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Journal of Prosthodontics and Implantology

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Editorial

Experience has forged lessons of self-improvement, wisdom, and expectations for prosthodontists. Furthermore, strength in faith and determination has led to tremendous growth over 30 years.

As the founding member, it is my honor to serve as a committee member and dedicate myself to the Academy.

There are no short cuts to success. It is a direct result of preparation, hard work, and lessons learned from failure. A reflection of the past helps one to understand the present.

In this volume, we reflect on two original studies and two case studies.

Case reports serve to increase judgment through experience. In place of studies such, the experiences provide the basis to amass measures for further dental practices.

As the aforementioned articles are worth reading, it gives me great pleasure to share this issue with you. We are also pleased to share with you additional information of importance. As of March 2020, all JPI articles with registered DOI can now be found online at the Airiti Library.

Lastly, it is with great appreciation to all participants that I say, we look forward to additional distinct articles for the benefit of all prosthodontists.

Hsiu-Na Lin
Editor-in-Chief

The Academy of Prosthetic Dentistry R.O.C., Taiwan

Overview

Concept of occlusion for dental restoration and occlusal rehabilitation - an overview

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Abstract

Restoring defects on teeth is a daily practice of a dental practitioner. However, the proper restoration of the destructed occlusal surfaces should not jeopardize the occlusal scheme that a patient already has. Therefore, the restored occlusal surfaces should be able to maintain the occlusal scheme that exsisted before the treatment. However, if the overall dentition is to be reconstructed due to loss of too many teeth, severe attrition or an improper jaw position, or the occlusal form of majority teeth of one jaw or both jaws needing to be changed, then an ideal occlusal form including point centric occlusion, canine guidance, posterior eccentric disclusion, etc. should be provided according to the demands of the patient and esthetic and functional expectations of the dentist. Computer-aided techniques for the construction of occlusal surfaces may enhance the production of said occlusal forms, yet properly applying the concepts for either dental restoration or occlusal rehabilitation remain the key to success.

Key words: dental restoration, occlusal rehabilitation, ideal occlusal form, computer-aided techniques

Introduction

The restoration of destructed teeth caused by dental caries or fractures of parts of the coronal dental structures is a common daily work of a dentist. The area to be restored is limited, such that, the occlusal scheme of the patient should be followed because otherwise the restored parts could become interferences during centric and eccentric inter-arch tooth contact. However, when many teeth of a patient are lost or when a wide area of dental occlusal surface could not be easily identified, or when the destruction of teeth due to excessive attrition has caused shortening of the dental-facial height, the restoration of individual teeth may be very difficult and of limited practical effect. In such cases, all of the occlusal surface and the missing teeth should be reconstructed. The occlusal scheme that a patient already has is often unstable and irreproducible, or even hazardous to the health of the masticatory system because of the acquired centric jaw position developed after long term use of the deteriorated dentition. Such centric position is different from the centric relation of the jaw with complete dentition[1]. Besides, the esthetic demands of such patients cannot easily be satisfied with small scale dental restorations.

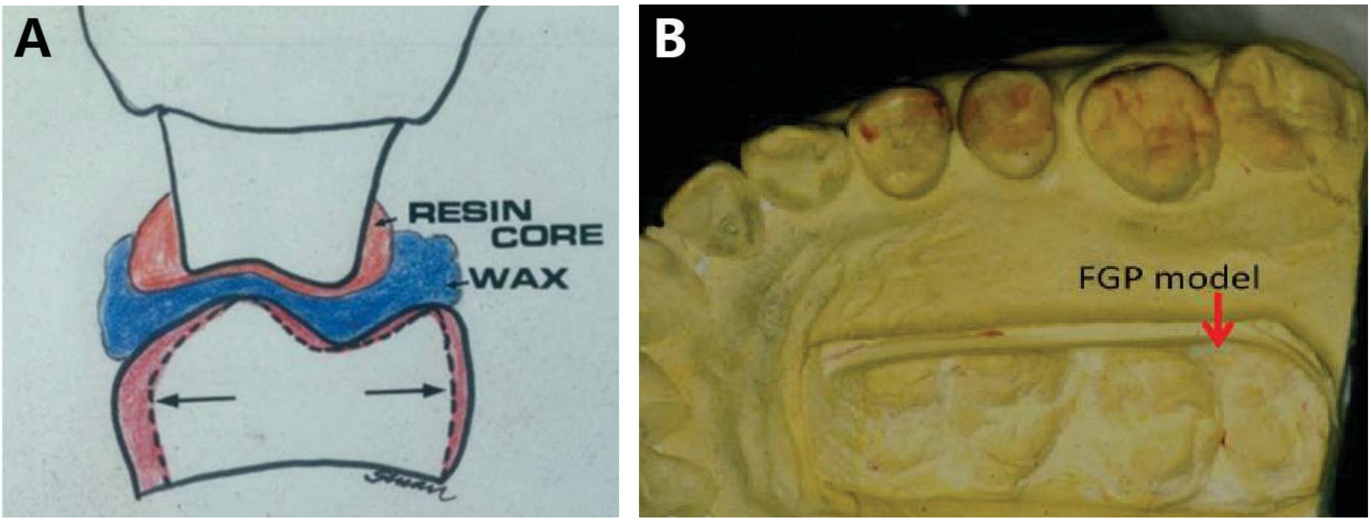

Figure 1. Applying functionally generated path technique for the formation of the antagonized models with wide fossa and lower cusps.
(A): Resin core on the prepared tooth and the bite wax on the occlusal surface for the formation of a functional model of the opposing teeth.
(B): Model of the opposing teeth formed with the functionally generated path technique. The model on top is the anatomical form of the opposing teeth.

1. Dental restoration:

By definition, dental restoration is the act of reforming the contours of teeth destroyed by lesions or injury[2]. Therefore, the vertical dimension of the teeth, relative position of the jaws, and facial height that the patient already has are not changed.

1-1. Restoration of dental occlusal defects with direct methods:

After the destructed parts of the tooth were removed, filling materials such as amalgam or composite resin are placed into the prepared cavity, and the patient is often asked to clench the teeth at centric and eccentric positions of the jaw. By doing so, the occlusal surface is formed before complete setting of the filling materials. The so called "Functionally Generated Path (FGP) Technique" is actually a direct method that can be used to obtain the occlusal form of a restoration, but the details of the restoration other than occlusal form, such as the contours and margins of a crown are formed on the dental models[3] (Fig.1). Additional adjustments of the occlusal surfaces of the restoration are often necessary to obtain an unhindered and smooth contact patterns with the opposing teeth. Restorations thus formed provide occlusal surfaces that meet the opposing teeth without centric and eccentric interferences.

1-2. Restoration of occlusal defects with indirect method:

When a restoration requires accurate proximal contact, proper contours and fitting margin, or when the restorative materials are metals or ceramics, direct methods become impractical and prone to be inaccurate, then the use of indirect method becomes necessary. Such restorations can be made only on the dental models with an articulator in a dental laboratory. The restorations are made outside the oral cavity and thus the occlusal form of the restorations is produced without the help of chew-in performance on the part of the patient. In addition to the factors that may cause inaccuracy in dental models such as dimensional changes in the impression materials and dental stones, the relative movement of an articulator's upper and lower members may not be the same as that of human jaws. Therefore the occlusal form of the restorations made in an articulator may not be able to mimic that of the patient when they are inserted in the mouth. Thus, accurately reproduce the relative position of the opposing dental arches and the path of jaw movement should be obtained first in order to ensure the success of indirect method restoration (Fig.2). Efforts aimed at accurately reproducing the centric and eccentric occlusal contact patterns on dental models in an articulator have been performed by many dental scientists and practitioners, especially those who are called gnathologists[4]. Many designs, techniques and instruments were developed for such purposes starting at the beginning of twenty century[5]. Sophisticated instruments and meticulous procedures were developed and advocated for dental restorations made using indirect methods (Fig. 3). Unfortunately, the accuracy and complete

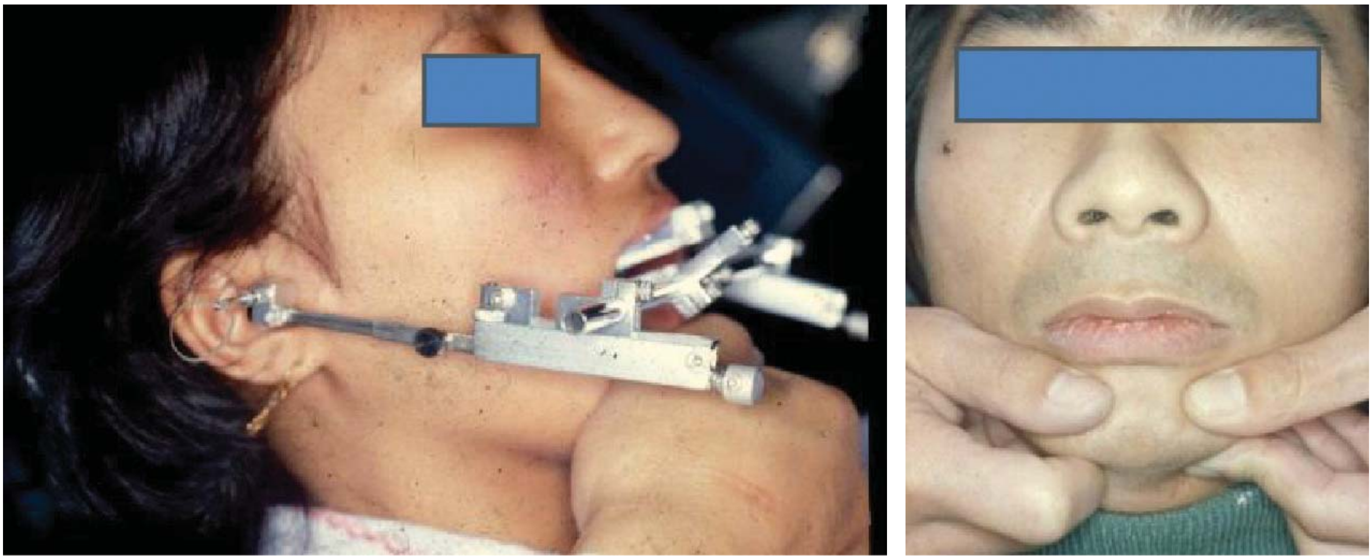

Figure 2. Centric position of the jaw may not always be reproducible with or without the manipulation of the operator.

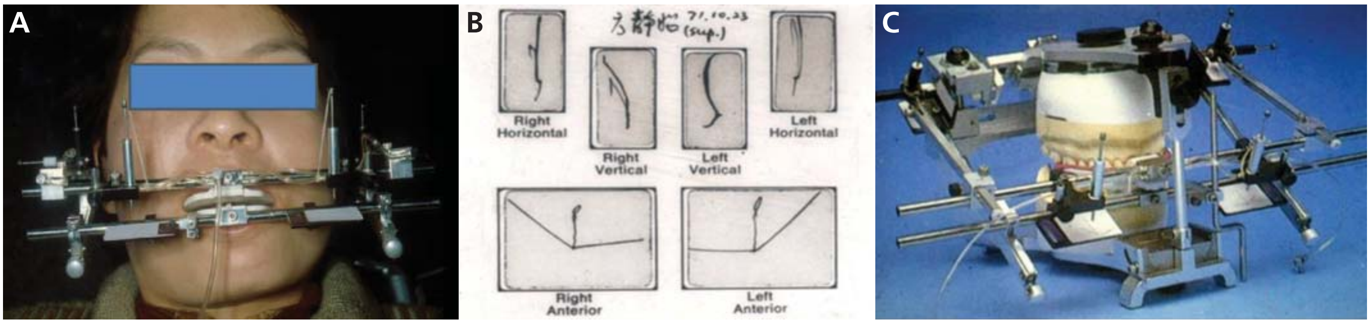

Figure 3. (A): Pantograph tracing for the mandibular border movement and
(B): The tracing records on six tracing tables.
(C): The tracing records are transferred to a fully adjustable articulator.

reproducibility of the jaw movements in an articulator has not been reported and validated. Minor or even gross adjustments of the restorations made on an articulator remains necessary, thus the efficacy of those efforts are not always appreciated.

The main reasons for such impractical efforts aimed at centric and eccentric jaw movement recording and transferring have been well discussed, and the inconsistency of the term "centric" and the movements of the jaw based on the concept of reproducible centric can be found only when the teeth are completely erupted and before evident wear after functional or parafunctional tooth contact (Fig.4). It is thus not easy, if not impossible, to record and transfer all the jaw positions of an adult to an articulator[5]. Therefore, the occlusal form of restorations made in an articulator might not always be consistent with the occlusal form required in the mouth.

Recent progress in the development of computer-based technology using virtual reality and virtual articulator ideas might help clinicians in producing reasonable contact relationship between upper and lower dental arches[6,7]. With such technology, the occlusal form of a crown is fabricated based on the image of the neighboring teeth and the calculation of the sites where the opposing teeth come into contact[8]. It seems that, such virtual articulator technique may reduce the efforts required for mechanical articulator transfer[9]. However, the underlying idea for such restorations still entails applying the FGP technique, and the requirements for intraoral adjustment of either the templates or the final restorations are not much less that would otherwise be expected. Nevertheless, computer aided dentistry holds considerable promise, and could become user-friendly in the near future.

