth in wax, heat curing acrylic resin was processed in the laboratory.

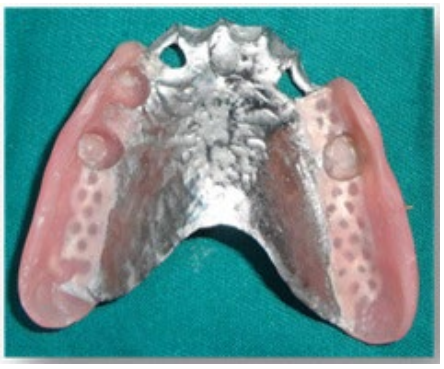
After the occlusal adjustments, the ball attachments were tightened at a torque of 30 N according to the manufacturer's recommendation (Figure 9).

Figure 9. *Clinical Steps for the Positioning of the Ball Attachment System*



Recesses were prepared in the acrylic resin to accommodate space for the attachment housings. A minimum of 2.5 mm of space between the denture and metal cap was arranged for the chemical relining resin (Figure 10). A contact between denture and the cap can lead to excess pressure on the implant.

Figure 10. *Recesses Preparation*



A plastic disc was positioned over the ballabutment between the male and female parts to block out any undercuts beneath the metallic cap (Figure 9).

A permanent self-curing acrylic resin (DuraBase) was ap-

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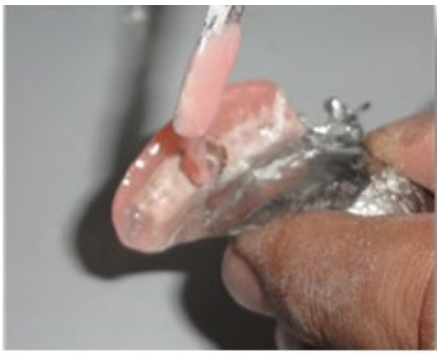
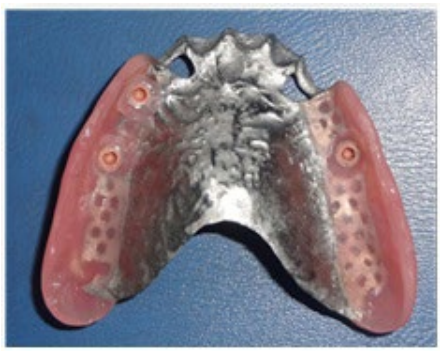
plied in the head of metal cap and inside the recesses. During the denture material set, the patient was guided into occlusion. In fact, the denture should be held in the maximum intercuspal position without compressing the soft tissue (Figure 11).

Figure 11. *Application of the Permanent Self-Curing Acrylic Resin*



After complete curing of acrylic resin, the denture was removed. Voids were filled and excess were removed from around the housings (Figure 12).

Figure 12. *The Finished RPD after Capturing the 3 O-Ring*



The patient was instructed about the proper insertion and removal, and hygiene maintenance of the metal frame RPD.

The patient was recalled for check up every 1 to 3-months, she reported satisfaction about retention, esthetic and masticatory efficiency. No maintenance required except the nylon retainer became worn after 1-year and were replaced by a more retentive one.

DISCUSSION

The patient described in this report presented an extensive partial maxillary edentulisum arch bordered by the right canine and the left lateral incisor.

Removable partial denture (RPD) and implant-supported fixed dental prosthesis are the most common therapeutic options for this situation.

Common clinical problems about distal extension RPD are lack of retention and stability and unaesthetic appearance because of the clasps.

Since this kind of prosthesis is sustained both by hard and soft tissues, the difficulty comes from the differences in the supporting tissues behavior, compromising the support and stability of the denture. The residual ridge tissue yields more under compression than the periodontal ligament of the supporting teeth does.[1] Thus, long-term use of an RPD is associated with poor adaptation of retainers, occlusal disharmony, pain, periodontal problems and resorption.[2]

As for implant-supported fixed dental prosthesis, they are considered as the best prosthetic treatment due to their stability, aesthetics and capacity of preserving the periodontal tissues of the remaining teeth and the alveolar ridge bone. Despite these advantages, this kind of prosthesis cannot be applied to all patients because of high cost, limitations of oral structures or compromised systemic health.

In this clinical report, a sufficient number of implants were not available to support fixed prostheses due to the lack of maxillary bone and financial constraints.

In this regard, implant-supported removable partial denture (ISRPD) has been proposed as an alternative treatment option, which allows additional support and retention with a few implants.

Many clinical reports[6-8] and clinical studies evidenced by *in vivo*[3,4] and *in vitro*[9-11] have shown the advantages of the removable denture on the implant over the conventional RPD in term of stability, retention, esthetics and satisfaction of patients. This suggests that strategic implant placement associated to removable partial denture should be considered as an efficient treatment option especially for patients with free end and extensive edentulism.

In this clinical case, 3 implants were used to provide additional posterior and anterior retention in maxillary Kennedy Class1 with large extent with only remaining 4 incisors and the right canine.

This proposed implant in the region of the left canine have many advantages: reduce overload on the abutment teeth, especially for the left incisors, improve their periodontal health, improvement of the anterior retention,[12] removal of the anesthetic metal clasps and transform this maxillary arch from asymmetric to symmetric Kennedy Class I.

Two implants should be placed at the posterior regions as far as possible but may necessitate sinus floor elevation and vertical ridge augmentation due to the lack of bone, which was refused by the patient. So the implants were placed at the regions of the second premolar to avoid specific technique with increased time and cost. Those implants serve as posterior anchors and increase the overall retention and stability of the metal cast RPD.[13]

A ball attachment system was used as a connector between implant and denture. Two parameters to be considered for the choice of the connection means: the vertical prosthetic space and parallelism between implants.[8,14] In this case the vertical space was more than 12 mm as shown in Figure 8, a lack of space could be solved by the use of a Locator system which might tolerate a very small vertical height between implant and the opposite tooth. A rigorous parallelism between implants and the path of insertion was retrieved thanks to the 3D surgical guide used in the placement of implants. A divergent implant from the pathway can be managed by the use of a bar connector.

The attachment ball system provide good long-term stability and retention, favorable clinical outcomes in terms of occurrence of complications and maintenance. Biomechanical studies show a long-term success rates for implant due to the resilience provided by the plastic retainer, which facilitate the stress distribution to the other structures and minimize the oblique forces applied on the implant.[14,15]

Association between implant and RPD has shown to be a reasonable treatment with acceptable functional and aesthetics results. Mitrani et al[16] evaluated during 4-years the satisfaction degree of 10 patients with Kennedy Class I and II, initially unsatisfied by their conventional RPD. Implants were associated to their preexisting metal cast and satisfaction was assessed using clinical, physical, and radiographic examinations of the oral cavity's tissues. In addition to the increase of satisfaction, they observed an improvement in physiologic function, minimal wear of attachment, no radiographic signs of excessive bone resorption, and healthy tissues surrounding implant.

Mijiritsky[17] described through a literature review the advantages of the removable partial denture on the implant, he stated psychological advantages for patients with extensive Class I who fear about total edentulism, easy maintenance and oral hygiene, lower cost, reduced number of office visits and easily convertible to fixed implant prosthesis.

However, the main disadvantage of this treatment is the lack of biomechanical and clinical outcomes with long follow-up periods for specific conditions.

CONCLUSION

Implant-retained removable partial dentureis considered as satisfactory treatment options for patients with extensive edentulous ridge, good biomechanics and aesthetics outcomes in a less invasive and economical way. A well-placed strategic implants associated to metal frame RPD could be in some cases more advantageous than fixed implant-supported restorations.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Case Report

Using PF-MOUTH GEL™ for Sore or Painful Tongue Improved Symptoms and Stabilized Dryness and Trapping of Food: A Case Report

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ABSTRACT

We describe herein the case of a 72-year-old woman with persistent and symptomatic sore or painful tongue (SPT) treated using PF-MOUTH GEL™ (PF-Gel; Daiichi-Sangyo, Osaka, Japan), which includes 30% fucoidan and 0.75% sword bean. PF-MOUTH GEL™ was applied to the tongue and kept in place for 3-min. Application was performed twice a day (morning and evening) for 3-months, and resulted in marked improvement of symptomatic sore or painful tongue. Because only one case was reported in this study, clinical trials are required to confirm the efficacy and safety of topical PF-MOUTH GEL™ for the treatment of symptomatic sore or painful tongue.

