A Comparison Of Crestal Bone Loss During Osseointegration Between Using Healing Abutment And Customized Titanium Abutment: A 6-Month Prospective Study In Human: A Pilot Study

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Abstract

This was a prospective pilot clinical observation on the comparison of crestal bone loss around the subcrestal dental implant system between using healing and customized titanium abutment during the osseointegration period. Fourteen patients who required a single posterior implant-supported prosthesis were randomly divided into two groups, which were the healing abutment group (Control group)and the customized titanium abutment group (Test group). Patients received one dental implant between 4.0 and 5.0 mm. diameter (Dentium Superline, Dentium, Seoul, Korea) with 8 to12 mm. in length. All patients had an implant placed 2 mm below the crestal bone using a surgical template. Customized titanium abutments were installed immediately after the implant placement while the healing titanium abutment was replaced with the final abutment 3 months later according to conventional prosthetic technique. XCP jig was fabricated for an individual patient to produce the same position of periapical film and x-ray tube to be able to compare periapical radiograph images during the evaluation period. Radiographs were taken to assess marginal bone loss immediately after surgery (day 0), then at 1-month, 3-month, and 6-month, respectively. All images were measured and compared for crestal bone loss in each patient. Results showed none of the specimens had a bone loss at the implant platform. Bone remodeling at crestal bone in 6 months has been found in both control and test groups, which were 1.507 ± 1.060 mm and 2.028 ± 0.790 mm, respectively. Within the limitation of this study, the customized titanium abutment has shown less marginal bone loss compared to the healing abutment. However, there was no statistically significant difference between healing and customized titanium abutment.

Keywords: *Customized titanium abutment, Healing abutment, A single posterior implant-supported prosthesis, Marginal bone loss*

1. Introduction

In the past, the success of implant therapy always mainly focused on osseointegration. However, the achievement is not only the osseointegration, but the success should also be osseointegration and soft tissue adhesion around the implant at the same time. The stability of hard and soft tissues around dental implants plays an important role in long-term implant prognosis (Rotundo et al., 2015). The soft tissues around dental implants represent the seal. This seal is called a hemidesmosome that represents a barrier from contamination. Therefore, this can protect the bone from contamination and remodeling. The soft tissue always attaches to the prosthetic aspect, especially the prosthetic component by forming biological emergence profile.

In fact, to accommodate the soft tissue healing process, a minimum dimension of biological width is needed: if this dimension is not present, bone resorption can occur to allow the peri-implant soft tissue barrier to create a sufficient biological dimension (Abrahamsson et al., 2003; Berglundh & Lindhe, 1996). To achieve soft-tissue stability and bone preservation, this morphology should be considered as one factor to maintain the crestal bone stability, which is crucial to determining the long-term success of dental implants. Moreover, dental implant prosthetic protocol, repeated dis- and re-connection of implant abutments, resulted in contamination and mucosal barrier injury (Abrahamsson et al., 1997), which is associated with an apical shift of epithelium and the marginal bone resorption. These occurred to reestablish a connective tissue attachment of a sufficient biological dimension (Becker et al., 2012). In this era, focusing on reducing soft and hard tissue trauma, the one abutment one-time procedure was introduced as a minimally invasive prosthetic treatment(Atieh et al., 2017; Grandi et al., 2014; Hamudi et al., 2021). This procedure required the use of one definitive abutment instead of a cover screw or a healing/provisional abutment at the time of implant placement to address the possible drawbacks of frequent changing abutment (Canullo et al., 2010). However, there is a lack of information on the clinical relevance of the effect and the number of repeated abutment changes.

Recently, Computer-aided design and computer-aided manufacturing (CAD/CAM) systems have been noticeably used to fabricate implant prostheses. This technology is crucial to create the CAD/CAM healing abutment and definitive abutment from diagnostic casts and mimic the contours of the tooth or the designed final prosthesis before the implant surgery. These can provide optimum soft-tissue contours, shorten the prosthetic phase of the dental implant, and enhance the definitive esthetic outcome. Therefore, this study intended to compare the effect on crestal bone between using standard healing abutment and customized healing abutments (customized titanium abutment), which is the non-removal abutment. The null hypothesis of this study was that there are no differences in marginal bone loss by using healing abutment and customized titanium abutment

2. Objectives

To compare the effect on marginal bone loss between using a healing abutment and a customized titanium abutment

3. Materials and Methods

Patients who required dental implants in the posterior region with remaining adjacent teeth, needing a single implant at the Department of Esthetic Restorative and Implant Dentistry, Chulalongkorn University were enrolled in this study from June 2020 to July 2021. Inclusion criteria included patient with an age of 20 years or more, good general health at the time of selection (ASA class I or II), and had sufficient bone volume to support the implants (at least 2 mm bone thickness at buccal and lingual walls), which was evaluated by implant planning program (3Shape). Each of them received implant 4-5mm diameter double thread & tapered design, sandblasting with large grits and acid etching (Dentium, Superline, Korea). Exclusion criteria, patients were excluded from the study if they had any of the following conditions; Dehiscence or lack of buccal bone plate, Irradiation in the head and neck area, Immunosuppressed or immunocompromised patients, Treated or under treatment with intravenous amino-bisphosphonates, Uncontrolled diabetes, Addiction to alcohol or drugs, Adjacent tooth between dental implant has pocket depth>5mm., Heavy smoking (>10 cigarettes daily). All patients were informed and signed a specific written informed consent form.

The study protocol was approved by the Ethics Committee of the Faculty of Dentistry, Chulalongkorn University. Patients were randomly divided into 2 groups, Healing abutment (Control group), and Customized titanium abutment (Test group).