1-3. The most frequently discussed occlusal interferences produced by using indirect methods for restoration:

a. Discrepancy between the centric relation tooth contact (CRC) and centric occlusal contact (CO) or

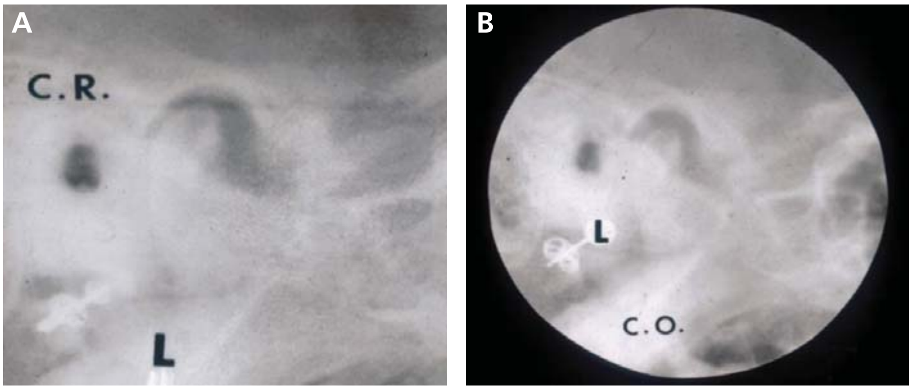

Figure 4.
These two X-ray images were taken from a single patient whose head position was fixed and the mandible was at the retruded (A) and non-retruded (B) jaw positions. Evident difference in condylar position can be seen.

Figure 5. Stone models of a patient at retruded centric occlusal contact (A), and at maximum interocclusal position (B). There is a difference of about 2 mm. This patient had a long history of dental restoration with many amalgam fillings on the posterior teeth (C).

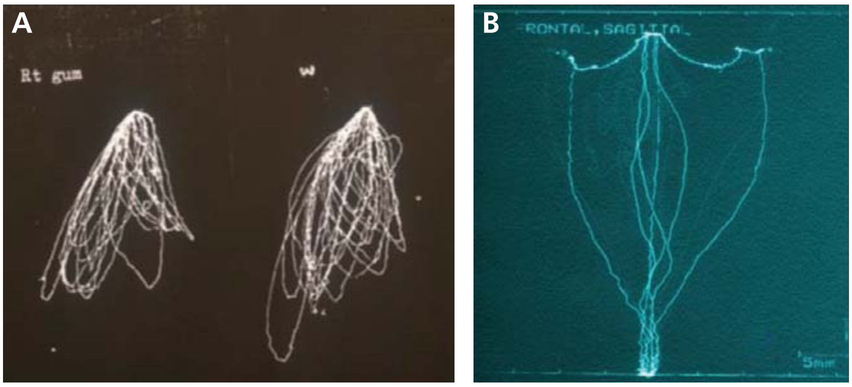

Figure 6. Tracing of the chewing movement of a subject who had wide occlusal fossa with mandibular side-shift (A) and another subject with narrow occlusal fossa (B). Frontal view of a mandibular border movement tracing shows a flat and wide centric stop area (C).

Figure 7. Wax patterns of the restoration for patient with evident side-shift and long centric showing wide fossae (in red) laterally and mesiodistally.

maximum interocclusal contact position (MICP) in normal adults is often found. Such discrepancy can be very limited or wide, depending on how much tooth wear has occurred and how much dental restoration was performed previously (Fig. 5). Therefore, if the restoration is fabricated outside the mouth without considering the presence of that discrepancy, then the free movement of the jaw in centric positions will be hindered, and the feeling of interference may be annoying to the patient. Although a close correlation between centric interference and bruxism and muscle fatigue is no longer regarded as valid scientifically[10], feelings of interference are often reported by patients who pay too much attention to their occlusion[11].

b. Side shift of the mandibular condyles during lateral excursion of the jaw: Under normal condition, the cusps, fossae, grooves and ridges should be compatible with functional and parafunctional mandibular movements[12]. (Fig.6). Therefore, the condyles of the mandible in patients whose teeth have wide fossae and lower cusps, will demonstrate side shifting during lateral excursion. The range of the side shift may vary, but the occlusal form of a restored tooth should not limit such side-shifting (Fig. 7). When the restoration is made outside

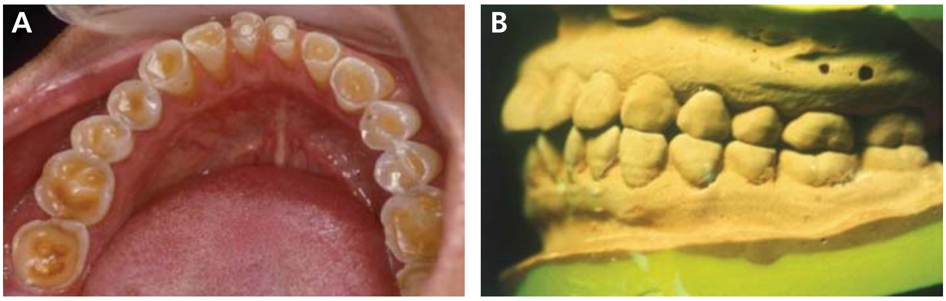

Figure 8.
(A) Attrition of teeth due to bruxism.
(B) Attrition of teeth with depressed posterior teeth.

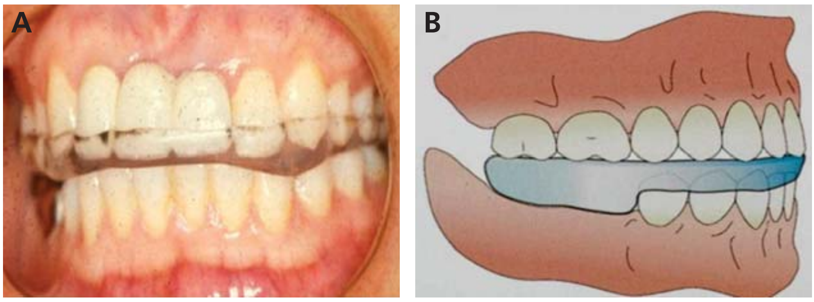

Figure 9.
A flat surface occlusal bite splint can be used to evaluate the degree of vertical height increase before preparation of teeth for reconstruction (A). For edentulous posterior of a lower dentition, a flat bite splint with distal extension to meet the upper posterior teeth is suggested (B).

the mouth of a patient who has a wide range of side shift, and the transfer of the side shift to an articulator is not correct, then the restoration made in that articulator will not be compatible with the mandibular movement of the patient.

2. Occlusal reconstruction or rehabilitation:

By definition, occlusal rehabilitation is the restoration of the dentition to its optimal functional status by means of occlusal adjustment, orthodontic alignment of teeth, prosthetic restoration, surgical correction, and other dental procedures aimed at restoring normal masticatory function, proper esthetic appearance, as well as at preservation of teeth and periodontal ligament[13]. In addition to restoring the occlusal form or dentition with better esthetics, restoring or maintaining the health of the masticatory function is also emphasized. Moreover, bruxism or functional wear of teeth can often cause shortening of the dental vertical dimension if the continuous eruption of teeth does not compensate for the loss of dental height due to attrition or intrusion[12] (Fig. 8). Some believe that the facial appearance and /or the health of jaw muscles and joints will be compromised due to such loss of the loss of dental occlusal height. In contrast, many studies have indicated that the vertical dimension is not a major contributor to disorders of the masticatory system[14]. As such, the benefits of increasing the occlusal height for such patients are controversial[15]. Nevertheless, esthetic demands and the correction of functional disturbances remain the primary reasons for dental rehabilitation with a certain amount of vertical dimension increase. To evaluate the possibility that and degree to which the occlusal vertical height can be increased, an occlusal splint can be used (Fig. 9). Through weeks or months of observation and adjustment, the effects, beneficial or detrimental, of increasing the occlusal vertical height per a patient's request, can be evaluated. Most often after a period of observation and adjustment of the splint, the patient's desire for a vertical dimensional change may become weak, and the amount of increase can be minimized[16].

2-1. Repositioning the mandible with or without increasing the facial vertical height:

For the treatment of patients with TM joints clicking or with limitations with or without deep bite occlusion, repositioning bite splints or a guidance ramp on a bite splint are often used[17,18]. Clinical experience has suggested that clicking of the jaw joints can be prevented or eliminated if the mandible is in a protruded and/or downward position and the discs are no longer displaced anteriorly[18]. However, when the splint or the ramp is removed, clicking often recurs. Long- term use of such a splint would result in posterior open bite of the dentition when the splint is not in the mouth (Fig. 10). Reconstruction of the dentition to meet the non-clicking position with a fixed or removable prosthesis can maintain the advanced jaw position with stable posterior occlusion (Fig. 11). Orthodontic approaches to extrude the posterior teeth to meet the therapeutic jaw position are also suggested, but such approaches take more time

Figure 10.
Due to the lack of posterior support, a deep bite patient shows severe attrition on the labial surfaces of the lower anterior teeth. This type of attrition is very difficult to restore without the adjustment of the upper anterior prosthesis and the increase of occlusal vertical height.

Figure 11. A patient with evident retruded mandible and an wide horizontal overjet (A).A repositioning splint with metal framework and simplified acrylic occlusal form was applied (B). The patient can chew with the functional splint at a more anteriorly positioned mandible to avoid jaw joint compression and muscle discomfort (C).

Figure 12.
Skeleton of a medieval British soldier shown in The British Museum. Although the soldier was not old, his dental occlusal plane is flat without cusps (A). The head bone of an Egyptian Pharaoh shown in The British Museum has flat dental occlusal form (B).

and effort and the occlusal form of the realigned teeth may not be improved. Orthognathic surgical approaches can be more radical, but not practical to utilize just for TM joint disc displacement.

2-2. Should the already existing occlusal pattern be reproduced on the occlusal surface of the reconstructed teeth?

In general, deteriorated or abraded teeth often have wider antero-posterior and lateral occlusal contacts with the opposing teeth during functional and parafunctional jaw movement, or more specifically, a wide centric pattern including longer CR-CO differences and wider side shifts before eccentric excursion of the jaw. Studies of stone age humans and some modern aboriginals who eat rough, tough or more abrasive foods have commonly found attrition of the teeth[19-22] (Fig. 12). Such attrition of teeth in modern humans is also regarded physiological instead of pathological unless it occurs too suddenly or to an excessive degree. Therefore, reforming the abraded tooth structures to their original form is not necessary. Reconstruction or rehabilitation of dentition is mainly for replacing missing teeth and to obtain better masticatory function, as well as improved dental and facial esthetics. There is no scientific evidence suggesting that increase or resume occlusal vertical dimension is a treatment or prevention modality for masticatory function disturbances. Moreover, unless a change in the occlusal vertical dimension is more than 10 to 12 mm, jaw closing muscles such as the temporalis muscle, seldom exhibit evident EMG changes[23]

Figure 13. An orthodontically treated patient with unstable jaw position (A). Clinical findings suggested that an advanced lower jaw is better for her muscles and TM joints (B). The advanced position was evaluated with a flat bite splint. After six months of splint wearing and adjustment, a repositioning lower splint with simplified occlusal surface was applied (C) and (D).

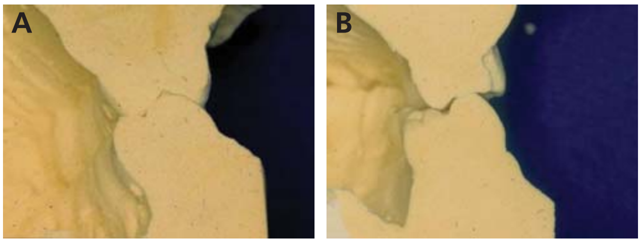

Figure 14. Coronal section of a dental model of a patient with cusp to incline occlusion and minimum attrition of the cusp tip (A). Dental model of another patient with cusp to fossa occlusion shows flat fossa and short cusp (B).

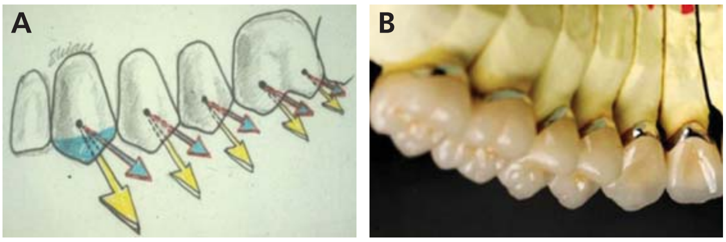

Figure 15. (A): Diagrammatic expression of canine guidance during lateral jaw excursion. Blue arrows indicate the downward jaw movement during lateral excursion and yellow arrows indicate a more horizontal lateral movement without canine guidance. (B): Reconstructed dentition with evident canine guidance and prominent cusps of the posterior teeth.

(Fig. 13). Therefore, guidelines for properly increasing of the occlusal vertical dimension can only be based on esthetics, the patient's comfort and clinical findings such as those pertaining to the rest position, phonation and swallowing[24].

2-3. What type of dental occlusal form is suggested for the reconstructed dentition with or without the increase of occlusal height?

Because the reason for reconstruction is mainly to achieve a better appearance and chewing function, missing areas should be replaced and the anatomical form of the abraded occlusal surfaces should be restored[25] (Fig. 14). If the reconstruction is to be performed on natural teeth with minimum missing areas, fixed onlays, crowns or bridges are more often recommended. After bite splint evaluation, a suggested vertical dimension is obtained and transferred to an articulator with a carefully located centric position. A trial or provisional prosthesis can be made on the working casts, and then applied on the prepared teeth. There is no need to reproduce the slide-in-centric and side-shift of the jaw, because the new occlusal form of the dentition is no longer attritional[26]. If only one jaw is to be reconstructed, the occlusal surface of the opposing teeth must be well adjusted to avoid a distorted or exaggerated curve of Spee and any possible interference before the preparation of the teeth to be reconstructed. Aspects of the occlusal scheme such as posterior disclusion with canine guidance or group function[25], should be decided first according to the understanding of the dentist and the preference of the patient[27] (Fig. 15).

For full mouth rehabilitation, the occlusal surfaces of all posterior teeth and often with upper anterior teeth should be reconstructed. Ideally, both the upper and lower arches should be reconstructed simultaneously. However, for convenience, quadrant or segmental techniques have been proposed. For whatever approaches are used, all posterior teeth should have stable centric contact[28]. Canine guidance and anterior guidance[29], which are often worn out before treatment, can be restored to disclude eccentric contacts of opposing teeth and to simplify the construction of the occlusal form of the posterior teeth[30] (Fig. 16).