Keywords
Tongue; Fucoidan; Inflammation; Treatment; Gel.

INTRODUCTION

The clinical characteristics of sore or painful tongue (SPT) are well-defined and often involve atrophic glossitis, fissured tongue, median rhomboid glossitis, or burning tongue, although the precise etiology remains unclear or incomplete and definitive treatment has yet to be clarified. The diagnosis, clinical presentation and severity of symptomatic sore or painful tongue are key factors in selecting treatment. The objectives of treatment are controlling pain, suppressing the inflammatory response, and improving quality of life for the patient. Drug delivery represents a major challenge, because topical medications are easily rubbed or rinsed away from the target area through normal oral movements and salivary flow. The use of topical corticosteroid ointments for patients with symptomatic sore or painful tongue is expected to control the inflammatory process associated with the formation of symptomatic sore or painful tongue, but side effects such as burning, changes in taste perception and secondary oral candidiasis may be induced. Some effectiveness of corticosteroid ointment has been shown in the treatment of symptomatic sore or painful tongue, but has not been satisfactory. Furthermore, treatment for one month or more has been required to reduce symptoms.

Fucoidans are fucose-rich polymers that were identified in brown algae by Kylin in 1918.[1] Fucoidans have been reported to show bio-activities[2-4] such as anti-viral, anti-bacterial, anti-coagulant and anti-tumoral properties. Further, fucoidans have been used as supplements in cancer patients, and reportedly exert anti-inflammatory effects in patients with advanced cancer.[5] Although, many studies have attempted to determine the effective of fucoidans as medicines or cosmetics, few have examined effects on oral diseases.

In a previous case study, we reported that Power Fucoidan Cream (PFC; Daiichi Sangyo, Osaka, Japan) comprising 4%

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fucoidan isolated from Nemacystus decipiens, achieved marked improvement of recurrent aphthous stomatitis,[6] and oral herpes labialis.[7] We have also reported[8] that fucoidans showed anti-microbial activity against *Streptococcus mutans*, and significantly inhibited the adhesion of *S. mutans* to bovine teeth and porcelain. PF-MOUTH GEL™ (PF-Gel; Daiichi-Sangyo) includes 30% fucoidans and 0.75% sword bean (Figure 1), and has been developed to overcome weaknesses of of Power Fucoidan Cream™ such as difficulty retaining the cream on mucous membranes and a bitter taste. In this report, we describe a case of painful symptomatic sore or painful tongue that proved resistant to various medications. This case was successfully treated using topical application of PF-MOUTH GEL™ (Figure 1). This is the first report describing topical use of PF-MOUTH GEL™ on symptomatic sore or painful tongue.

CASE REPORT

A 72-year-old Japanese woman with painful symptomatic sore or painful tongue visited our clinic. At 58-years-old, she had been diagnosed with chronic illnesses such as hypertension and hyperlipoidemia, and subsequently developed symptomatic sore or painful tongue. Various medications including topical corticosteroid ointment (triamcinolone acetonide) and non-steroidal anti-inflammatory drugs had been attempted, but the lesions proved resistant to all treatments. Dermatological and clinical examination revealed fissured tongue, with deep grooves on the surface and annular white plaques on the middle part of the tongue (Figure 2), and the superficial mucosa of the tongue was red and uneven. The patient was constantly suffering from sores and pain on the tongue, making eating and drinking difficult. The clinical evaluation suggested that, it was not a purulent tongue inflammation. In addition, this case is not an infectious tongue lesion, as blood test values are stable during the clinical trial (Table 1).

After obtaining informed consent, PF-MOUTH GEL™ was applied to the tongue after tooth brushing and kept in place for 3-min. PF-MOUTH GEL™ was applied to the surface of the tongue with light force by the patient using her fingertips. Application was preformed twice a day, in the morning and evening (Figure 3A). Treatment was continued for 3-months. At 1-month after starting treatment, deep grooves were still visible on the surface of the tongue, but the number of grooves had decreased. The color tone of the tongue surface had improved from bright red to coral. Symptoms of soreness, pain, and trapping had slightly improved without any side effects (Figure 3B, Table 1) and no exacerbation of any symptoms. After 3-months, deep grooves in the tongue surface were further decreased (Figure 3C, 3D; Table 1).

Follow-ups at 4-months (Figure 3E, Table 1), 5-months

Figure 1. *PF-MOUTH GEL™*

Figure 2. *Application of PF-MOUTH GEL™ to the Patient's Tongue (Before status)*

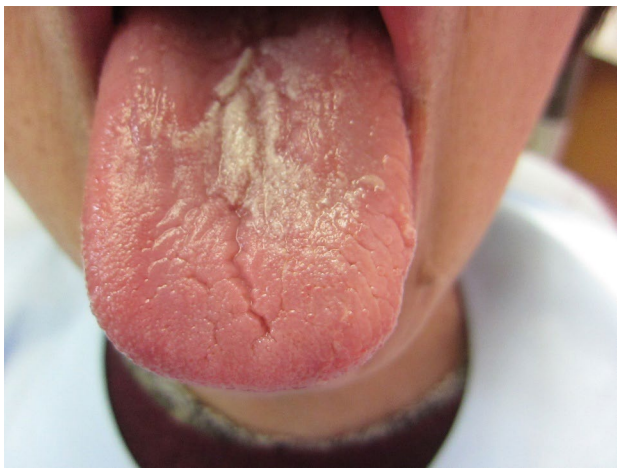

Table 1. *Distribution of the WBC, Hb, Ht, HDL, LDL and T-G*

	WBC(10^2/μL)	Hb (g/dL)	Ht (%)	HDL (mg/dL)	LDL (mg/dL)	T-G (mg/dL)
Before treatment	69	14.0	41.6	75	105	83
After 1-month	69	14.0	41.6	75	105	83
2-months	59	14.1	43.4	74	127	100
3-months	65	14.0	42.2	73	125	100
4-months	62	14.6	44.1	76	120	103
5-months	67	13.8	43.3	68	109	102
6-months	62	14.2	45.3	71	113	113
12-months	71	13.6	42.3	62	108	109

WBC-White blood cell 35~91102/μL; Hb-Hemoglobin 11.3~15.2 g/dL; Ht-Hematocrit 33.4~44.9%; HDL-High-density-lipoprotein cholesterol 40-96 mg/dL; LDL-Low- density-lipoprotein cholesterol 70-139 mg/dL; TG-Triglyceride 35-149 mg/dL

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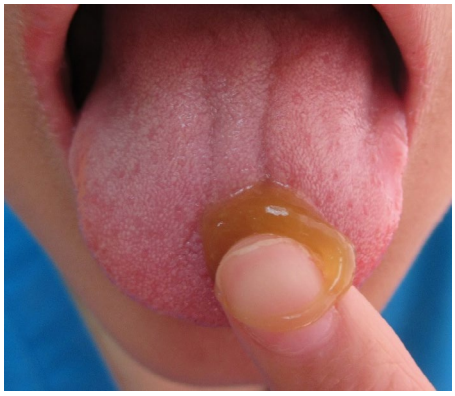
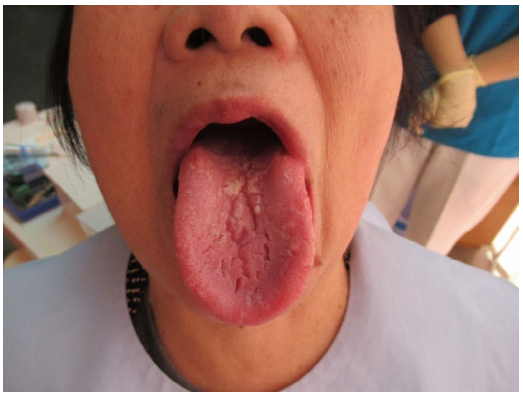
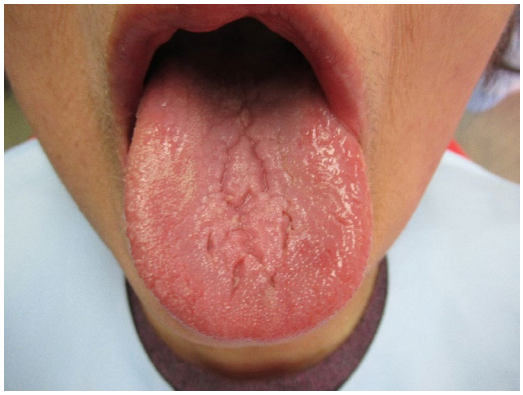
Figure 3



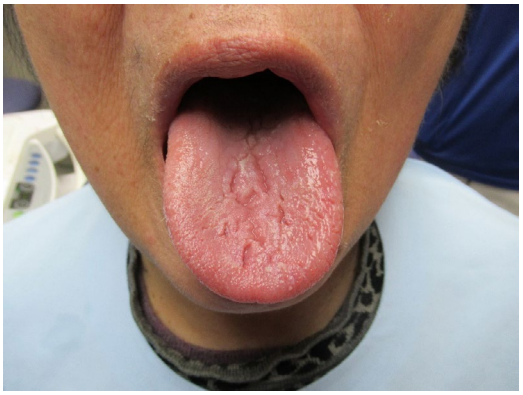
3A. *Applying PF-MOUTH GEL™ (Subject Different from the Case)*



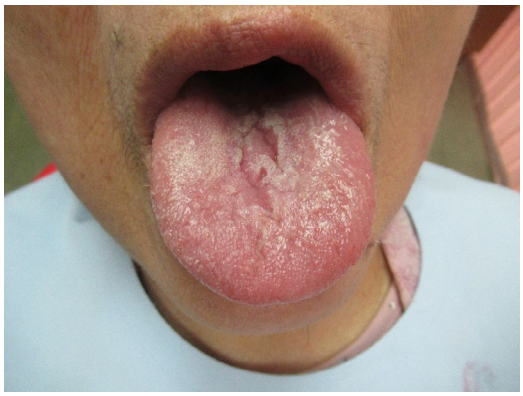
3B. *1-month later*



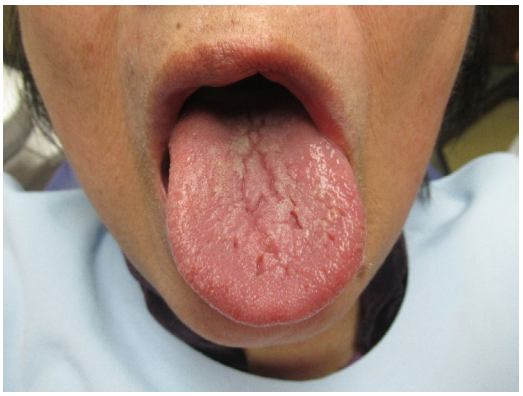
3C. *2-months later*



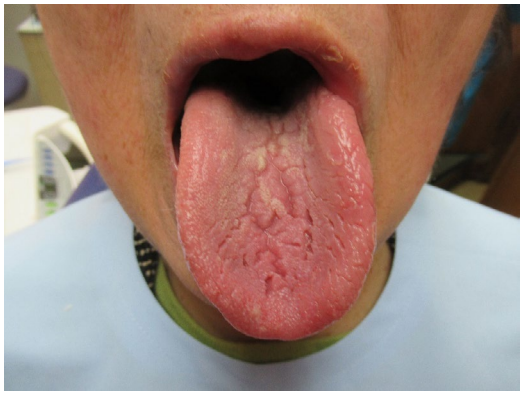
3D. *3-months later*



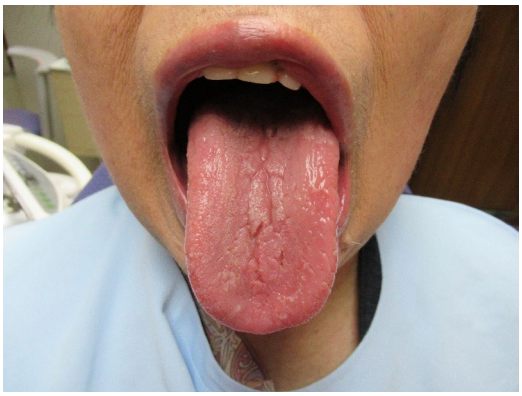
3E. *4-months later*



3F. *5-months later*



3G. *6-months later*



3H. *12-months later*

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Table 2. *Distribution of Tongue Symptoms by Self-Scores*

	BT	1-month	2-month	3-month	4-month	5-month	6-month	12-month
Soreness	1	2	2	3	3	3	3	3
Pain	1	2	3	3	3	3	3	3
Malodor	1	1	2	2	2	2	2	2
Dryness	1	1	1	2	2	2	2	2
Trapping	1	2	3	3	3	3	3	3

BT: before treatment; 1m: 1 month after starting treatment; 3: Excellent; 2: Good; 1: Not good

(Figure 3F, Table 1), 6-months (Figure 3G, Table 1), and 12-months (Figure 3H, Table 1) revealed no esthetic or clinical problems. Deep grooves on the tongue surface and annular white plaques had decreased. As of the last follow-up, tongue symptoms had almost completely resolved. No systemic effects of PF-MOUTH GEL™ during daily life were identified (Table 2).

DISCUSSION

Symptomatic sore or painful tongue is a mucous inflammatory condition of unknown etiology. Typical clinical conditions in symptomatic sore or painful tongue include atrophic glossitis, fissured tongue, and burning tongue. The patient in this case complained of highly painful lesions and trouble with food intake for several years. Tongue problems included a variety of signs and symptoms, such as soreness or pain, color changes, and changes in taste perception. Diagnosis of tongue abnormalities requires examination of tongue morphology, thorough elicitation of a detailed history, symptom durations and intra-oral lifestyle habits, such as use of tobacco products or intake of alcoholic beverages. The 1988-1994 National Health and Nutrition Examination Survey described the prevalence of tongue lesions as 15.5% among adults in the United States. The most common abnormal condition of the tongue is geographic tongue, followed by fissured tongue and hairy tongue.[9] Our patient was instructed to dab PF-MOUTH GEL™ on the affected areas of the slightly dried tongue to keep the gel in place for 3-min, and to avoid eating or drinking for 30-min after application. PF-MOUTH GEL™ contains 30% fucoidan and 0.75% sword bean extract, along with propylene glycol (PG), glycerin, polyethylene glycol 8 (PEG-8), xylitol, xanthan gum and water. The fucoidan is extracted from *N. decipiens* from Tonga and sword bean grown in Japan.

In this case, we diagnosed the tongue condition as fissured tongue or burning tongue based on clinical circumstantial evidence, although biopsy was not performed. Siddhanta and Murthy[10] reported that fucoidan showed anti-tumoral and anti-inflammatory effects, and Aisa et al[11] found that fucoidan exhibits anti-cancer effects, such as against human lymphoma HS-Sultan cells. According to such activities, fucoidan appears to have pharmaceutical potential in various applications, such as for anti-viral medication and cancer therapy.

Various medications have been applied for symptomatic sore or painful tongue, but consistent good results have remained elusive. In the previous, we have experienced significant cases using Power Fucoidan Cream™ on the lip mucosa.[6,7] However, it was considered that the Power Fucoidan Cream™ was not optimal for the surface layer of the tongue due to insufficient viscosity. We therefore decided to apply PF-MOUTH GEL™. During applications of PF-MOUTH GEL™, the patient experienced no side effects and did not complain of stinging. The most dramatic effect was the rapidity of healing for sore and painful lesions. Such activity may occur *via* the inhibition of enzymes including matrix metalloproteinases, hyaluronidases and elastases.[12]

This report is the first to describe topical use of PF-MOUTH GEL™ for symptomatic sore or painful tongue, and further studies are required to determine the effectiveness and safety of topical PF-MOUTH GEL™ for symptomatic sore or painful tongue.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this work. S. Tsubura designed the study and interpreted the results. M. Kanazawa, S. Oka, R. Hirama and T. Tsubura collected test data and drafted the manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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Comparative Study of the Antimicrobial Activity of Clove Oil and Clove Extract on Oral Pathogens

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ABSTRACT

Objective
The main objective of the present study was to do the comparative study of clove oil and clove extract on the oral micro-biota causing dental caries and also to assess the antifungal activity.