If the rotation center of the articulator for the reconstruction is properly related to the rotation center of the mandible at a given vertical height, then point centric occlusion without the provision

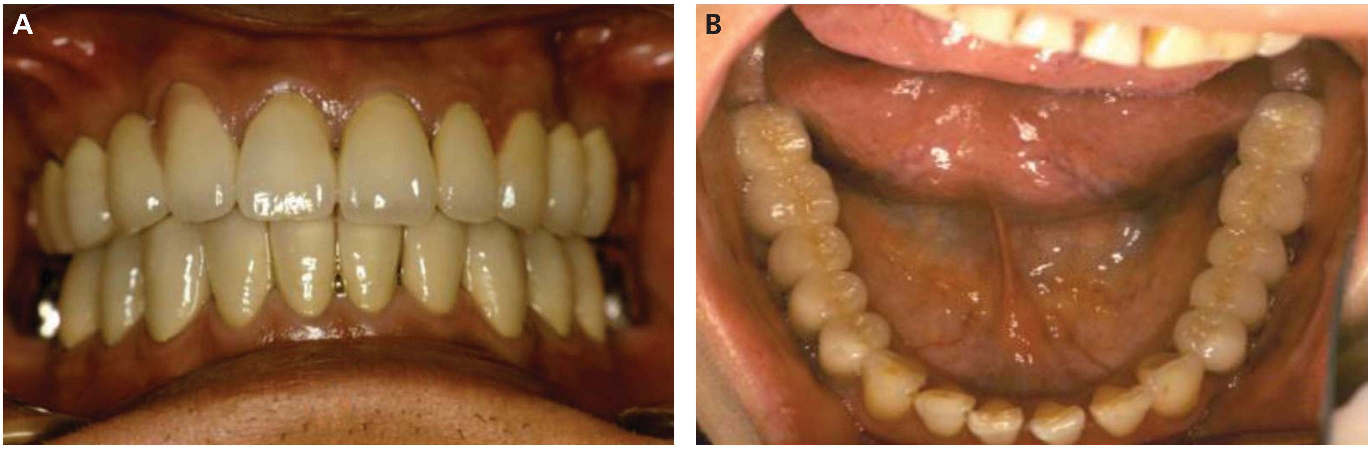

Figure 16. Reconstructed upper and lower occlusion with ceramic crowns and bridges. Anatomical occlusal form is applied with canine and anterior guidance and eccentric posterior disclusion.

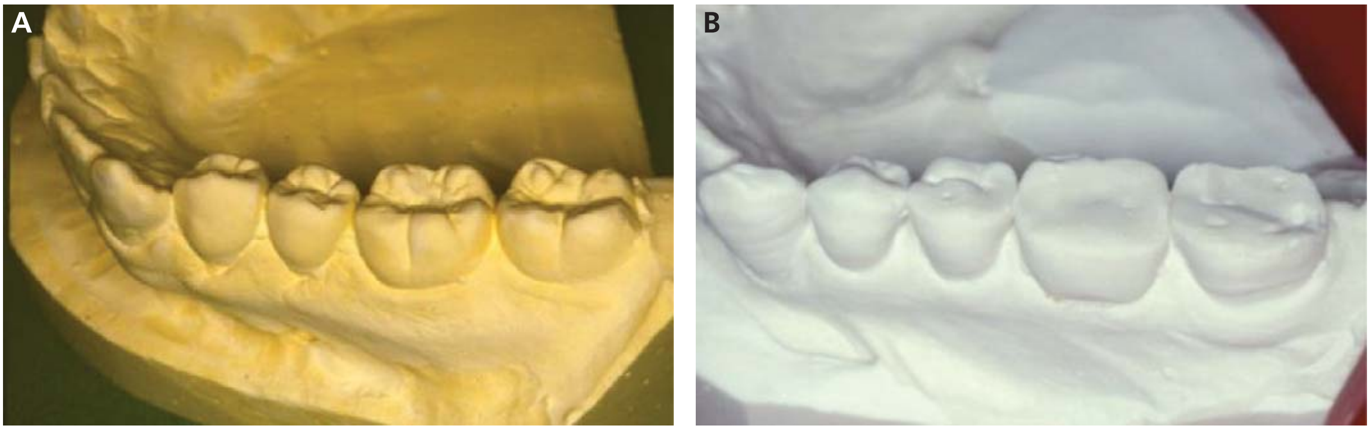

Figure 17. (A): A stone model of a young dentition showing prominent cups and evident ridges and grooves.
(B): The occlusal form of a dentition with severe attrition. Should the occlusal form be reconstructed back to (A), or remain as that of (B)?

of a side-shift can be built on the occlusal surface of the restorations. Stable centric contact on all teeth in the centric position of the jaw is the ideal occlusal form for efficient chewing function without trituration. However, as Celenza suggested, minimum centric contact or even no contact on anterior teeth should be considered to prevent too much non-axial force on the upper anterior teeth[31].

It is safer for the reconstructed occlusal surface to have freedom in centric occlusion[5,29], because of the possibility of an improperly located centric position. Ideally, point centric occlusal contact without a side-shift allowance is still advocated for better esthetics, chewing function and centric stability[32]. However, modifications of gnathologic concepts for rehabilitation have been suggested by some gnathologists[33].

If computer-aided technology is applied for the reconstruction of one jaw or two jaw dentitions, the tooth forms with different cusp heights and fossa widths for the selected size and shape of the dental arches can be decided. The dentist and his/her technicians should work together with their patients to obtain a general consensus regarding the reconstruction (Fig. 17). Full arch acrylic onlays or full crown templates should be formed and cemented on the prepared teeth for a period of time for observation. After a few adjustments along with the adaptation of the patient, the templated dentition can then be scanned and manufactured with a CAD/CAM system.

Conclusions

Small scale dental restoration should provide occlusal surfaces compatible with the existing occlusal scheme of the patient. Reproduction of the centric position of the jaw and jaw movement in an articulator is necessary. However, when the reconstruction scale is large and all the occlusal surfaces are to be changed, the size, shape and height of teeth can be determined according to the preferences of the patient and the understanding of the dentist. The new occlusion can have no or minimum centric sliding and side-shifting with better facial and dental appearance.

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Original Article

A retrospective study of crestal bone changes at fixture-abutment junctions for implants with horizontal offsets

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Abstract

Purpose: *The esthetics and longevity of dental implant-supported prostheses depend on the successful integration of peri-implant soft and hard tissues , with the phenomenon of early bone resorption up to 1.5 mm being a key factor for success. The purpose of this study was to track the effect of horizontal platform switching (PS) that hides microgaps in the height of the alveolar bone around the implant .*

Materials and methods: *Periapical radiographs of 54 implants in the control group and 41 implants in the PS group were collected. These radiographs were digitized to measure the amount of peri-implant crestal bone resorption. Such data was recorded every 3 months between the baseline (2nd stage surgery) and 12-month follow-up and every 12 months after the 1st year of loading. The amounts of bone loss in both groups were compared using the Student t-test.*

Results: *There was no significant difference in crestal bone loss between the control group and the PS group except at the 36-month follow-up (P<0.03). The mean crestal bone loss was 1.20±0.67 mm in the control group and 1.18±0.59 mm in the PS group at 12 months. The annual bone loss after the 1st year in the control group and the PS group was 0.12±0.3 mm and 0.08±0.35 mm, respectively.*

Conclusion: *The amount of early peri-implant bone resorption and annual bone loss after the first year of loading in this study was comparable with the amounts reported in the literature. The results indicating no significant difference in crestal bone loss between the two groups may have been due to when the PS was performed. The smaller diameter abutments were connected to implant fixtures when the prostheses were delivered, rather than at the time of the surgical exposure of the implants. As for the effect of horizontal offsets on late implant bone loss, studies with larger sample sizes should be conducted. The results of this study indicated no significant difference in the amounts of crestal bone loss between the control group and the PS group except at the 36-month follow-up. These results suggest that a further study with a larger sample size and PS performed before the 2nd stage surgery should be conducted to clarify the effect of PS .*

Key words: Dental implants; Bone loss; wide-diameter dental implants; microgap; platform switching

Introduction

Since osseointegration was discovered and defined in the 1960s by Dr. Brånemark and his colleagues[1,2,3], dental implants have become a reliable treatment option in contemporary dentistry. Dental implants have been proven to have a high success rate[4,5], with long-term success rates of up to 92%[6] for more than 15 years of service. Among the criteria for evaluating the success of implants[7,8], the amount of alveolar bone resorption around the implants is a key factor. The crestal bone resorption in the vertical direction is about 0.9-1.6 mm in two-piece submerged implants in the first year after healing abutments or prosthetic abutments are attached. The annual alveolar bone resorption then decreases to 0.05-0.13 mm[9,10] after the first year of service of implants. The phenomenon of larger bone resorption in the first year of loading is called early bone loss. The smaller amount of peri-implant bone loss afterward is called late bone loss[4,5]. From the late 1980s, wide-diameter (5 ~ 6 mm) implants were used to increase the contact area between the bone and implant. The resulting average amount of alveolar bone loss around an implant was reported to be 0.9 ~ 1.4 mm after short-term follow-up[11,12].

Factors possibly affecting peri-implant crestal bone loss include the establishment of biologic width[13,14,15,16,17], the occlusal overload[18,19,20], the microgap[21,22,23,24], and the crest module[25,26]. Lazarra[27] proposed the use of platform switching (PS) to diminish the adverse effect of microgaps by connecting small-diameter abutments to large-diameter implant fixtures. He found less early peri-implant crestal bone loss in implants with PS.

The purpose of this study was to compare the amounts of crestal bone resorption for wide-diameter implants with PS (the PS group) and without PS (the control group). The hypothesis of this study was that the use of PS with externally hexed implants could reduce peri-implant crestal bone loss.

Materials and methods

I. Data screening and collection

The flow chart of this research is shown in Figure 1a. All samples were collected from patients treated with implant restoration following standard surgery, prosthetic, and recall protocols at least 1 year after the 2nd stage surgery in the Department of Dentistry of China Medical University Hospital between 1998 and 2005. All of the patients signed informed consent forms before undergoing implant placement. The implants placed were all large-diameter implants of the Osseotite Parallel Walled system (Biomet 3i, Palm Beach Gardens, Florida). The implant fixtures were placed equicrestally. Healing abutments with the same diameter as the implant fixtures were then attached in the 2nd stage surgery. Implants with prosthetic abutments of the same size as the implant fixtures were used for the control group, while implants with prosthetic abutments 1 mm smaller than the diameter of the implant fixtures were used for the PS group, as shown in Figure 1b. The beam-guiding film holder (XCP® Instrument Kit, Dentsply) was used when taking periapical radiographs of these implants. The inclusion criterion for the radiographs was that they consist of clear images of externally hexed large-diameter implants. If the image quality of a radiograph was such that the highest point of the bone-implant contact area could not be determined, then that radiograph was excluded from the data collection.

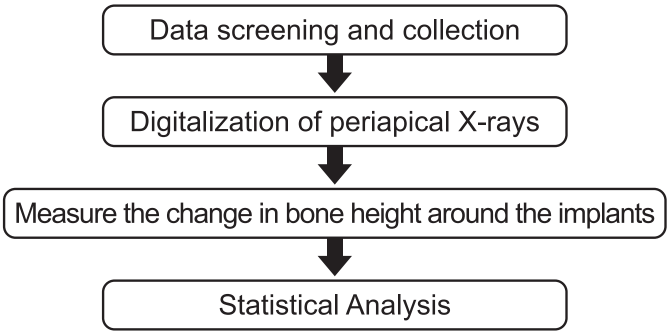

Figure 1a. Theflow chart of this research.

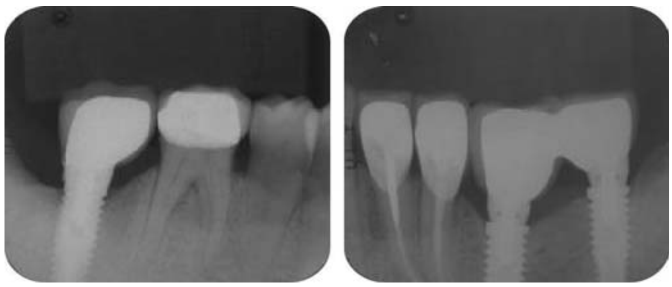

Figure 1b. Periapical radiographs of research subjects.
(a) Control group - left, (b) PS group - right.

II. Digitization of radiographic images

The periapical radiographs of all samples meeting the inclusion criterion were collected. Digitization with a 16-bit grayscale and 720 dpi resolution mode was performed with a scanner (Epson Perfection 4990 PHOTO, Seiko Epson Corporation, Nagano, Japan).

III. Measurement of the height of the alveolar bone around the implant

The bone height on the mesial and distal sides of each implant was recorded every 3 months between the baseline (2nd stage surgery) and the 12-month follow-up and then every 12 months after the 1st year of loading. AutoCAD software (Autodesk, Inc., San Rafael, California) was utilized for the measurement of the bone height. Bone height is defined as the length between the top of the implant fixture (i.e., the original point) and the highest point of the crestal bone. The calculation of actual bone height is shown in Figure 2. A negative value for bone height indicates bone loss, and a positive value indicates bone gain. The crestal bone change was obtained by subtracting the value of the bone height recorded at a given follow-up time point from that at baseline.

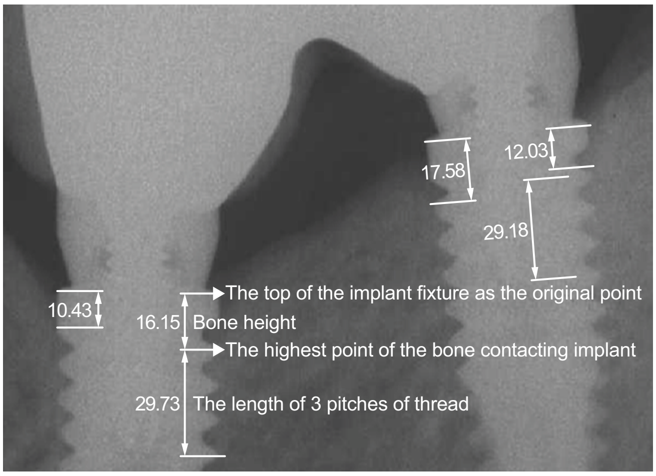

Figure 2. Measurement of bone height around the implant. Taking the 36 distal side as an example, the bone height measured by the software was -16.15, and the length of 3 pitches of threads used for calibration measured by the software was 29.73. In fact, the length of 3 pitches of threads is 2.7 mm, so the real bone height is: -16.15/29.73 x 2.7 =-1.47 mm (rounded to the second decimal place).

The bone height on the mesial side and the distal side were recorded respectively. A specification of the implant fixture (i.e., the actual length of 3 pitches of threads was 2.7 mm) was used for calibration of the measurement.

IV.Statistical Analysis

The Student *t* test was used to compare the data of the PS group and the control group. The paired t test was used to compare the bone height data for the mesial and the distal sides within both groups.

Results

I. Implant distribution

The distribution of the implants is listed in Table 1. There were 34 patients with 54 implants in the control group and 24 patients with 41 implants in the PS group. For all subjects, same sized healing abutments were connected to the implant fixtures in the 2nd stage surgery. The average time period for restoration connection was 2.4±1.2 months after the 2nd stage surgery in the control group and 2.7±2.4 months in the PS group. The average follow-up period for the implants was 26.6±13.6 months, with a range of 10.5 months to 67 months.

Table 1. Distribution of the implants

	Neck designs		
	Control	Platform switching	Total
Diameter			
5 mm	47	34	81
6 mm	7	7	14
Length			
10 mm	7	11	18
11 mm	34	19	53
13 mm	12	10	22
15 mm	1	1	2
Jaw			
Maxilla	13	8	21
Mandible	41	33	74
Site			
Canine	2	4	6
Premolar	7	3	10
Molar	45	34	79
Type of prosthesis			
FPD	43	26	69
Single	11	11	22
Removable	0	4	4
Gender			
Male	36	24	60
Female	18	17	35
Mean age	47.1 (20~67)	50.3 (30~67)	48.5

II. Results of crestal bone changes

The sizes of the samples and the amounts of crestal bone loss on the mesial side at different follow-up time points in both groups are shown in Table 2 and Figure 3. The amounts of crestal bone loss on the distal side are shown in Table 3 and Figure 4. The average amounts of crestal bone loss on both the mesial and distal sides are shown in Table 4 and Figure 5.

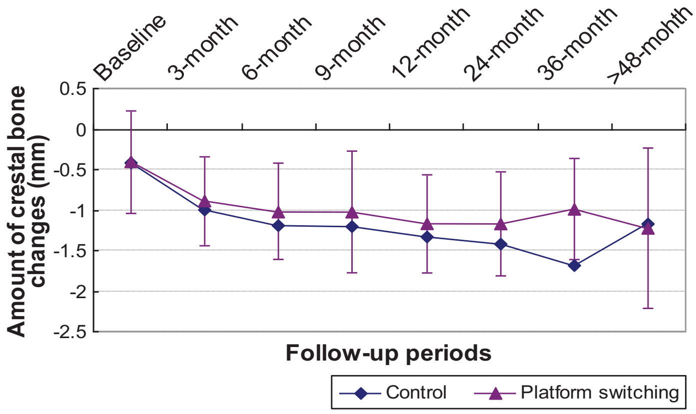

Figure 3. Crestal bone changes from baseline-- mesial side.

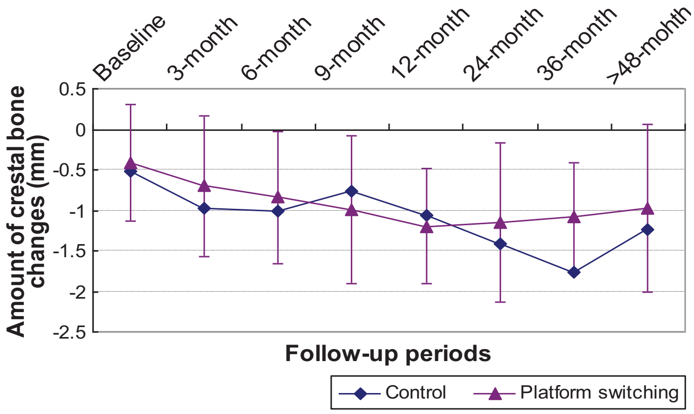

Figure 4. Crestal bone changes from baseline-- distal side.

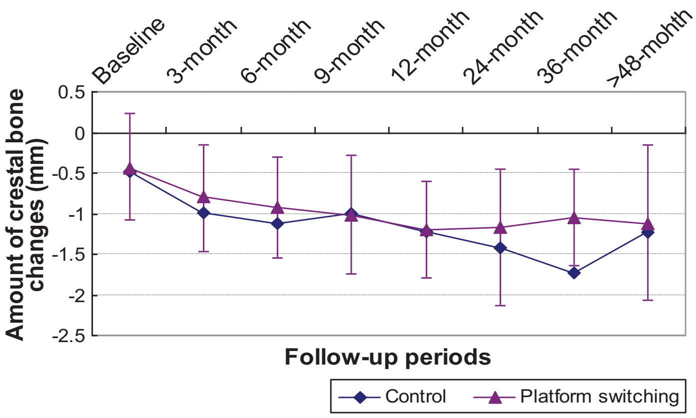

Figure 5. Crestal bone changes from baseline.

Table 2. Crestal bone changes from baseline -- mesial side

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.42	0.69	41	-0.40	0.63
3-month	44	-1.02	0.57	37	-0.89	0.55
6-month	17	-1.19	0.96	19	-1.01	0.60
9-month	10	-1.20	0.94	17	-1.02	0.75
12-month	34	-1.33	0.76	28	-1.16	0.60
24-month	28	-1.42	0.87	24	-1.17	0.64
36-month	10	-1.67*	0.77	7	-0.98*	0.62
>48-month	6	-1.17	0.76	7	-1.22	0.99

*$P < 0.05$

Table 3. Crestal bone changes from baseline -- distal side

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.52	0.74	41	-0.42	0.72
3-month	44	-0.97	0.59	37	-0.70	0.87
6-month	17	-1.00	0.87	19	-0.84	0.82
9-month	10	-0.77	0.50	18	-0.99	0.91
12-month	34	-1.06	0.74	28	-1.20	0.71
24-month	27	-1.42	0.90	24	-1.15	0.98
36-month	10	-1.77*	0.68	7	-1.08*	0.67
>48-month	6	-1.24	1.05	7	-0.97	1.04

*$P < 0.05$

Table 4. Crestal bone changes from baseline

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Baseline	54	-0.47	0.67	41	-0.41	0.65
3-month	44	-0.98	0.51	37	-0.80	0.66
6-month	17	-1.10	0.84	19	-0.92	0.62
9-month	10	-0.98	0.70	18	-1.00	0.74
12-month	34	-1.20	0.67	28	-1.18	0.59
24-month	28	-1.40	0.84	24	-1.16	0.72
36-month	10	-1.72*	0.69	7	-1.03*	0.60
>48-month	6	-1.21	0.86	7	-1.1	0.96

*$P < 0.05$

Bone resorption started at the 2nd stage surgery in more than 50% of the samples. Even though bone height was supposed to be 0 (i.e., fixtures were equicrestally placed) at the 2nd stage surgery, this was not observed in more than half of the subjects. There was no statistically significant difference in peri-implant crestal bone loss between the control and the PS groups except at the 36-month follow-up visit. The bone losses on both the mesial and distal sides in the PS group were less than those in the control group at 36 months ($P<0.03$).

The annual crestal bone loss results after the 1st year of loading are shown in Table 5. Comparing the amounts of annual peri-implant bone loss on the distal and mesial sides in both groups, it can be seen that there was more bone loss on the distal side than on the mesial side in the control group ($P<0.05$). However, there was no such difference in the PS group. Comparing the annual bone loss between the control and the PS groups, it can be seen that no statistically significant difference was revealed.

Table 5. Annual crestal bone changes after the 1st year of loading

	Neck designs					
	Control			Platform switching		
Follow-up	n	Mean (mm)	SD	n	Mean (mm)	SD
Mesial	22	-0.01*	0.37	29	-0.08	0.30
Distal	21	-0.22*	0.38	29	-0.08	0.47
Ave	22	-0.12	0.30	29	-0.08	0.35

*$P < 0.05$

Discussion

Most of the clinical studies on wide diameter implants have focused on assessing the mid-term and short-term success rates of such implants, which have been reported to range from 82.0% to 97.7%[28]. The average crestal bone resorption in the first year reported in these studies was about 0.9~1.4 mm[11,12]. The average crestal bone loss around the implant measured in the present study in the first year was 1.2±0.67 mm, and the average annual bone loss was 0.12 mm. These rates were in accordance with the standards for successful implants proposed by Albrektsson et al[7].

In the literature, the reference points for bone height are generally set between the 2nd stage surgery[11, 29] and the time of prosthesis delivery[30]. In this study, the 2nd stage surgery was chosen as a baseline to include all the causes of early crestal bone loss except for the loading factor that is activated after the healing abutment is connected. Hermann et al[16]. showed that the bone height dropped sharply within the first month after the healing abutment was attached, and the bone height had stabilized in the 2nd and 3rd months, with only a small amount of bone loss. The results of this study, as depicted in Figure 3 to Figure 5, also show that the slope of the graph in the first three months is the steepest and the bone resorption rate is the highest. Therefore, to accurately measure the early bone resorption, it is reasonable to choose the bone height at the 2nd stage surgery as a baseline.

The average bone height measured at the baseline in this study was 0.4-0.5 mm subcrestally. There are two possible reasons for this. First, although surgeons try to place the top of an implant flush with the top edges of the crest, a patient's crestal bone position may be different on the mesial and distal sides, resulting in a difference on both sides. However, statistical analysis showed that there was no significant difference between the mesial and distal bone heights at the baseline in this study. Therefore, a difference in bone height caused by unevenness of the operation area should not have affected the subsequent bone resorption measurement results. The second reason for crestal bone loss seen at the baseline is surgical trauma. A study by Wilderman et al[31]. showed that after osseous surgery, which opens the periosteum, horizontal bone resorption occurs, with an absorption volume of about 0.8 mm. During the 2nd stage surgery for implants that had achieved successful osseointegration, Adell et al[32]. and Misch et al[33]. also found bone losses of approximately 0.2 and 1.3 mm respectively. However, unlike in the findings of Wilderman et al., this bone loss did not appear horizontally in all surgical areas where the periosteum was elevated, but only around the implant.

Histological research indicates that approximately 0.75 mm of inflamed connective tissue is normally found above and below the implant-abutment connection microgap, and the alveolar bone can exist 1 mm down the connective tissue with inflammatory cell infiltration[34,35]. Therefore, in order to create enough space for the soft tissue, about 1.75 mm of bone resorption has to occur. Lazarra[27] has indicated that a horizontal offset creates additional room for inflamed connective tissue and, as a result, less vertical room is needed for connective tissue, leading in turn to reduced peri-implant bone resorption. Owing to the 90-degree platform that it provides, the horizontal offset may also produce an isolating effect that allows for a higher alveolar bone position. According to Lazarra's theory, two requirements must be met for PS to be successful. The first is that regardless of whether one-stage or two-stage surgery is performed, the healing abutment must have a small diameter. The second is that the resulting platform must be large enough to accommodate connective tissue infiltrated by inflammatory cells. In this study, the abutments were converted to smaller size from prosthetic abutments connections. Bone remodeling had already started from the healing abutment connection during the 2nd stage surgery, which was performed 4-8 weeks earlier than prosthetic abutments connection; this could be the reason for the early bone resorption seen in both the control group and the PS group.

The late bone loss observed from the 12th month to the 36th month after the abutment was attached was generally found to be mimimal in the PS group. However, the bone height of the control group continued to decline until the difference between the two groups reached statistical significance at the 36th month of tracking, showing that the two groups had different performance in terms of late bone resorption.

Previous studies have showed the effects of various factors on the average annual bone loss after the first year of loading, including the surface treatment of the implant, the width of the keratinized gingiva, the type of prosthesis installed, the implant site, the implant length and diameter, the state of opposing teeth, and smoking[36,37,38]. In this study, the amount of alveolar bone loss around the implant before the 36th month of tracking showed a stable trend in both groups. However, after the 48th month, the bone height of the control group suddenly increased, showing a phenomenon of bone gain. This result may have been due to the small sample sizes. Specifically, there were only 6 and 7 cases, respectively, in the two groups. To clarify this issue, more complete mid-term and long-term follow-up data should be obtained by tracking patients for longer periods of time in the future.

Conclusion and expectations

As this study was a retrospective study, a number confounding factors (e.g., smoking habit) could not be controlled. The results of this study show that the alveolar bone resorption of implants with horizontal offsets seems to be the same as that of implants without horizontal offsets in the first year. As the time of use is increased, however, the crestal bone resorption of implants with a horizontal offsets appeared to be less than that of the control group implants after the first year and reached a statistically significant difference at the 36th month. At the 48th month, the crestal bone height of the control group suddenly increased, causing the trend to change. There was no significant difference in the overall average annual bone resorption of the two groups in the first year after the abutment was attached to the implant. Early conversion of the horizontal platform interface, extending the tracking period, and increasing the number of samples are the directions for future related research.