Materials and Methods
The antimicrobial activity of clove oil and clove extract was assessed against *Halobacterium sp.*, *Lactobacillus sp.*, *Pseudomonas sp.*, *Micrococcus sp.* and *Streptococcus mutans* (major causative bacteria of dental plaque) by the paper disc diffusion method. For each extract three replicate trials were conducted against each organism. The antifungal activity of clove oil and extract was also assessed against seven fungal species (*Aspergillus niger*, *A. fumigatus*, *Aspergillus sp.*, *Alternaria sp.*, *Rhizomucor sp.*, *Rhizopus sp.* and *Penicillium sp.*) by agar disc diffusion method.

Results
Both clove oil and clove extract was found to exhibit broad spectrum of antibacterial activity inhibiting all the ten test bacterial species involved in dental caries. Clove oil produced maximum inhibition zone of diameter (IZD) against themajor causative bacteria of dental plaque as compared to clove extract, thereby, showing that clove oil possesses strong bactericidal activity against oral pathogens. The highest inhibition zone of diameter was observed by clove oil as compared to clove extract against the test fungal species

Conclusion
The clove oil has the potential to be used as a natural antibacterial agent for oral pathogens.

Keywords
Syzygiumaromaticum; Clove extract; Clove oil; Antimicrobial; Oral pathogens.

INTRODUCTION

Dental caries, a chronic disease is unique among humans and is one of the most common important global oral health problems in the world today. Dental caries is caused due to the destruction of dental hard acellular tissue by acidic by-products from the bacterial fermentation of dietary carbohydrates and sugars. It progresses slowly in most of the people which results from an ecological imbalance in the equilibrium between tooth minerals and oral biofilms. This is characterized by microbial activity, resulting in fluctuations in plaque pH due to bacterial acid production, buffering action from saliva and the surrounding tooth structure. The microbial community of caries is diverse and contains many facultative and obligate-anaerobic bacteria. *Streptococcus mutans* isan important etiologic agent in dental caries. Dental caries can affect the humans in various ways such as presence of tooth pain, infection or dysfunction of the stomatognathic system which can limit the necessary ingestion of energetic foods, affecting the growth in children and adults including their learning, communication skills and recreational activities.[1]

Gum disease involves bacterial growth and production of metabolic substances that gradually destroy the tissue surrounding and supporting the teeth. Oral cavity pathogens include *Streptococcus mutans, Streptococcus salivarius, Halobacterium sp.*, *Veilonella sp.* etc. These bacteria grow and attack the tissues causing gingivitis, char-

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acterized by inflamed gums that bleed easily. The causative bacteria reside in plaque, the deposit that forms on the base of the teeth and hardens to form tartar. Poor oral hygiene is the major cause of gum disease.[2] Lifestyle, nutrition and ageing affect the immune response and increase the risk of gum disease.

In the present study, we have compared the antimicrobial activity of clove oil and clove extract on oral microbiota. The major difference between the two is mainly in the method of their extraction. Clove oil is extracted using steam distillation method (Clevenger Apparatus in lab) while clove extract is obtained through decoctionby immersing in a suitable organic solvent or *via* super critical fluid extraction.

MATERIALS AND METHODS

All chemicals used were of analytical-reagent grade and obtained from E. Merck (Mumbai, India). Readymade clove buds and clove oil was purchased from local market of Meerut (Uttar Pradesh, India).

Bacterial Strains

Ten bacterial strains 6 Gram positive (*Streptococcus mutans*, *Streptococcus salivarius*, *Lactobacillus spp*., *Bacillus spp*., *Micrococcus spp*., *Staphylococcus aureus*) and 4 Gram negative (*Halobacterium spp*., *Veilonella spp*., *Pseudomonas aeruginosa*, *Pseudomonas spp*.,) bacterial species that were commonly involved in dental caries were selected for the study. The bacterial stock cultures were obtained from the culture collection unit of Department of Microbiology, C.C.S University, Meerut, India. The stock on nutrient agar medium (Hi Media, Mumbai, India) was incubated for 24 h at 37 °C following refrigeration storage at 4°C until required for sensitivity testing.

Determination of Antibacterial Activity

Antimicrobial activity of the essential oil of clove and its extract was evaluated by the paper disc diffusion method.[3] Paper discs impregnated with 50 µL of a solution of 10mg/mL of chlorhexidine (positive control) as standard antimicrobials for dental caries were used for comparison. Sterile dimethyl sulfoxide (DMSO) served as negative control. Antimicrobial activity was determined by measurement of zone of inhibition around each paper disc. For each extract three replicate trials were conducted against each organism.

Determination of Antifungal Activity

The antifungal activity of clove oil and extract was determined by the method of Gupta et al[4] and Fiori et al[5] with minor modifications.

RESULTS

Table 1 shows the antimicrobial activity of clove oil and clove extract on the indigenous oral microbiota that cause dental caries. Both the clove oil and its extract were effective against both Gram positive and Gram negative bacteria.

However, the clove oil was more effective as compared to clove extract against all the test bacterial species. The highest inhibition zone was produced against *Halobacterium spp*. and *Lactobacillus spp*. with an IZD of 19.0 mm each. The second highest inhibition zone was produced against *Pseudomonas spp*. with an IZD of 18.0 followed by *Micrococcus spp*., *Streptococcus mutans*, *Staphylococcus aureus* and *Veilonella spp*. with an IZD of 17.0, 17.0, 16.0 and 15.0 mm respectively. The clove extract produced an IZD of 15.0 mm against *Streptococcus mutans*. Chlorhexidine, on the other hand was lesseffective producing an inhibition zone of diameter 13 mm. Amongst the Gram negative bacteria, the cloveoil showed highest activity against *Pseudomona sspp*. with an IZD of 18.0 mm while clove extract producedan IZD of 16.0 mm against *Pseudomonas spp*.

Table 2 shows the antifungal activity of clove oil and clove extract on the food spoilage fungi. Though both the clove oil and its extract inhibited all the tested fungi but clove oil again showed much better antagonistic activity than its extract counterpart. The oil produced the widest IZD against Aspergillus niger with an IZD of 42 mm followed by activity against Rhizopussp. and *Penicillium sp*. with an IZD of 40 mm each respectively. The

Table 1. *Comparison in Inhibition Zone Diameter (IZD) (mm) by Clove Oil and Clove Extract on Indigenous Oral Microbiota on Mueller-Hinton Agar Medium at 37 °C for 24 h;Volume of Oil in each Well=50 µL)*

S. No.	Bacteria	Clove Oil (mm)	Clove Extract (mm)	Chlorhexidine (+ve C) (mm)	DMSO
1.	*Bacillus sp.*	14.0	13.0	12.0	Nil
2.	*Halobacterium sp.*	19.0	15.0	14.0	Nil
3.	*Lactobacillus sp.*	19.0	14.0	15.0	Nil
4.	*Micrococcus sp.*	17.0	15.0	15.0	Nil
5.	*Pseudomonas aeruginosa*	15.0	14.0	13.0	Nil
6.	*Pseudomonas sp.*	18.0	16.0	15.0	Nil
7.	*Staphylococcus aureus*	16.0	13.0	14.0	Nil
8.	*Streptococcus mutans*	17.0	15.0	13.0	Nil
9.	*Streptococcus salivarius*	9.0	0.0	8.0	Nil
10.	*Veilonella sp.*	15.0	13.0	12.0	Nil

Table 2. *Comparison in Zones of Inhibition (mm) by Clove Ail and Clove Extract on Food Spoilage Fungi on Mueller-Hinton Agar Medium at 37 °C for 24 h;Volume of Oil in each Well=50 µL)*

S. No.	Fungus	Clove Oil (mm)	Clove Extract (mm)	Sodium Propionate (+ve C)	DMSO (-ve C)
1.	*Aspergillus niger*	42.0	27.0	25.0	Nil
2.	*Aspergillus fumigatus*	30.0	20.0	19.0	Nil
3.	*Aspergillus sp.*	36.0	21.0	20.0	Nil
4.	*Alternaria sp.*	28.0	30.0	22.0	Nil
5.	*Rhizomucor sp.*	35.0	26.0	21.0	Nil
6.	*Rhizopus sp.*	40.0	29.0	25.0	Nil
7.	*Penicillium sp.*	40.0	22.0	18.0	Nil

clove extract produced widest inhibition zone against *Alternaria sp*. followed by *Rhizopus sp*. The commonly used antibiotic chloramphenicol was used as positive control in the antifungal assay.