Acknowledgements

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Original Article

Accuracy of an inverted scanning technique used with an intraoral scanner: a pilot study

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Abstract

Introduction: *The two main difficulties in using intraoral scanners (IOS) are the accuracy of full-mouth impressions and the need for gingival retraction. However, the methods traditionally used for gingival retraction may not meet the needs of IOS. The concept of using an IOS to conduct inverted scanning of a polyvinyl siloxane (PVS) impression was proposed to overcome this limitation. However, the accuracy of this technique and concept still requires verification. Therefore, the purpose of this study was to provide such verification.*

Materials and methods: *A 3DP acrylonitrile butadiene styrene (ABS) maxillary model with tooth 21 crown preparation and 0.5mm width gingival sulcus was used as the standard model. This standard model was scanned with a tabletop scanner (TS) and an IOS to obtain TS and IOS digital standard models. Five PVS impressions of the standard model were made, and each PVS impression was scanned using the IOS three times without powdering and three times with powdering. The results of the inverted PVS impression scanning were then superimposed on the TS and IOS digital standard models.*

Results: *The accuracy levels of the inverted scanning based on the TS model with and without powdering were 35.6± 4.9μm and 42.7± 5.0μm , respectively. The accuracy levels of the inverted scanning based on the IOS model with and without powdering were 21.8± 4.1μm and 31.7± 8.5μm, respectively. The inverted scanning technique presented the best accuracy (22.1± 3.0μm) when intraoral scanning was used without powdering in the marginal area.*

Conclusion: *The inverted scanning technique's accuracy is clinically acceptable, and it provides the most accurate results when intraoral scanning is used without powdering in the marginal area.*

Key words: Intraoral scanner, accuracy, digital impression,margin, inverted scanning

Introduction

Nowadays, the intraoral scanner (IOS) is becoming more and more important in dental clinical work. Using an IOS to make impressions is more comfortable for the patient and more efficient than using the methods traditionally used to make impressions[1,2]. This approach also facilitates communication between dentists, technicians, and patients[2, 3].

The two main difficulties in using an IOS are the accuracy[3,4,5,6,7] of full-mouth impressions and the need for gingival retraction[8,9]. Supragingival margins are not always applicable for natural teeth prostheses, so gingival retraction is necessary to ensure equal gingival and subgingival margins. In other words, in the treatment of natural teeth, if there is a need for subgingival margins, clinicians will inevitably face the problem of gingival retraction.

Traditionally, many methods have been used for gingival retraction, such as the placement of gingival retraction cords, using retraction pastes, and using lasers[10,11,12,13]. However, these traditional gingival retraction methods may not meet the needs of IOS. Moreover, in order to properly expose the margins, the problem of bleeding must be solved, as bleeding will affect the quality of any optical impressions.

Mandelli et al[9]. proposed a mixed analog-digital technique for capturing subgingival margins. Mangano et al[14]. applied a similar concept in 30 patients and achieved good outcomes. However, the accuracy of this technique and the relationship between the prepared abutment, the impression scan, and the stone cast poured from the impression need to be verified in order to achieve reliable clinical outcomes. Also, an even more simplified technique is needed to minimize possible errors stemming from the digital stacking procedure.

On the other hand, a tabletop scanner (TS) can be used to scan traditional impressions in order to avoid human errors, and it has already been proven that the results provided by such scanners are accurate[15,16]. However, without cutting dies, a TS is limited by the fact that it cannot always access all the undercuts, such that such a scanner may not be as practical as an IOS.

This study sought to determine the accuracy of an inverted impression scanning technique, especially with regard to gingival margins. Furthermore, powdering is a technique that can be used to facilitate digital optical scanning, and evaluation of the effects of powdering on the inverted impression scanning technique is also needed. Therefore, this study also sought to determine those effects.

Material and methods

Fabrication of the standard model:

A 3DP acrylonitrile butadiene styrene (ABS) maxillary model (Stratasys J750 3D printer, Digital ABS plus) with tooth 21 full crown preparation was used as the standard model. The 21 prepared abutment margin design had a 1.0mm chamfer, supragingival margin of 1.3mm, and an abutment height of 7mm. The gingival sulcus was 0.5mm in width and 1mm in depth (Fig. 1, Fig. 2).

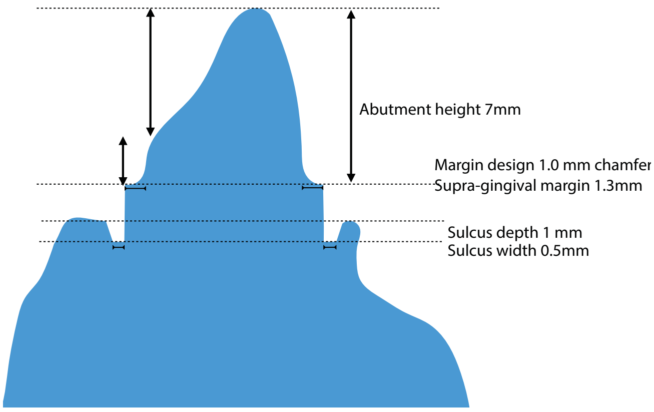

Figure 1. The standard model, 21 prepared abutment margin design is 1.0mm chamfer, supragingival 1.3mm, and the abutment height is 7mm. The gingival sulcus is 0.5mm in width and 1mm in depth.

Acquiring the digital standard model with a tabletop dental scanner (TS model):

The 3DP ABS maxillary model was scanned with a tabletop dental scanner (DOF Freedom UHD) to acquire the digital standard TS model in STL file format (Fig. 2).

Acquiring the digital standard model with an intraoral scanner (IOS model):

The 3DP ABS maxillary model was scanned with an IOS (3Shape Trios 3 wireless) to acquire the digital standard IOS model in STL file format (Fig. 2).

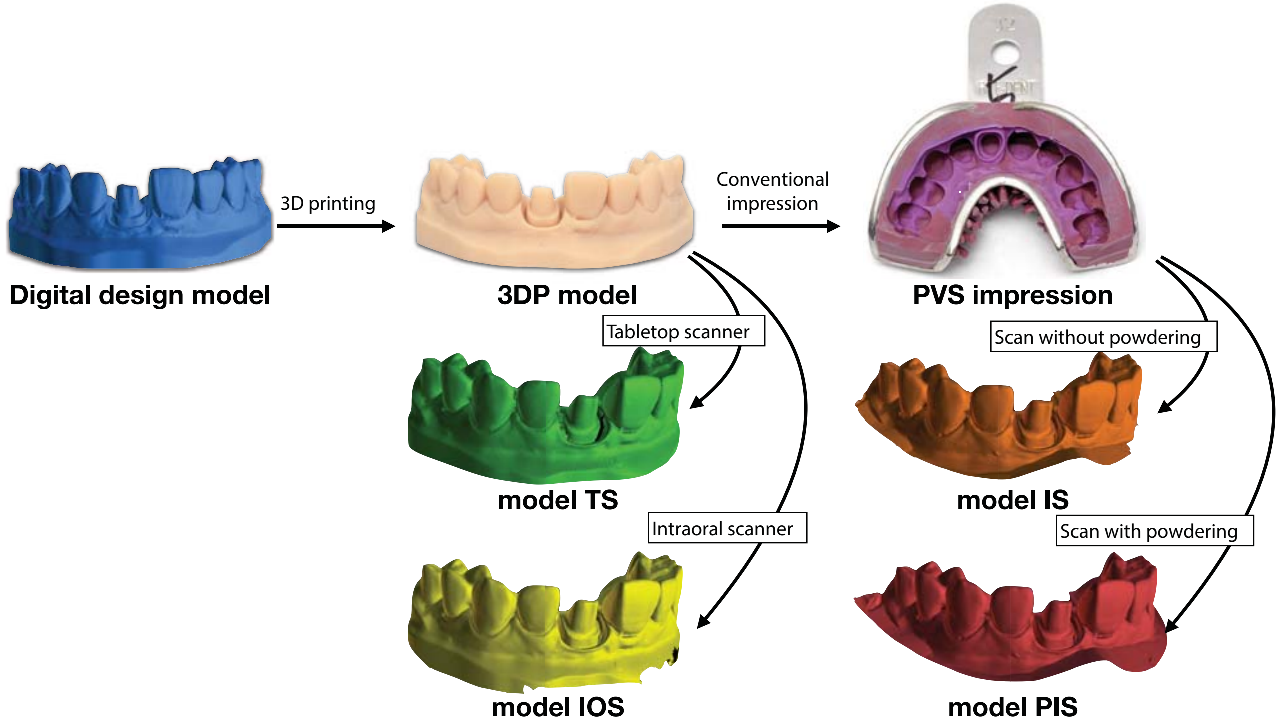

Figure 2. The figure shows the workflow to generate all the study models. 3DP model was fabricated according to the digital design model. Digital impressions were made on this 3DP model to generate model TS and model IOS as standard models.
Conventional PVS impressions were made on the same 3DP model, and the PVS impression was scanned to create model IS and model PIS. Digital superimposition and comparison were made between models, TS-IS, TS-PIS, IOS-IS, IOS-PIS.

Conventional PVS impression:

Five conventional impressions of the standard model were made with polyvinyl siloxane (PVS; Panasil contact plus X-light and 3M Inprint II heavy body) with a stainless steel perforated lower impression tray and a one-step two phases impression technique (Fig. 2).

Inverted scanning of the PVS impressions:

Using an IOS (3Shape Trios 3 wireless) to scan, the AI scan was turned off, and the scanning was performed in normal mode. In order to enable the IOS to scan the PVS model as clearly as possible, a No.15 blade was used to remove any PVS material that may have interfered with the scanning of key areas. The key areas included the teeth, abutment, and gums extending about 3mm around the teeth. The results of each scan were exported as STL files, and all the scans were performed by the same experienced operator. The operator held the handle of the impression tray in his left hand and the IOS in his right hand to perform the scanning. Each PVS impression was scanned 3 times without powdering, and 3 times with powdering. The inverted digital models were then inverted again (software: Autodesk Meshmixer 3.5) to generate the PIS (with powdering) model and IS (without powdering) model (Fig. 2).

3-dimensional digital model superimposition and comparison:

A 3d inspection and metrology software (Geomagic control X) program was used to proceed with digital model superimposition. In each digital model, the targeted abutment tooth was selected, and the 4 neighboring teeth surfaces were selected for superimposition with the "best fit" mode. After conducting the superimposition, the same selected area (abutment and marginal area of the abutment) was used to crop all the models to be compared. Then a 3D comparison was performed in the software and the root-mean-square deviation (RMS) was used to represent the deviation between the two digital models (Fig. 3).

Comparison of areas of interest:

The digital model was divided into 2 parts, the margin portion and the abutment portion (Fig. 3). The margin portion (M) was the portion extending from 1mm below the margin to 2mm above the margin. The abutment portion (A) was the portion extending from 2mm above the margin to the top of the abutment. The all portion (All) was the combination of both the margin and abutment portions.

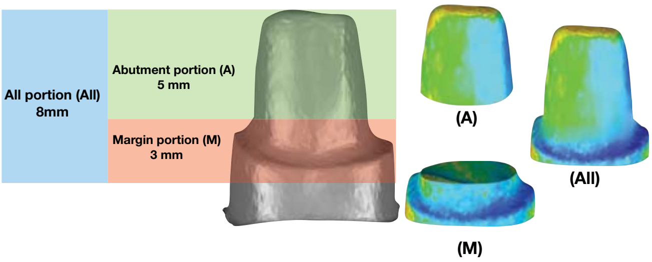

Figure 3. After the superimposition of STL files, the digital die was compared in three portions. Margin portion (M), from 1mm below the margin to 2mm above the margin. Abutment portion (A), from 2mm above the margin to the top of the abutment. All portion (All), combining both the margin and abutment portions.

Statistics:

A one-way ANOVA with the non-parametric Wilcoxon method was used to test the following:

1. The accuracy of the inverted scanning performed with the tabletop dental scanner with and without powdering.
2. The accuracy of the inverted scanning performed with the regular IOS with and without powdering.
3. The impact of the powdering procedure on that accuracy.
4. The accuracy of the margin portion in comparison with the abutment portion.

Results

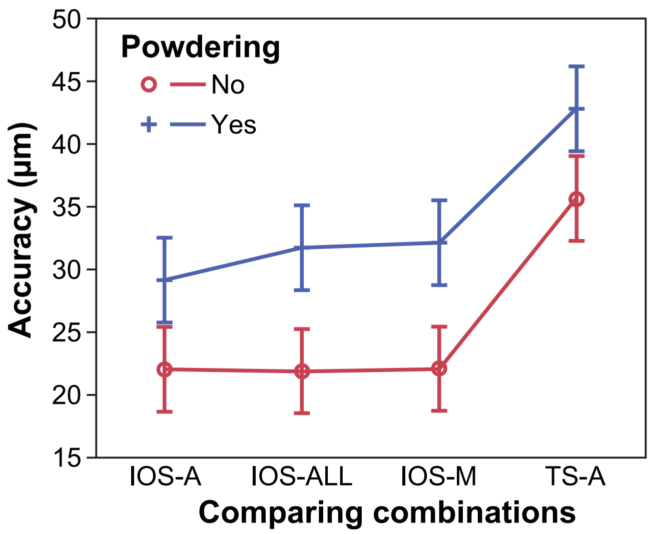

Figure 4. This figure shows that powdering procedure causes larger deviations, and TS-A group has larger deviation then IOS groups.

Table 1. The table shows the measuring outcome of all groups

Accuracy (μm)	IOS-All (all portion)	IOS-A (abutment portion)	IOS-M (margin portion)	TS-A (abutment portion)
No powder (IS)	21.8± 4.1	22.0± 6.2	22.1± 3.0	35.6± 4.9
Powder (PIS)	31.7± 8.5	29.1± 6.8	32.1± 10.9	42.7± 5.0

IOS-All: Model IOS as standard, test all portion of the die.
IOS-A: Model IOS as standard, test abutment portion of the die.
IOS-M: Model IOS as standard, test margin portion of the die.
TS-A: Model TS as standard, test abutment portion of the die.
IS: The inverted scanning performed without powdering.
PIS: The inverted scanning performed with powdering.