DISCUSSION

From this investigation, it was observed that both clove oil and its extractare active against both groups of bacteria (oral pathogens) and fungi though clove oilwas proved to be more effective than its extract counterpart.

Syzygiumaromaticum (Family-Myrtaceae) contains many compounds such as eugenol which is considered as one of essential component of clove oil and is known to possess antimicrobial activity against many pathogens. The other chemical constituents are eugenol acetate 4- allyl-2-methoxyphnol acetate β-caryophyllene; trans – (1R, 9S)-8-methylene-4, 11, 11-, bicycloundec-4-ene trimethylbicycloundec-4-ene, and 60-90% of another secondary compounds.[6]

Clove oil is one of the essential oil commonly used in seasoning of food. Antimicrobial activity is mainly attributable to eugenol, oleic acid and lipids present in it. In a similar study using oil extracts on dental caries causing microorganisms and found the zones of inhibition produced by these oil extracts ranged from of 14.7 mm to 33.7 mm which were comparable to the present study.[7]

The high-levels of eugenol contained in clove essential oil are responsible for its strong biological and antimicrobial activities. It is well known that both eugenol and clove essential oil phenolic compounds can denature proteins and react with cell membrane phospholipids changing their permeability and inhibiting a great number of Gram-negative and Gram-positive bacteria as well as different types of yeast.[6,8]

The otherbioactive compounds present in clove are kaempferol and vanilic acid.[9] Chemically, the major bioactive constituents in clove belong to the group of secondary metabolites such as tannins, alkaloids and phenols, which are responsible for their antimicrobial[10] and antifungal activity.[9,11]

Due to medicinal properties of *S. aromaticum*, it is used in drugs for gums and toothache.[12] The oil of *S. aromaticum* has inhibitory activity against bacteria, fungi and insect repellent[13] and it is also used as an analgesic and a natural antiseptic in dentistry to reduce dental pain.[14]

CONCLUSION

In conclusion,clove oil was found to be a much better antagonistic agent, exhibiting broad range of antimicrobial activity against the microbes causing dental caries than clove extract and chlorhexidine. The antifungal effect of clove oil was also found to be more promising as compared to clove extract. Hence, it represents an alternative source of natural antimicrobial substances for use in chemotherapeutic agents.

Thus, clove oil has the potential to be used in oral dentifrices, mouthwashes, topical gels etc. However, future research efforts are needed for the evaluation of quality and efficacy of the plant products for their regular use in the oral hygiene products. It must be converted to viable form for daily use in toothpastes and mouth rinses. Further studies on the safety and efficacy of such products must be carried out to establish whether they offer therapeutic benefits, either alone or in combination with conventional therapies that can help to reduce the overall burden of oral diseases worldwide.

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INSTITUTIONAL REVIEW BOARD (IRB)

None.

ETHICAL ISSUES

There is none to be declared.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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A Clinical Paradigm and Pertinent Literature Review for Placing Short Implants

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ABSTRACT

Placing an implant to replace missing teeth can be challenging because of lack of vertical and/or horizontal bone ridge, maxillary sinus pneumatization and inferior alveolar nerve position. Additional surgical procedures may be necessary, with varying predictability, where vertical augmentation being the least predictable. An alternative option is to place short implants and exclude the additional surgical grafting procedures. By reviewing studies, this paper explores the predictability of the short implants for use in the methods. Bicon SHORT® implants are available in 5 and 6 mm lengths and seem to be able to overcome such limits but more long-term studies are still needed to determine long-term prognosis and success of short implants in terms of them being comparable or equal to longer or standard length implants.

Keywords
Short implants; Bone augmentation; Ridge height; Implant length; Implant width.

INTRODUCTION

Patients lose their teeth for various reasons such as caries, periodontal disease or trauma. When patients are missing a tooth/teeth, they have several options for replacement, such as removable dentures, fixed prostheses and endosteal implants. Which option is best for the patient depends on several factors such as oral anatomy, esthetics and finances. Implants are often appealing to patients because of their ability to closely mimic a natural tooth in terms of appearance and function. However, placing an implant can be challenging because of bone ridge height and/or width, maxillary sinus pneumatization and position of the inferior alveolar nerve, and these may require additional surgical procedures such as maxillary sinus membrane elevation, and bone graft, distraction osteogenesis, guided bone regeneration, onlay bone graft and displacement of the inferior alveolar nerve. With these procedures, there can be additional complications such as infection, sinus membrane perforation, flap dehiscence and post-operative pain.[1] The predictability of success of these procedures is also variable. Vertical bone grafting is the most unpredictable[2] since the patient after the procedure still may not have gained enough bone height to position a standard-size implant.[3] An alternative option is to place a short implant, which may exclude the need for the aforementioned surgical procedures. One such study by Scarano et al[4] showed no complications and predictable rehabilitation of the atrophic posterior mandible with short implants.[4] The purpose of this paper is to explore the predictability of the placement of short implants to replace missing teeth.

MATERIALS AND METHODS

Papers were chosen from those published between 2012 through 2021. Studies needed to include placement of short implants. Additional criteria could include comparison to standard length implants, a range of prosthesis and placement in grafted bone sites.

Studies

Al-Johanny et al[5] tried to propose an implant design based classification system classifying for implant design, length and diameter of implants to try to standardize terminology in the scientific literature. In an attempt to propose a classification scheme, they looked at 1) clinical studies, 2) intervention studies based on implant length and/or diameter, 3) studies that clearly stated the measurements and names of their implants and 4) studies based on the implant systems of some manufacturers which are listed in Table

1. Based on the terms used most frequently, they made a classification with Extra-narrow, Narrow, Standard and Wide in regards to implant diameters and Extra-short, Short, Standard and Long in regards to the implant length as listed in Table 2. The diameter was defined as the width of the implant at the neck area regardless of the diameter of the platform. The length was defined as the measure from the end (base) to the neck of the implant regardless of the length of the platform. The main advantage to this classification is to allow for standardization in communication and research and allows comparisons of study results and methodologies. Limitation of this study is that it was difficult to create a systematic approach to answer the question (replacement of missing teeth) and that animal (*in vitro* studies are far from the aim to set a predictable success rate of short implants compared with the standard length ones, so it's better not to include *in vitro* studies) studies were not included and therefore other implants may also have been overlooked. The authors advice this classification for future studies.

Table 1. *Implant Systems*[5]

• Straumann (Andover, MA, USA)
• Astra Tech (Mölndal, Sweden)
• Nobel Biocare (Kloten, Switzerland)
• XiVE (Mannheim, Germany)
• OsteoCare (Berkshire, UK)
• Camlog (Basel, Switzerland)
• Zimmer (Carlsbad, CA, USA)
• 3MESPE (3M,St.Paul,MN, USA)
• ANKYLOS (Mölndal,Sweden)
• Bicon (Boston, MA, USA)
• BioHorizon (Birmingham, AL, USA)
• IntraLock (Boca Raton, FL,USA)
• MIS (Vienna, Austria)
• BIOMET3i (Carlsbad,CA,USA)

Table 2. *Implant Classification*[5]

Measurements
• Diameter
o Extra-narrow: <3 mm
o Narrow: ≥3 mm-<3.75 mm
o Standard: ≥3.75 mm–<5 mm
o Wide: ≥5 mm
• Length
o Extrashort: ≤6 mm
o Short: >6 mm-<10 mm
o Standard: ≥10 mm-<13 mm
o Long: ≥13 mm

While there are multiple definitions for which length an implant is qualified as a short implant, for this paper it has been defined as less than 8 mm. Benefits of a short implant are a less invasiveness/more simplicity, shorter surgical time and lower morbidity rates and cost.[6] However, short implants are often associated with high failures rates because of a smaller bone to implant contact and disadvantage in the crown to implant ratio. Studies have been conducted comparing the *in vivo* placement of short implants to the placement of standard length implants with additional surgical grafting procedures.