1. The accuracy of the inverted scanning using the TS-A model with no powdering (42.7± 5.0μm) was better than that with powdering (35.6± 4.9μm), p=0.016.
2. The accuracy of the inverted scanning using the IOS-All model with no powdering (21.8± 4.1μm) was better than that using powdering (31.7± 8.5μm), p=0.0005.
3. All the groups without powdering showed better accuracy than the groups with powdering, including for the IOS-All (p=0.0005), IOS-A (p=0.0037), IOS-M (p>0.0013), and TS-A (p=0.0016) models.
4. There was no statistically significant difference between the margin and abutment portions. However, the results showed a slightly larger deviation with powdering for the margin portion (32.1± 10.9μm) than for the abutment portion (29.1± 6.8μm).
5. It was interesting to note that the IOS-A model showed better accuracy than the TS-A model in both the powdering (p<0.0001) and no powdering groups (p<0.0001).
6. The inverted scanning technique presented the best accuracy (22.1± 3.0μm) when used with an IOS and without powdering in the marginal area.

Discussion

What had we learned from previous studies?

Güth et al., in 2016, scanned a traditional impression with multiple different ISO systems. They concluded that the accuracy of a single quadrant was clinically acceptable[17]. However, the study sample consisted of a titanium bridge die without the gingival portion, so more investigation was needed to evaluate how the gingiva would affect the outcome. Mandelli, in 2017, was the first researcher to present evidence that inverted impression scanning was able to capture deeper margins than regular intraoral scanning in his clinical cases, thus revealing the advantages and potential of this method[9]. Mangano et al., in 2020, presented successful outcomes of 30 single zirconia crown cases treated with a similar technique[14]. The current study might be the first, however, to verify the accuracy of inverted impression scanning and thus prove that its use is clinically feasible.

Limitations of the present study

Although this study's setting included a supragingival margin in the standard cast to test whether a tabletop dental scanner could capture the margin, unfortunately, the results indicate that the tabletop dental scanner still could not recognize the complete margin (Fig. 5). We therefore decided to discard the margin data for comparison and only considered the abutment portion in this group. The IOS model groups showed better accuracy than the TS model groups, although the accuracy levels for both types of groups were still clinically acceptable. This outcome did not match the author's original expectation. One possible reason why the TS was not as accurate might have been related to the scanning resolutions for different machine settings and their effects on the digital superimposition procedure. On the other hand, the IOS group was scanned under the same settings, and the information matching was straightforward. More experiments and research are thus still needed to clarify this issue.

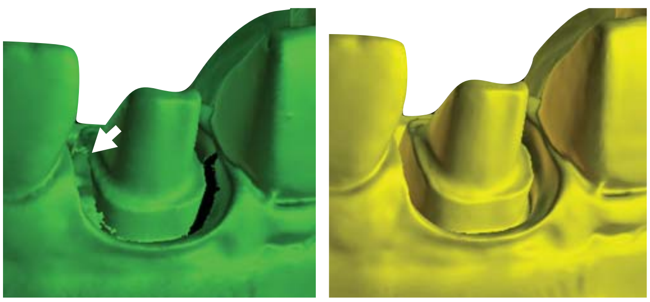

Figure 5. The margin information of model TS is incomplete (arrow) due to limited access for the tabletop scanner. We decided to avoid using the margin portion of model TS for digital comparison.

A possibility to improve both analog and digital workflows

Although accurate stone casts are still the clinical standard, using such casts might not be the best way to obtain information from a conventional impression. The process of pouring casts might cause errors such as, for example, a bubble in the marginal area or fractures in slim abutments. Also, repeated pouring causes dimensional changes[18] and damage to a conventional impression. With the investigated inverted impression technique, we could avoid such errors from pouring casts.

On the other hand, it is known that the model-less digital workflow is more efficient than the conventional workflow[19]. However, intraoral optical scanners have not yet overcome the limitations posed by subgingival margins or bleeding. Therefore, finding a solution that combines their use with conventional impressions is a wise strategy, and the investigated inverted scanning technique perfectly fits this need.

Practical suggestions and future exploration:

The group without powdering showed better accuracy than the group with powdering, which indicated that one should perform this technique without powdering in order to obtain better results. Relatedly, the powder used in powdering might accumulate on the margin area and affect the outcome. At the same time, the experiences in the present study showed that the scanning procedure is more comfortable and faster when performed with powdering. Therefore, when using this technique, the operator needs to fully understand these issues in order to decide whether or not to use powdering.

The accuracy of an impression includes the details and the shape of the die and the die's position. An accurate die means proper fit of the restoration. At the same time, the die's position affects occlusion and contact quality, which are also essential concerns. An improper digital superimposition might result in a precisely fitting crown but a massive mistake in occlusion and contact, and clinicians who would like to apply this method should be aware of this possibility. Professional superimposition software is essential, and the operator should evaluate superimposition quality; this is the weak link of dental CAD/CAM software at present. Further studies are needed of this and related topics, such as the margin location, the scanner's scanning depth, and the reflective properties of the impression materials used.

Conclusion

Notwithstanding the limitations of this study, the following conclusions can be drawn:

1. The accuracy of the inverted scanning technique is clinically acceptable.
2. To achieve the best outcome when using this technique, one should use the technique in combination with a regular IOS and perform the scanning without powdering.

Acknowledgments

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Case Report

Mandibular overlay removable partial denture for the restoration of worn dentition: a case report

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Running title: Mandibular overlay removable partial dentures

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Abstract

Within most relational definitions, tooth wear and such treatment may range from simple operative care to full mouth reconstruction. This case report describes and evaluates a method in which fixed dental prostheses and mandibular overlay removable partial denture were used in a patient with severe tooth wear and posterior bite collapse. After evaluation of the remaining tooth structure and usable space needed for the prosthesis, fabrication of the prosthesis aimed at increasing the vertical dimension (VD) was planned. To begin with, the freeway space and facial profile were used to determine new VD, then interim dentures were placed to evaluate the patient's tolerance of a change on VD. As the patient adapted to the new VD during follow-up period, provisional prostheses were used as a guide for the definitive treatment, and maxillary Kennedy Class III removable partial denture and mandibular Kennedy Class I overlay removable partial denture were placed. This overlay denture is a conservative and reversible treatment to provide the patient with improved esthetic appearance and chewing function.

Key words: tooth wear, overlay removable partial denture

Introduction

Tooth wear is found in most dentitions and presents as either localized or generalized loss of tooth substance depending on the number of teeth affected[1,2], which may also involve physiological or pathological causes. When tooth wear occurs due to natural physiological processes, the average wear rates on occlusal contact areas are estimated to be 29 μm per year for molars and 15 μm per year for premolars[1,3]. Pathological wear occurs when the rate of wear is greater than expected for the patient's age.

When teeth are lost from a dentition, fewer teeth are available for mastication and the absorption of occlusal forces[4]. In one cross-sectional study, it was reported that a decrease in the number of occluding teeth was associated with increased occlusal tooth wear, especially in cases where all of the molars were missing[5]. It is therefore reasonable to assume that the remaining teeth will experience excessive occlusal wear compared to teeth in a complete dental arch[4].

The treatment of tooth wear can range from simple operative care to full mouth reconstruction[2]. The decision to proceed with treatment or not should be guided by the patient's needs, the severity level of the wear and the potential for progression[2,6]. In addition, economic considerations may also determine the type of prosthesis that a patient may receive[7].

This case report describes and evaluates a method in which fixed dental prostheses and mandibular overlay removable partial denture were used in a patient with severe tooth wear and posterior bite collapse.

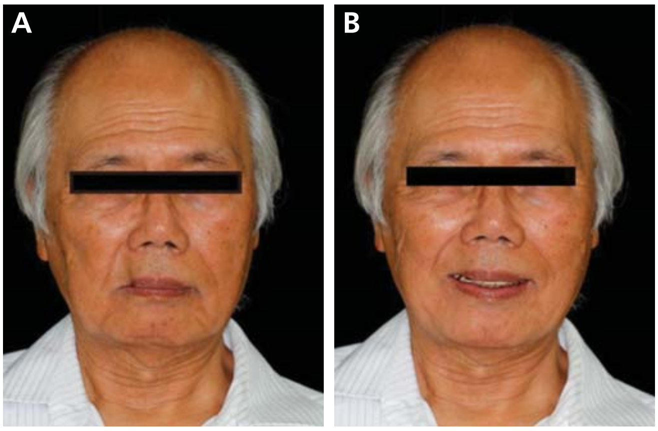

**Figure 1. Extra-oral view.
(A): Frontal view. (B): Smiling view.**

Case report

A 72-year-old man requested restorative treatment to improve his esthetic appearance and chewing function. Clinical examination revealed facial asymmetry (Fig. 1), a large overbite of 11 mm, severe tooth wear on the mandibular anterior teeth and maxillary central incisors (score of 3 in the Smith & Knight tooth wear index)[8], multiple missing teeth (13, 14, 15, 35, 36, 37, 46, and 47 in the FDI numbering system), and ill-fitting prostheses (16, 34, 45). In addition, posterior bite collapse and an irregular occlusal plane were noted due to the long-term loss of occlusal support units (Fig. 2).

The evaluation indicated that the conditions of the remaining tooth structures and the space for a potential prosthesis were insufficient. Therefore, a treatment consisting of fixed dental prostheses and overlay denture aimed at increasing the vertical dimension (VD) was proceed upon.

**Figure 2. Intra-oral view.
(A): Frontal view.
(B): Lower occlusal view.
(C): Right buccal view.
(D): Left buccal view**

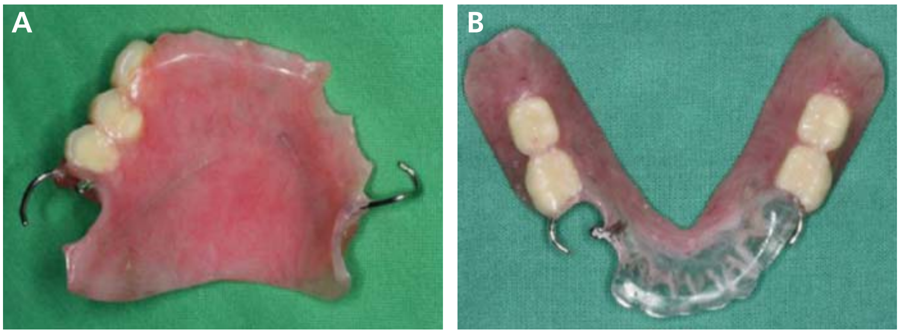

Figure 3. Interim denture.
(A): Upper interim denture.
(B): Lower overlay interim denture.

Figure 4. Frontal view with temporary crowns and interim denture denture.

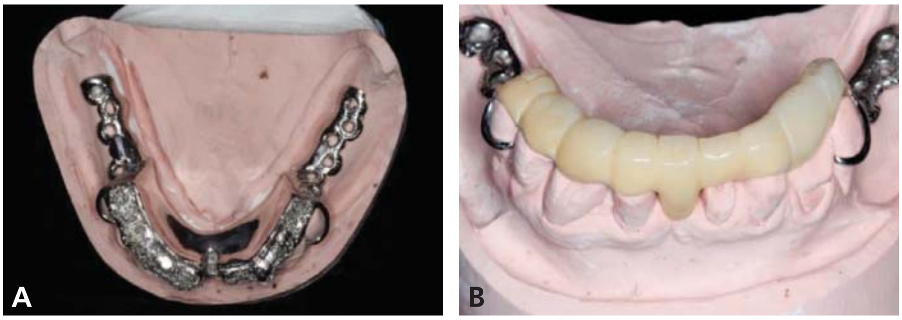

Figure 5. (A): Lower overlay denture with metal beading.
(B): Light-curing micro hybrid composite build-up.

The prosthetic treatment began with the fabrication of fixed provisional prostheses (11, 16, 21, 34, and 45) with the original occlusal relationship, followed by, the space available for removable partial prostheses evaluated to determine the necessary increase in the VD.

Moreover, the necessary increase in the VD was determined based on physiological factors of the patient such as his facial profile and freeway space. As drooping commissures around the mouth were observed and for the reason that the freeway space was 7 mm larger than normal, the new VD were determined to require a 4 mm increase in the posterior dentition for the improvement of the posterior bite collapse.

According to the new VD, maxillary Kennedy Class III interim denture and mandibular Kennedy Class I overlay interim denture were fabricated, with the overlay portion being processed with heat-curing acrylic resin (Fig. 3). After the interim dentures were placed, the patient was asked for follow-up visits to evaluate the occlusion, chewing function, and acceptability of the facial profile. During the follow-up period up to 12 months, additional problems were not found such as temporomandibular disorder, difficulty in chewing, or unstable occlusion (Fig. 4). The patient adapted to the new VD that would be required for further prosthetic treatment. Based on these clinical findings, the provisional prostheses were used as a guide for the definitive treatment.

Porcelain-fused-to-metal prostheses (11, 16, 21, 34, and 45) were made, and the next step was to fabricate the denture metal framework. Regarding the metal framework design, metal beading was applied on the overlay portion and then built up with light-curing micro hybrid composite resin (CERAMAGE®, ShoFu, Japan) (Fig. 5), and the artificial teeth were arranged in the edentulous areas. After laboratory remounting and polishing, the dentures were adjusted and placed (Fig. 6).

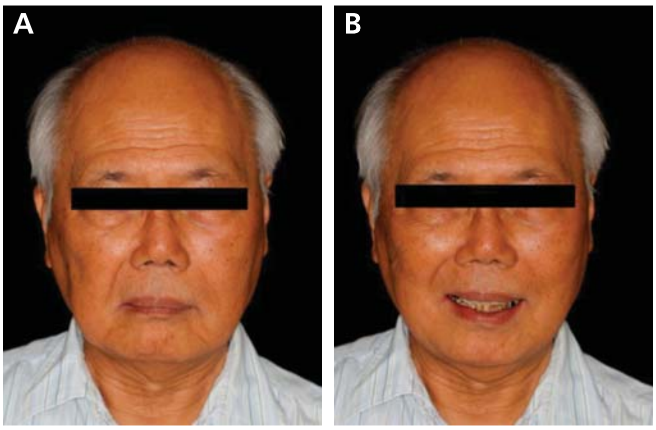

Figure 6. Extra-oral view with definitive prostheses.
(A): Frontal view. (B): Smiling view.