Jain et al[7] summarized biomechanical considerations broken into 3 categories: 1) diagnostic, 2) surgical and 3) prosthetic. These three categories are further broken down (Table 3). They also included Nisand et al[8] guidelines for placement of short implants and additional surgical procedures based on bone height, bone quality and risk factors, such as smoking, age and periodontal disease. A resorbed mandible of any bone quality with a ridge height <8 mm will need advanced surgical procedures, while a resorbed mandible of any bone qualities with a ridge height ≥8 mm, can receive short implants. For the resorbed maxilla, they recommend a sinus lift procedure where the ridge height is <5 mm and in type IV bone where the ridge height is 5-6 mm. They recommend short implants where the ridge height is ≥6 mm in any bone qualities and where the ridge is 5-6 mm in bone type I, II, III bone. The above mentioned guidelines are applicable in ridges which are wide

Table 3. *Biomechanical Considerations*[7]

1. Diagnostic
a. Implant diameter–wider implant will increase the primary stability and functional surface area at the crest bone level.
b. Crown/implant ratio–improvements of surfaces and implant systems allow high crown/implant ratio.
c. Bone quality–primary factor for short implant success.
d. Lack of cantilevers–eliminating cantilevers favors biomechanics.
e. Number of implants–multiple implants will increase functional surface area.
f. Implant design–surface area can be increase by:
i. Thread number–more
ii. Thread depth–deeper
iii. Thread shape–square has higher bone implant contact
iv. Implant surface–rough microtopography
2. Surgical
a. Two step–advocated for short implants because it provides good stability during healing phase.
b. Adapted surgical protocol–possibly eliminated steps in standard surgical protocol such as countersink or final drill.
3. Prosthetic
a. Implant to abutment connection–morse taper connection induces less marginal bone loss, internal hex implant abutment connection shows wider force distribution and platform switching maintains crest bone.
b. Occlusal table–small table reduces offset loads on implant.
c. Incisal guidance–should be similar to natural teeth.
d. Splinting–increase functional surface area or support and transmits less force to prosthesis.

enough to place an implant of at least 5 mm in diameter. Their indications for short implants supported prostheses whether fixed or removable were as follows:

1. Single and multiple fixed prosthesis in posterior jaw (mandible).
2. Four short implants for an overdenture or 6 short implants for a fixed prosthesis in the severely resorbed edentulous mandible.
3. Two short distal to longer implants placed in the premaxilla for a maxillary overdenture or fixed prosthesis.

Their conclusions were: short implants can be successful when the biomechanical factors and clinical protocols are taken into account in the pre-operative planning of intervention and prosthesis.

Goncalves et al[9] developed a standard evaluation protocol based on their systematic review of essential parameters required to access the long-term clinical performance of short and extra short implants. Their proposed protocol includes both surgical and prosthetic parameters of the patient and implant, both surgical and prosthetic (Table 4). It is advocated that it will help regiment further investigations and help in the decision making process.

Thoma et al[10] in a narrative review created a decision tree for treatment in the posterior maxilla and mandible based on several parameters such as scientific evidence, operator surgical skill and experience and patient's preference. For the posterior maxilla they recommend the following choice as based on the residual vertical bone height: 1)) in case of 6-8 mm of bone, short dental implant and 2)) in case of >8 mm of bone , standard length implant with transcrestal sinus floor membrane elevation. For the posterior mandible based on vertical bone height: 1) in case of 10 mm, standard-length implant. They feel that short dental implants have a number of advantages for the patient and clinician.

A Short Implant System

A number of studies summarized in Table 5 find that short implants are a favorable option, especially in sites where an additional surgery may be needed to augment the bone prior to placing a standard length implant. However, they also agree that more studies need to be conducted and more long-term results are needed.

Bicon implant system[32] has challenged the concept that short implants are reserved for situations when there is a limited amount of available bone height. Bicon SHORT® implants are short dental implants in 5 mm and 6 mm height. They have a bacterially-sealed, 1.5 degree locking taper abutment to implant

Table 4. *Patient and Implant Parameters*[9]

1. Biological parameters a. Plaque index b. Bleeding index c. Probing depth d. Pain	5. Prosthetic protocols a. Location b. Distance between implants c. Type of prosthesis d. Type of abutments e. Splinted f. Prosthesis material g. Cemented or screwed h. Platform switching i. Cantilever length j. Occlusion
2. Observation a. Parafunction b. Smoking habits c. Diabetes d. Alcoholism e. Osteoporosis f. Radiotherapy in head/neck	6. Radiographic parameters a. Anatomical crown length b. Implant length c. Crown height space d. Resorption e. Bone gain
3. Implant parameters a. Brand b. Length c. Diameter d. Surface treatment e. Shape f. Abutment connection	7. Additional parameters (integrity of prosthesis) a. Major failures: i. Fracture of bridge ii. Fracture of implant iii. Infection iv. Implant mobility or removal v. Before loading vi. After loading b. Minor failures i. Fracture of retention screw ii. Fracture of esthetic veneering iii. Decementation
4. Surgical parameters a. Bone level b. Location c. Bone density d. Insertion torque e. Loading protocol f. Primary stability g. Healing cap (submerged or transmucosal) h. Special surgical technique (mini sinus lift, split crest) i. Biomaterial	

Table 5. *Summary of Studies*

Reference	No. of patients	Grouping	Survival Rates and *p* value
Stellingsma et al[11]	60 edentulous patients total, each group 20 patients	Group 1-transmandibular implant (base plate, 4 implant posts (8, 10 or 12 mm length) and 5 cortical screws) Group 2-4 IMZ apical screws (lengths 13,15 or 18 mm) implants in augmented bone Group 3-4 short (length 8 or 11 mm) Twin Plus IMZ implants	**Cumulative 10 year implant survival rate:** Group 1=76.3%; Group 2=88%; Group 3=98.8% Between Groups 1 and 2- logrank test, p=0.068, not sig Groups 2 and 3–logrank test, p=0.009, sig; Groups 1 and 3–logrank test, p=0.0001, sig **Ten year retreatment rate:** Group 1=30%; Group 2=5%; Group 3=0% Between Groups 1 and 2 and Groups 1 and 3–logrank test, p=0.007, sig Groups 2 and 3–logrank test, p=0.317, not sig
Felice et al[12]	60 partially edentulous patients, each group 30 patients	Short–1 to 3 submerged 6.6 mm long implants Long–1 to 3 submerged 9.6 mm or longer implants in vertically augmented bone 61 total inserted implants (long) and 60 total inserted implants (short)	**Up to 5-years after loading:** Long (n=25): prosthesis failures (patients)=5(5); Implant failures (patients)=5(4);Augmentation procedures=2 Complications (patients)=25(21); Short (n=27): prosthesis failures (patients)=5(5); Implant failures (patients)=5(3) Complications (patients)=6(6) ***p* value:** prosthesis failures=1.00; Implant failures=1.00; Complications <0.0001 Both groups had statistically significant marginal peri-implant bone loss at loading, 1, 3 and 5-years after loading (p<0.001)
Rossi et al[13]	45 patients	60 moderately rough surface implants 30 implants (6 mm long, 4.1 mm diameter)–test 30 implants (10 mm long, 4.1 mm diameter)–control	**Survival rates after 5-years:** 86.7% test; 96.7% control Radiographic bone levels around implants **Median value:** At time of surgery 1.8 mm test; 2.08 mm control; p<0.05 At 5 year follow-up 2.23 mm test; 2.70 mm control; p<0.05
Fan et al[14]	60 patients	**554 implants:** 265 implants, 24 patients in short implant group 289 implants, 36 patients in long implant group	Survival rate p=0.96, not significant Complication rate p=0.02, significant, short group had lower complications compared to long group Surgical time p<0.05, significant, shorter time for short group
Lemos et al[15]	Total of 1269 patients who received a total of 2631 dental implants	1650 standard implants 981 short implants	Implant survival p=0.24, not sig Marginal bone loss p=0.06 not sig Complications p=0.08, not sig Prosthesis failures p=0.92, not sig
Bechara et al[16]	33 patients-short implant (6 mm) group 20 patients-sinus floor elevation (lateral technique)/standard length implant (≥10 mm) group	45 implants inserted in each group	IImplant survival rate at 3 years=100% short, 95% standard p=0.38, not sig Mean ISQ (implant stability quotient) **Values:** At placement=68.2 short, 67.8 standard, p=0.1 At delivery of final restoration=69.5 short, 69.4 standard, p=0.9 After 1-year=71.0 short, 71.5 standard, p=0.1 At 3-years=71.6 short, 72.4 standard, p=0.004, sig **Mean MBL (marginal bone loss):** At 1-year=0.14 mm short, 0.21 standard, p=0.006, sig At 3-years=0.20 mm short, 0.27 standard, p=0.01, sig Surgical time and cost significantly higher in standard group, p<0.0001
Pohl et al[17]	101 patients with partial edentulism in the posterior maxilla and remaining bone height of 5-7 mm	137 implants placed Group short–6 mm length implants, 50 patients, 67 implants Group long-11-15 mm length implants and simultaneous sinus grafting, 51 patients, 70 implants	33 year follow-up – 94 patients with 129 implants Group short–45 patients, 61 implants Group long–49 patients, 68 implants Implant survival rate 100% in both groups Marginal bone level (MBL) changes -0.44 mm short, 0.45 long, p>0.05 MBL implant placement to 3 year follow-up p= 0.974: Group short=-0.44+/-0.56 mm, p=0.000 Group long=-0.43+/-0.58 mm, p=0.000 MBL implants loaded to 3 year follow-up, p=0.110: Group short=-0.1+/-0.54 mm, p=0.636 Group long=-0.25+/-0.58 mm, p=0.004 Probing pocket depth at 3 year follow-up–significantly less short group, p=0.035 **Plaque accumulation:** At 1 year follow-up, p=0.098; At 3 year follow-up, p=0.262 **Bleeding on probing:** At 1 year follow-up, higher number of sites short group, p=0.034 At 3 year follow-up, p=0.380
Esfahrood et al[18]	Review–24 papers out of 253 papers selected		Survival rate of short implants in the posterior edentulous maxilla is high and applying short implants under strict clinical protocols seems to be a safe and predictable technique