The prostheses were designed with an anterior overlay portion of mandibular denture which made contact with the palatal plate of the maxillary denture (Fig. 7). The occlusion was adjusted to group function during lateral movement with anterior contact at the overlay portion of the maxillary denture during protrusion. Oral hygiene instruction was provided and regular follow-ups were conducted (Fig. 8).

Porcelain chipping over 16 prosthesis mesial-buccal area was found at 1 year follow-up appointment. Smoothing the chipping area was performed due to minor chipping effect on retention and stability of denture.

The patient did not complain about his esthetic appearance or chewing function during the 2.5 years follow-up period.

Figure 7. Intra-oral view with definitive prostheses.
(A): Frontal view. (B): Frontal view with mouth opening
(C): Upper occlusal view. (D): Lower occlusal view

Figure 8. Panoramic film after treatment.

Discussion

Tooth wear inevitably occurs during the lifetime for a patient. The etiology of tooth wear is multifactorial and includes factors such as bruxism or diet. Because of its multifactorial etiology, tooth wear may result in a combination of processes, making it difficult to determine its diagnosis and the appropriate treatment required[2,9].

Even in cases of extreme tooth wear, the lower facial height may not be significantly reduced. As the teeth being damaged for successive days, tooth eruption usually takes place and the alveolar bone undergoes an adaptive process, such that they can together compensate for the loss of tooth structure to maintain the VD[10,11,12]. However, if the rate of the tooth wear exceeds the compensatory process, even resulting in tooth fracture or tooth loss, the symptom of posterior bite collapse is usually found. Moreover, posterior bite collapse might combine with a change in the VD.

The aims of prosthetic management for worn dentition are restoring the appearance and chewing function while conserving the remaining tooth structure[2]. With respect to the diagnosis and treatment procedures, casts mounted on an articulator by face-bow transfer can be used to evaluate the dentition, occlusal relationship, contacts and interferences, and available restorative spaces. Such mounted casts can also be used to prepare a diagnostic wax-up and provide helpful information for the evaluation of treatment options[2,10].

When a patient presents with a reduced lower facial height due to a loss of the VD and space will be needed for further restoration, the amount of space required can be examined by assessing the freeway space and facial profile in conjunction with phonetic assessments[2]. In this case, the freeway space and facial profile were used to determine the VD. The tolerance of changes in VD is usually confirmed through the clinical evaluation of the patient with a diagnostic splint or provisional prosthesis applied during a trial period[13]. In the current case, interim dentures were placed to evaluate the clinical outcome of an overlay denture. These applications not only can be used to evaluate the changes in VD, esthetics, phonetics and performances, but also to observe the patient's capacity to adapt to removable appliances. The design of any prostheses can be reconsidered or adjusted prior to making the definitive prostheses[1,2]. With regard to definitive treatment, a fixed restorative method or removable restorative method can also apply to relative patients. Removable prostheses can be used alone or in combination with fixed prostheses.

An overlay denture consists of a prosthesis that covers the worn teeth, and the remaining coronal tooth structure can be used to support, retain, and stabilize the denture [2]. However, it should be noted that several disadvantages are associated with overlay dentures, such as complaints about oral discomfort and compromised esthetics when the dentures are removed. In addition, the abutments may carry a high risk of caries and periodontal disease owing to poor plaque control[2,14,15]. Other risks of treatment with overlay dentures include mechanical failures such as fractures of major or minor connectors, as well as occlusal rests, deformation, or fracture of retentive clasps[1,16]. The patient needs to understand the limitations of removable appliances, especially with respect to strong biting force and bruxism. A patient's cooperation and adaptation might also be considered to be significant factors related to the clinical results[2].

Conclusion

This report describes and evaluates the use of fixed dental prostheses and overlay denture to rehabilitate a patient with critical tooth wear and posterior bite collapse. In this case, the overlay denture was a viable, conservative and reversible treatment for the patient, who expressed concerns over the treatment cost, treatment longevity, and long-term maintenance.

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Case Report

Severe mandibular osteonecrosis and spontaneous teeth exfoliation after an outbreak of herpes zoster infection - a case report from surgical approach to prosthetic rehabilitation

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Abstract

Herpes zoster, also known as shingle, is an infection caused by Varicella-zoster virus (VZV), and it results from reactivation of endogenous latent VZV infection within the sensory ganglia. There are several complications of herpes zoster, but only limited reports of osteonecrosis with teeth exfoliation have been addressed. In this case report, we documented a prosthetic reconstruction utilizing the tilited implant in severe mandibular osteonecrosis and spontaneous teeth exfoliation after an outbreak of herpes zoster infection. Tilting implant with angled abutment was selected combining with straight implants, which provided an alternative and simple solution for post-shingle outbreak patient associated with an extensive osteonecrosis and teeth exfoliation to effectively reconstruct the oral masticatory function.

Introduction

Herpes zoster, also known as shingle, is an infection caused by Varicella-zoster virus (VZV), and it results from reactivation of endogenous latent VZV infection within the sensory ganglia. The virus spread along with the nerves to the associated dermatome causing vesicular eruptions. There are several complications of herpes zoster, but only limited reports of osteonecrosis with teeth exfoliation have been addressed. In this case report, we documented a prosthetic reconstruction utilizing the tilited implant in severe mandibular osteonecrosis and spontaneous teeth exfoliation after an outbreak of herpes zoster infection. Briefly, the surgical intervention was successfully associated with a good prognosis despite the accidental mandibular fracture, which was also fixed at that time. During the regular follow up, no further osteomyelitis or infection was noticed. The patient was in good compliance and well maintained regular follow-up after the treatment. Thus, he was transferred to our Prosthodontics Department for further prosthetic reconstruction. During comprehensive diagnostic workup for oral rehabilitation, we noticed the difficulty of conventional approaches in this case due to the anatomical limitation in the mandible. Tilting implant with angled abutment was selected combining with straight implants, which provided an alternative and simple solution for post-shingle outbreak patient associated with an extensive osteonecrosis and teeth exfoliation to effectively reconstruct the oral masticatory function.

Case report

A 58-year-old HIV-negative male came to our family dentistry department in December 2012 for evaluation of the facial swelling which had persisted for a while. According to his statement, he visited a local dental clinic due to a toothache and asking for routine teeth scaling. After scaling, the dentist prescribed with ibuprofen for pain control, which accidentally caused his allergic reaction. Then, he presented at our Dermatology Department in November 2012, with a chief complaint of a painful, reddish swelling sensation associated with a scab of the upper and lower lips as well as the right lower cheek. The dermatologist considered an allergic reaction. But teeth 44 and 45 spontaneously exfoliated after few days follow-up. He, therefore, was diagnosed with herpes zoster combined erythema mutiforme. After medication with Famvir and weekly monitoring, the patient was transferred to our family dentistry for further evaluation within a week.

Extraoral examination revealed a reddish swelling and scab on the lips and the right lower cheek. Intraoral examination showed a significant mandibular bony exposure around the socket and the distal extension around exfoliated teeth. Tooth 48 was mobile with Miller's grade II mobility. The remaining teeth were vital, with fair oral hygiene, though a mild to moderate of periodontal disease was noticed. Panoramic radiographic revealed a prominent massive radiolucency shadow around the right mandibular body. Moreover, we noticed a dramatically distal infiltration of osteonecrosis within two days as compared with the difference of panoramic films. Furthermore, another exfoliation of tooth 48 was seen during the next visit.

The patient was immediately referred to the Oral and Maxillofacial Surgery Department for further management. After two days follow-up, herpes zoster infection related osteonecrosis of the right area of the mandible was considered, and sequestrectomy was arranged. The patient was admitted on December 27th, 2012. The operative sequestrectomy of right lower mandible under general anesthesia was performed on the next day. Laboratory data was normal from the pre-operative investigation. The whole procedure of debridement of necrotic bone was successful, and postoperative recovery was uneventful. The patient was discharged after 3-day post-operative care. The postoperative wound healing was uneventful. However, the patient presented to the Oral and Maxillofacial Surgery Department on January 9th, 2013 because of accidentally biting a chicken bone. Physical examination showed tenderness and extraoral swelling on right mandibular angle and submandibular area without intraoral swelling. Furthermore, the panoramic x-ray revealed an oblique fracture line at the right mandibular angle. He was admitted immediately. An open reduction and internal fixation with intermaxillary fixation were performed under general anesthesia. The whole operative procedures were successful, and he was discharged two days later. During his regular follow-up and no further evidence of infection or exfoliation of the tooth was noticed.

Prosthetic Rehabilitation

The patient presented and asked for further prosthodontics treatment after regular follow-up appointments and the osteonecrosis and exfoliation teeth were stable. In his first appointment, preliminary impressions with irreversible hydrocolloid were made. The study casts were mounted on the articulator with the aid of a face-bow. Intraoral examination revealed only teeth 33, 34, 37, and 38 were remaining. The crossbite of teeth 33 and 34 was noticed. Limited remaining teeth was possibly the factor causing the crossbite. However, the occlusion was stable with the remaining teeth. The mylohyoid muscle was detached during the surgery. Thus, a significant elevation of mylohyoid muscle from the lingual side was observed during the movement of the tongue. At the buccal side, the extremely shallow vestibule and the lack of keratinized gingiva were noticed. The maximum mouth opening was within normal limit. The panoramic radiograph revealed the amount of mandibular bone in posterior right side was limited. Conventional partial removable prosthesis could not achieve the patient's expectation due to unfavorable bony, teeth, and soft tissue support. Intraorally, in his right side of the mandible, there was limited prosthetic space without enough vestibule or keratinized gingival tissue. On the other side of the jaw, the remaining teeth were questionable to serve as abutment teeth due to mild mobility and poor crown-root ratio.

Diagnostic teeth arrangement on the base plate for the lower arch with wax up for tooth 37 was performed for surgery reference. Because of the crossbite with remaining lower anterior teeth, the space of lower anterior area was wider than that of in normal population. We, therefore, placed five lower anterior teeth to achieve better esthetics and designed an edge-to-edge relationship to reach a stable mutual-protective occlusion. Four simulated dental implants were located at 46, 43, 41 and 32 positions. After checking the wax denture in the patient's mouth and reviewing the panoramic radiograph and CT scan, a surgical stent was fabricated, and implantation surgery was arranged.

Four dental implants (Nobel Biocare, Sweden) were placed on mandible based on surgical guide under general anesthesia in June 2014. We chose to place three straight implant and one distally titled implant due to limited bone height. The tilted implant was placed around the area of projected tooth #46, connected with 30-degree multi-unit abutment. All other three implants were connected with straight multi-unit abutments, covered with healing caps. Simultaneously, the bone plate and screw previously placed for fixation were removed. The surgical procedures were smooth and successful, and the wound healing was uneventful. Due to the fact that the primary stability of less than 30Ncm was achieved, the conventional implant loading protocol[1] was decided to adapt.

The definitive impression at the abutment-level was performed with an open-tray, splinted technique six months later. The wax rim retained with two screws were used for bite registration. Wax denture was successfully applied to check occlusion, fitness, and esthetics. Acrylic teeth with high impact pink acrylic were fabricated with one screw. After confirming the occlusion, the rest of the screws were picked-up with titanium prosthesis abutments. The prosthesis was fixed with hand-torque, and the screw holes were sealed. The patient was received oral hygiene instruction reinforcement with dental flossing and interdental brush to be able to clean around the implant-supported prosthesis. Weekly follow-up was arranged in the first month. The patient occasionally complained cheek biting while chewing in the first and second week follow up. After slightly adjustment of the mandibular right canine tip, that situation was significantly improved. Proper oral hygiene was observed in every follow-up appointment. The patient tolerated well of the prosthesis throughout the whole observation period. The 4-year follow-up showed the stable and pleasant outcome of the implant-supported prosthesis.

Discussion

Osteonecrosis of the jaws is an infrequent complication of herpes zoster infection. Only 41 cases of severe osteonecrosis of the jaws have been reported. In this case report, the first case discovered in Taiwan have been completely diagnosed, treated, and monitored. In the general population, the incidence of herpes zoster infection has been reported to be 5.4 %[2]. The incidence has been reported 0.3%-1% among the people older than 80 years[3]. In Taiwan, from 2000-2008 annual incidence of herpes zoster was increasing gradually, from 4.45 per thousand cases to 6.89[4]. Moreover, the incidence rate increases for those experience varicella infection in childhood, especially in those experience varicella before two years old[5]. The infection of herpes zoster may affect cranial nerve, but the trigeminal nerve is the most frequently affected[6]. The unilateral infection is the unique feature. In our case, the shingle, the area of osteonecrosis and exfoliation of teeth are at the same unilateral right mandibular distribution.

The mechanism of the osteonecrosis followed by teeth exfoliation from herpes zoster infection remains to be disclosed. Several hypotheses have been proposed. Two possible factors of the pathogenesis mechanisms were concluded in Mendieta's review[7], including (1) ischemic necrosis affecting localized dermatome area and (2) local inflammation at involved area causing tissue necrosis. Besides, (3) preexisting plural or periodontal inflammatory condition or surgery performed in the infected zoster site might aggravate bone necrosis[8]. However, in a recent study, the majority of patients were edentulous, indicating local dental problems might not be the primary factor[9]. Osteonecrosis could affect the periodontal tissue such as alveolar bone as well as the periodontal ligament. Consequently, this pathological scenario results in the shedding of the tooth[10]. Spontaneous exfoliation of teeth usually occurs in the first two weeks of the infection[11]. Nevertheless, this severe complication should be aware by dentist and physicians in the future.

In our case, the patient denied having any systemic disease or any predisposing factor such as HIV or immunosuppression disease. However, after the breakout, severe osteonecrosis followed by spontaneous three teeth exfoliated approximately occurred within ten days. Antiviral medication therapy and keeping the intraoral wound clean by irrigation daily were successful in controlling the further damage. Surgical debridement was necessary to limit the spread of the bone necrosis. While most of the cases remained missing of prosthetic reconstruction after wound healing, our patient was cooperative, maintained regular follow-up after the treatment. Thus, he was transferred to our Prosthodontics Department for further prosthetic reconstruction.

To our best knowledge, the complication of mandibular fracture after herpes zoster infection was only reported once before our current report[12]. In the previous case, mandibular fracture due to pathologic factors was suspected. However, in this case, the fracture happened due to accidentally biting into chicken bone. The sequestrectomy results in the weakened mandible and causing fracture at mandibular angle.

After sequestrectomy, the amount of posterior right side of the mandible bone was limited. A conventional partial removable denture could not fulfill patient's expectation due to the unfavorable bony, teeth, and soft tissue support. Intraorally, in his right side of the mandible, there was limited prosthetic space without vestibule or keratinized gingival tissue. On the other side of the jaw, the remaining teeth were questionable as abutment teeth due to mild mobility and poor crown-root ratio. Thus, the implant-support prosthesis was the best-fit in this circumstance. To achieve an adequate implant height, we utilized one tilted implant and three straight with the advantage of cross-arch stability to restore the oral and masticatory function.

In Guido's systemic review[13], for a partial fixed dental prosthesis, a 5-year and 10-year prosthetic with a respectively 98.9%, 97.8% survival rate were estimated on 2-4 implants prosthesis. Though it was tough to compare and evaluated the varieties of replaced-units to implant ratios, the ratio of 2/3 was recommended to achieve an adequate result in that review. In our case, it was impossible to replace the total of nine teeth with six implants due to the anatomical limitation. Implants distribution was also improved by utilizing the tilted implant.

The typical All-on-4 concept provides a reliable surgical and prosthesis protocol with a high success rate to overcome anatomical limitations[14,15]. Typical All-on-4 was used for full arch rehabilitation. However, we used the tilted implant in this case for the partial fixed prosthesis. A predictable good result was expected with the improvement of the implant distribution. According to Fabbro's review, an excellent outcome can be expected regarding short and medium prognosis[16]. Moreover, using tilted implantation allowed the longer implant to be placed, and avoided using short implants or bone grafts. Moreover, it enhanced the load distribution and made it possible to use the all-acrylic prosthesis. Nevertheless, long-term prognosis should be evaluated carefully in the future.

When encountering atrophic bone deficiencies, the straight implant may have difficulty in achieving adequate length for osseointegration. In Zampelis's analysis, distal tilting of implants splinted by fixed prosthesis did not increase the stress to the bone[17]. Furthermore, using the tilted implant could result in a favorable soft tissue seal[18]. In our case, there was an incident soft tissue dehiscence with the straight implant abutments at first two months after the implant surgery. The patient was unable to keep good oral hygiene at the beginning of the healing stage. That might be the possible factor influencing the healing process. oral hygiene reinforcement and wound irrigation with chlorhexidine during the follow-up appointments, soft tissue began to heal with implant abutment. By keeping an adequate level of oral hygiene, using the tilted implant for partial fixed denture provides a predictable technique for prosthetic rehabilitation[19]. However, long-term study is minimal and more evidence need to support this technique in the future.

Using metal ceramics is considered as the gold standard for the fabrication of the implant-supported prosthesis. Recently, the CAD/CAM technology provided an innovative way of using inexpensive material, and predictable manufacturing outcome can be achieved. In this case report, the acrylic prosthesis was selected due to the limitation of the CAD/CAM technology in our facility back in 2014. The advantage of using acrylic is that it is easier to repair, and the material is relatively lower cost. The complication of using acrylic is the wear of occlusal surface and catastrophic fracture[20]. The other consideration of using multiple abutment is the fatigue of the abutment screw. However, no complication was noted since the prosthesis was delivered.

In summary, in this case report, we have illustrated the severe oral complications of herpes zoster infection including, osteonecrosis, exfoliation teeth, and mandibular fracture. The progress of the complications was extremely rapid and severe. This shingle outbreak results in severe complications should be aware both in medical and dental professionals to prevent further damage for future treatment strategy and monitor. Moreover, the post-operative care of sequestrectomy should be concentrated on avoiding potential mandibular fracture and recovering and reconstructing the masticatory function. Taken together, in this case report, we provided a successful treatment strategy and complete prosthetic rehabilitation for shingle related osteonecrosis followed by tooth.

Figure 1. The extraoral view of the herpes zoster infected site.

Figure 2. The intraoral view of the herpes zoster infected site.

Figure 3. The close-up view of the herpes zoster infected site.

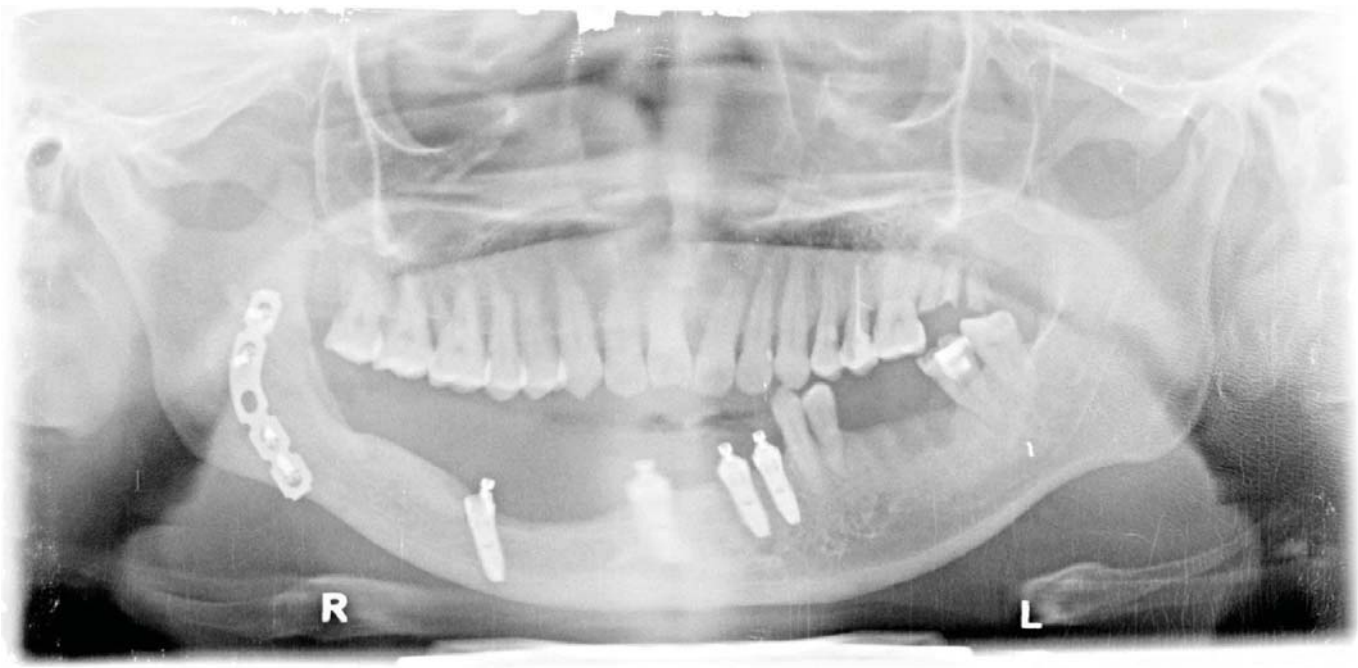

Figure 4. The panoramic radiograph of the implant placement. Noted that fixation plate was inserted in the right side of the mandible.

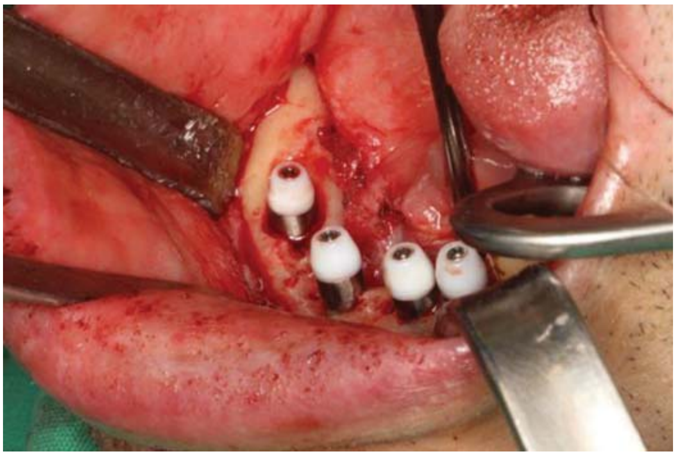

Figure 5. The intraoral view of the implant placement.

Figure 6. The two week follow-up after the implant placement.

Figure 7. Frontal view of the acrylic prostheses.

Figure 8. Front view of the prosthesis at the 4-year follow-up.

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Introduction for authors

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投 稿 須 知

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二、 凡與基礎或臨床補綴學、顳顎關節或咀嚼功能、人工植體相關、牙科補綴之技工學有關之著作，均為刊載之對象。接受的稿件類型共有下列五種，來稿請註明類型：

1. 社論 (editorial)
2. 學術綜論 (review article，限邀稿)
3. 研究論文 (original article)
4. 病例報告 (case report)
5. 技術報告 (technical report)

三、 稿件撰寫一般格式:

1. 稿件必須是沒有刊出或將被接受刊於其他雜誌者。
2. 以英文投稿，文章內容以複行 (double spacing) 繕打，字體大小12以上，其每邊邊緣至少須留2.5公分，不須任何格式編排。
3. 全文總頁數 (包括摘要、圖、表、參考文獻) 以八頁為限，必要時可增至十二頁。
4. 請以電子文件投稿，文書處理程式建議以IBM-Microsoft Word為主。須標示使用程式、投稿題目、第一作者姓名，將電子文件 e-mail 至 : prosthor@ms48.hinet.net。
5. 請同時附上致本誌主編簡短信函，表明投稿本誌之意願，並說明所有著者均曾過目並簽名同意。若為人體試驗須附人體試驗委員會之同意函。

四、 稿件內容詳細規格如下:

1. 首頁 (title page)：包括題目、作者姓名、服務單位、學歷；英文簡題(running title)長度在四十個字以內；稿件主要負責者(corresponding author)之英文姓名與地址、電話、傳真、e-mail。
2. 摘要 (abstract)：以400字為限，簡潔說明並標示研究目的、方法、結果、主要結論或新發現。若為原始著作則須說明並標示，並需附關鍵詞(key words) 5個以內。
3. 本文 (text)：
   A. 學術綜論 (review article) ─ 無一定格式。
   B. 原始著作 (original article) ─ 分前言、材料與方法、結果、討論、結論。
      (1) 前言 (introduction)：簡要說明研究由來。
      (2) 材料與方法 (material and methods)：敘述研究設計、對象、步驟。
      (3) 結果 (results)：研究結果以文字、表格或插圖表示之。
      (4) 討論 (discussion)：強調重要結果與論點，與前人論述作比較等。
      (5) 結論 (conclusion)：結論要簡要明確。
   C. 技術報告 (technical report) ─ 分前言、方法描述、討論。
   D. 病例報告 (case report) ─ 分前言、病例描述、討論。

4. 參考文獻 (references)：以出現於本文中之先後順序用阿拉伯數字(上標)排列之，書寫方式請參考 Cumulated Index Medicus，內容含作者姓名(全部列出)、篇名、期刊名、年代、頁數。例如：
   (1) 期刊之書寫 ：Lin YT, Chang LC. Space changes after premature loss of the mandibular primary first molar: a longitudinal study. J Clin Pediatr Dent 1998; 22: 311-6.
   (2) 書籍之書寫 ：McDonald RE, Avery DR. Dentistry for child and adolescent. 6th ed., Mosby Co, St Louis, 1994; pp339-41.
   (3) 有編輯者之書籍章節書寫 ：Moore BK, Avery DR. Dental materials. In: McDonald RE, Avery DR. Dentistry for child and adolescent. 6th ed., Mosby Co., St. Louis, 1994; pp349-72.
   (4) 電子期刊之書寫 ：Yavuz MS, Aras MH, üyükkurt MC, Tozoglu S. Impacted mandibular canines. J Contemp Dent Pract 2007; 8:78-85. Available at: http://www.thejedp.com/issue036/index.htm. Accessed November 20, 2007.

5. 插圖與表格 (figures and tables)：
   (1) 插圖請勿放置於本文中，圖與表之數量盡量少，也不要編排，應儲存於另外的檔案夾。影像圖檔應以 JPG、EPS 或 TIF 形式存檔。插圖以電子檔 e-mail 傳送投稿。
   (2) 插圖之標題及詳細說明，須另頁複行繕打。顯微照像須以比例尺 (internal scale marker) 標明放大倍數。
   (3) 病人臉部照片須遮蓋眼睛至無法辨認是何人的程度，否則須附病人之書面同意書。
   (4) 繪圖軟體應使用如Photoshop、Photoimpact、Illustrator等。彩色或灰階圖形須掃瞄至300 DPI，線條圖形則須至1200 DPI，並請標明圖檔名稱及所使用軟硬體名稱。
   (5) 圖或表中出現之字母或符號，均需於註解中詳細解釋。

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(1) 致主編簡短信函。
(2) 提供稿件主要負責者之姓名與地址(英文)、電話、傳真、e-mail、所有作者之服務機構(英文)。
(3) 附英文摘要(400字以內)，研究論文的摘要應分研究目的、方法、結果、主要結論。
(4) 附英文關鍵詞(5個以內)；附英文簡題(長度在40個字以內)。
(5) 確認所有參考文獻的格式、內容、引用順序皆完整無誤。
(6) 確認所有表格(標題、註腳)及插圖之標題及詳細說明，另紙複行繕打。
(7) 確認所有圖表皆符合格式。圖表皆儲存於另外的檔案夾，而未放置於本文中。
(8) 若為人體試驗須附人體試驗委員會之同意函。
(9) 全部作者同意簽名之證明函。

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