Bechara et al[19]	88 implants in 53 patients (33 women, 20 men)	45 implants inserted simultaneously with sinus grafting-control group 45 implants placed without grafting–test group	**ISQ (implant stability quotient):** Initial Sample=68; Control=66.8; Test=69.1; p=0.003 sig Notable increase over time Sample=1.8, p=0.001; Control=4.6, p=0.000 Test=3.2, p=0.000 Marginal bone level (MBL) changes In sample during first year of loading=0.18, p=0.017 Later changes=0.06, p=0.5 Significant difference between first year of loading and later, p=0.000 Significant strong negative correlation between MBL changes during 3-year loading period and implant's diameter, rho=-0.432, p=0.000
Pieri et al[20]	45 partially edentulous patients evaluated after 5-years	22 patients, 51 implants–augmentation group 23 patients, 46 implants–short group	8 surgical complication in augmentation group *vs* none in short group, p=0.003 1 short implant failed before loading and 1 standard length implant failed 4-years after, p=1 8 biological and 2 prosthetic complications in augmentation group *vs* 3 biological and 3 prosthetic complications in short group, p=0.09 and p=1.0, respectively **Mean marginal bone loss:** 1.61+/-1.12 mm augmentation group; 0.68 +/- 0.68 mm short group p=0.0002
Benatto et al[21]	**Case report** 1 patient with 2 failing zygomatic fixtures removed and replaced with 4 short implants	Straumann SLAactive: 4.1x4 mm (2) 4.8x6 mm (1) 3.3x8 mm (1)	Patient had remission of sinusitis episodes and no other signs or symptoms. The extra short implants had excellent stability
Svezia et al[3]	110 patients and 110 implants of 6 or 10 mm length placed Internal hex=60 Conical connection=50	Final group: 105 patients **105 implants:** 6 mm=58 10 mm=47	Success rate after 24-months similar between groups=98.3% (6 mm) *vs* 100% (10 mm), p=0.361 Success rate after 2-years similar between internal hex *vs* conical connection=100% *vs* 97.7%, p=0.233 Statistically significant loss marginal peri-implant bone in both groups=0.38 mm (6 mm) *vs* 0.43 mm (10 mm), p=465 At 24-months, loss marginal peri-implant bone internal hex vs conical connection, p=428; Operator, p=0.875
Cruz et al[6]	11 trials, 420 patients	911 dental implants	Survival rate, p=0.86 Amount of marginal bone loss, p=0.08 Higher rates of bio complications for long implants associated with maxillary sinus aug, p<0.00001 Higher prosthetic complication rate for short implants, p=0.010
Palacios et al[1]		458 short implants, 488 regular implants	Implant failure rate, p>0.05 Mean differences of marginal bone loss, at loading p=0.18 Mean differences of marginal bone loss at 1-year follow-up, significant in short group, p=0.002
Rossi et al[22]	35 consecutive patients	Forty 6 mm modified sandblasted large-grit acid-etched (mod-SLA), soft tissue level implants were installed in the distal segments of 35 consecutive patients	The marginal bone level variation from prosthesis delivering and 10-year follow-up ranged from -2.2 to 0.8 mm. The mean bone loss for implants between the prosthesis delivery and the 2-, 5-, and 10-year follow-up period were -0.4 mm, -0.7 mm, and -0.8 mm, respectively. Statistically significant differences were found between prosthesis delivering and all periods (p<0.001) evaluated as well as between 2 and 5-years (p=0.013) and 5-10-years (p<0.001) Bone level changes in mm (yearly visits) Prosthesis delivery—2 years=-0.4 (0.5) Prosthesis delivery—5 years=-0.7 (0.6) Prosthesis delivery—5 years=-0.6 (0.6) Prosthesis delivery—10 years=-0.8 (0.7) 5 years—10 years=-0.2 (0.4) p<0.05 between prosthesis delivery and the yearly visits.
Papaspyridakos et al[23]	637 short implants placed in 392 patients 653 standard implants were inserted in 383 patients	Short implants ≤6 mm Standard implants >6 mm	Implant survival rate with a follow-up from 1 to 5-years Short implant survival rate ranged from 86.7% to 100%, Standard implant survival rate ranged from 95% to 100% The risk ratio (RR) for short implant failure compared to standard implants was 1.29 (95% CI: 0.67, 2.50, p=0.45) The heterogeneity test did not reach statistical significance (p=0.67) The prosthesis survival rates short implant groups ranged from 90% to 100% longer implant groups ranged from 95% to 100%

Anitua et al[24]	50 patients	75 implants=30 in maxilla, 45 in mandible	Five dental implants failed giving a survival rate of 93.3%. All failures occurred in the mandible giving it a survival rate of 88.9%. All failed implants showed an excessive marginal bone loss (>2 mm).The difference in the survival rate between the mandible and maxilla was not statistically significant (p=0.063) There was a statistically significant difference in the number of implants to which the short implant was splinted to. The implants in the mandible were mostly splinted to one implant whereas in the maxilla they were splinted to 2 implants. p=0.000
Anitua et al[25]	**Two groups were identified:** Short-short splinted group (SS), when both implants had 6.5 mm lengths Short-long splinted group (SL), when one implant was longer than 6.5 mm.	A total of 48 dental implants were placed in 16 patients to support 24 two-implant fixed prostheses	Follow-up (months) 14±5 **6.5-mm-long implant:** Mesial bone loss (mm) 0.21±0.42 (SS); 0.51±0.88 (SL); p=0.949 Distal bone loss (mm) 0.37±0.55 (SS); 0.62±0.74 (SL); p=0.417 **Splinting implant:** Mesial bone loss (mm) 0.47±0.58 (SS); 0.36±0.67 (SL); p=0.688 Distal bone loss (mm) 0.37±0.55 (SS); 0.94±0.66 (SL); p=0.049 There were no statistically significant differences between the two groups regarding implant diameters of the extra-short (6.5 mm long) implants, p=0.255. The diameter of the splinted implant was not statistically significant between the two groups, p=0.365 Significant differences regarding the lengths of the splinted implants, p<0.0001
Shi et al[26]	225 patients 225 implants	3 groups with 75 implants each Group 1-6 mm implants alone Group 2-8 mm implants+osteotome sinus floor elevation (OSFE) Group 3-10 mm implants+OSFE	Implant survival rates Group 1=96%; Groups 2 and 3=100% No significant differences in implant stability quotient (ISQ) values, bleeding on probing (BOP), pocket probing depth (PPD), modified plaque index (mPI) and marginal bone loss (MBL) were found among three groups. Significant higher value of intra-operative discomfort was found in group 6 mm (p=0.02).
Amato et al[27]	55 patients	Implants immediately placed and loaded 62 extra short implants (5 and 6 mm) 15 short implants (6.5 mm) 69 standard implants (≥10 mm)	Cumulative survival rates=99.3%; Standard=100% Extra short=98.4%; Short=100% Marginal bone loss (MBL) Extra short=0.35 +/- 0.24 mm, short=0.25+/-0.17 mm *vs* standard=0.92+/-0.26mm, p<0.05 Since extra short and short were platform switched, difference resulted in absence (1.36 mm+/-0.19 mm) and in presence (0.48+/-0.32 mm) of platform switching in standard length, p<0.05 No difference between implants inserted in healed bone, fresh extraction sockets or with crestal approach sinus floor elevation
Malchiodi et al[28]	41 patients	50 ultra short sintered porous surface (5×5 mm)	Overall success rate=94%; Upper=94.4%; Lower=92.9%; p>0.05 No significant correlations between peri-implant bone loss and qualitative and quantitative variables. p-values all>0.05 Qualitative variables-sex, diabetes, smoking habit, antagonist dentition, type of prosthesis (splint/no splint), site (upper/lower), site (upper premolar, upper molar, lower premolar, lower molar) Quantitative variables–age, follow-up, anatomical C/I ratio (crown/implant), clinical C/I ratio BL (bone level)
Gašperšič et al[29]	11 patients	In each patient, one 10 mm (n=11) and one or two ultra short 4 mm (n=17) implants One 4 mm implant failed to integrate All patients were restored with splinted metal-ceramic crowns connecting the 4 mm implant to the 10 mm implant	Median (range) implant stability quotient At time of insertion 4 mm-61(14-72); 10 mm-66 (52-78) After 6-months 4 mm-68 (51-79); 10 mm-78 (60-83); p<0.05 Median (range) clinical crown/implant ratio 4 mm-2.79 (1-3.66); 10 mm-1.06 (0.85-1.46); p<0.05 Six-months after prosthesis rehabilitation, median (range) crestal bone loss 4 mm-0.3 mm (-0.7-1.7 mm); 10 mm-9.5 mm (-0.8-3.5 mm); p>0.05
Shi et al[30]	225 patients	225 implants with diameters of 4.1 and 4.8 mm and posterior maxillary residual bone height (RBH) 6-8 mm Group 1-6 mm implants alone Group 2-8 mm implants+osteotome sinus floor elevation (OSFE) Group 3-10 mm implants+OSFE) At the 3-year follow-up, 199 patients (Group 1: 67; Group 2: 62; Group 3: 70) were re-examined	**Implant survival rates:** 91.80% Group 1; 97.08% Group 2; 100.00% Group 3 Implant survival rate in Group 1 was significantly lower than that in Group 3 (p=0.029) A multivariate Cox model showed that the short-6-mm implants with wide diameter had a protective effect on implant survival (hazard ratio: 0.59, p=0.001) No significant differences in bleeding on probing (BOP%), probing pocket depth (PPD), modified plaque index(mPI), marginal bone loss (MBL) and complication-free survival rate were found among the three groups.

Pardo-Zamora et al[31]	74 patients	**99 implants:** short (7 or 8.5 mm); standard (10, 11.5, 13 or 15 mm) 47 short implants in 33 patients 52 standard implants in 41 patients Short 28 implants were placed in the maxilla 19 were placed in the mandible 44 (93.61%) of these were in the molar and premolar regions Standard implants 33 were placed in the maxilla 19 were placed in the mandible 24 in the anterior region (46.16%) 28 in the posterior region (53.84%)	12 month survival rate is 100% **ISQ measurements made:** on the implant placement (ISQ1); the prosthetic loading (ISQ2) at 12 months follow-up (ISQ3) Mean±SD Δ ISQ2-ISQ1 -0.745±2.192 (short); -0.057±2.796 (standard); p=0.316 Δ ISQ3-ISQ2 0.298±1.876 (short); 0.654±1.781(standard); p=0.336 p-value=0.014 (short), p=0.043 (standard) Marginal Bone Level (MBL) at mesial and distal in both implant groups on the day of surgery (MBL1); implant loading (MBL2) 12-months after loading (MBL3) Mean ±SD Δ MBL2-MBL1 -0.263±0.244 (short); -0.305±0.272 (standard); p=0.324 Δ MBL3-MBL2 -0.184±0.191 (short); -0.412±0.588 (standard); p=0.004 p-value=0.009 (short), p=0.889 (standard) There was no correlation between the increase in ISQ and bone loss/gain in relation to the implants, regardless of their length. A slightly positive correlation was found between the Δ MBL2-MBL1 and Δ MBL2-MBL3 values in the short implants (0.664, p=0.00000037). No correlation was found between the increase in ISQ and bone loss/gain in relation to the implants, regardless of their diameter. A weak correlation in wide diameter implants between Δ ISQ1-ISQ2 and Δ ISQ2-ISQ3 values (cc: 0.539, p=0.000194) and Δ MBL1-MBL2 and Δ MBL2-MBL3 values (cc: 0.467; p=0.0016)

connection and a sub-crestal positioning, sloping shouldered implant with a flattened tapered root form body. They claim that their plateau or fin design offers at least 30% more surface area that other implants of similar size. The 5 or 6 mm implant provides five threads in the bone that is adequate to retain the implant and handle the occlusal forces despite a crown to implant ratio greater than 1:1. The use of short implants allows for a less invasive surgical procedure and less post-operative complications. The placement can be also performed flapless. The osteotomy required for the 5 mm is about 6.5 mm in depth to allow for 1.5 mm sub-crestal placement this can be done with very slow drilling at 40 rpms and no irrigation. This also minimizes the surgical trauma to the site. Although the Bicon implant has threads, it is press fit into the site. It does not require a high-level of primary stability as is needed with screw fit implants. The platform switch design allows for the implant allows for the crestal stability needed with short implants.

The short implant can become the implant of choice regardless of the bone volume and restorative plan.[33] This concept of a shorter implant length will allow for less surgically invasive implant placement in all situations including those requiring vertical sinus augmentation.

Urdaneta et al[34] performed a retrospective cohort study to evaluate 5 mm length implants where the same patients received at least one 5 mm wide hydroxyapatite coated Bicon implant. They found that the survival of ultrashort (5 or 6 mm length) implants were comparable to short (8 mm length) implants over an average of 20-months. These short implants can also be used in guided implant surgery.[35]

DISCUSSION

Many implant companies are now incorporating short implants (8 mm or less) into their product line. Four mm length implants are actually available only from few brands. There is a demand by practitioners and patients for less invasive procedures and a reasonable predictability which seems to have a promising trend. The increased use of short implants in clinical practice will lead to improved surgical techniques and implant designs. The restoration using short implants will increase in number with the awareness that the crown-to-implant ratio does not need to be 1:1 for long term success. Short implants can be used instead of 10 mm implants in areas of adequate bone height with the aim to avoid major bone grafting procedures.

In the randomized clinical trial of Naenni et al[36] a comparison between Straumann 6 mm tissue level implants to same brand 10 mm tissue level implants in non-grafted bone areas over a 5 year period resulted that the 6 mm ones had a 91% survival rate compared to 100% of the 10 mm implants. The authors concluded that the use of 6 mm single implants are a reasonable alternative to implants of standard length because of a minor difference in survival rate. To complement, Scarano et al[4] analysed 63 short implants placed inpremolar and molar region of the posterior mandible. All short implants were splinted to at least one other implant. The short implants were machine collared and characterized by 2 portions implant screw and transmucosal collar tissue level, connected to a titanium abutment by a chemical cement seal. The short implants had a survival rate of 98.5% as compared to 97.4% for standard implants. There was no statistical difference of bone loss between the short and standard implants (p=0.1). They concluded that short implants can be used to predictably restore the posterior mandible and avoid the additional surgical procedures in resorbed sites when splinted to a standard implant or another short implant.

CONCLUSION

Clinicians should have short implants as an option for patients. Patients who cannot receive a standard sized implant may be a candidate for a short implant. Short implants may allow patients

with unfavorable sites to receive a functional implant without additional surgeries that can lead to complications. However, while this may be a viable option, clinicians should be aware that more studies are needed to determine long-term prognosis and predictability of success of short implants and how they compare to standard sized implants. Additional studies should compare short implants to zygomatic implants, should compare different jaw sites (mandible *vs.* maxilla, anterior *vs* posterior) and compare single unit *vs.* multi-unit prosthesis with short implants. But as more short implants are being placed, there will be more long-term (more than 5-years) data to evaluate short implants and their function.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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