Figure 1 shows the healing abutment

Figure 2 shows the customized titanium abutment

Customized titanium abutment fabrication

Customized titanium abutment will be fabricated from diagnostic casts and mimic the contours of the tooth or the designed final prosthesis before implant surgery by one dental technician at the dental lab.

3.1. Surgical Technique and Postoperative Management

- All patients received a prophylactic dose of antibiotics of 1 g amoxicillin 1 hour before surgery and 1 week after the surgical procedure. In addition, they were instructed to use chlorhexidine 0.2% mouthwash for one minute twice a day starting from 3 days before surgery until one week afterward.
- All implants were placed in healed sites by inexperienced surgeons using the guided placement systems, which were designed in 3shape Implant Studio (3Shape, Copenhagen, Denmark) by an experienced surgeon.
- The patient will be received 1 dental implant (Dentium superline, Dentium, Korea) in the posterior area of the maxilla/mandible with a diameter of 4.0-5.0 mm and a length of 8-12mm depending on bone support, and implants were placed by using a subcrestal technique 2 mm under the crestal bone to compensate a space for re-establishing the biological width.
- If implants do not reach an insertion torque of at least 45 Ncm patients were excluded from the study. In addition, each patient was randomly assigned to receive a healing abutment or customized titanium abutment before the surgery by using a simple randomized technique. Healing abutments were placed with no more than 10 Ncm of torque and 25 Ncm for the customized titanium abutment. Besides, oral hygiene instructions were provided, and patients were instructed to have a soft diet for 8 weeks.
- After surgery, Periapical radiographs were taken at the implant placement site as a baseline (T0), 1-month (T1), 3-month (T3), and 6-month (T6).
- Patients who received healing abutments had their abutments removed no more than two times, whereas patients who received customized titanium abutments would be excluded if their abutments were removed.

3.2 Prosthetic procedure

After 3 months, the Healing abutments group was removed and taken an impression by using an implant coping impression, with a close tray technic. This group abutments were removed 2 times at the impression and Delivery of final restoration. In a customized titanium abutment group, a conventional impression was made by using a retraction cord. Final restorations were delivered in both groups; a cement-screw hole was used in the healing abutment group while the customized titanium abutment group was using a cement-retained.

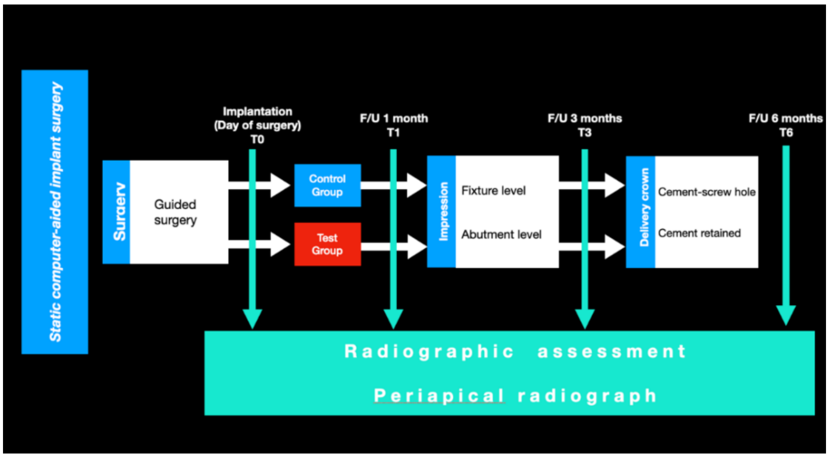

Figure 3 Flow of the study. After the surgery, the periapical radiograph was performed on the day of surgery and at 1-month follow-up, 3-month follow-up, and 6-month follow-up.

3.3 Measurement of bone loss around the dental implant

A periapical radiograph was taken by using the paralleling technique (60 kV, 10 mA, 0.250s) with an individual rigid index made from acrylic resin placed between the film holder and the opposing teeth. The peri-implant marginal bone levels were measured using ImageJ software. The periapical film was calibrated first before measurement. The length of a fixture in the film was used to compare with the actual length of the implant by choosing “Spatial calibration.” Then, the distance between the coronal margin of the implant collar to the first bone-to-implant contact or DIB was counted on both mesial and distal sides. The average distance in both mesial and distal was calculated. A reference line was created at the uppermost part of the rough surface of the fixture. The distance from the reference line to the first bone-to-implant contact was measured on both sides (figure 4). Then, the average of these two distances was made by;

$$DIB = (DIBmesial + DIBdistal) /2$$

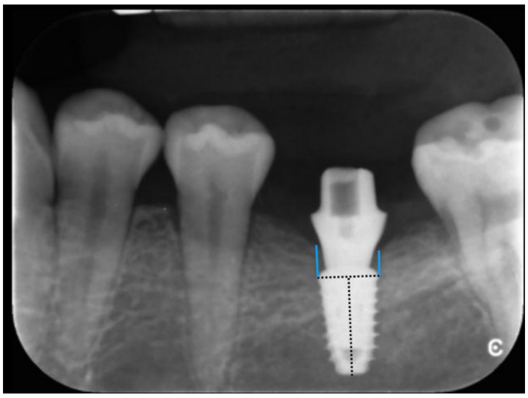

Figure 4 The implant shoulder line was created, then the perpendicular line was drawn along with the fixture. The perpendicular line was used to calibrate the implant length in the image compared to the actual length of the fixture. Then the blue line was measured according to the calibration.

One examiner was assigned to measure all intraoral examinations and periapical radiograph interpretations. Post graduated dental student in the Esthetic restorative and implant dentistry program was chosen to be an examiner. The examiner was not involved in any part of the treatment. Intra-examiner reliability had done by re-evaluating the score 3 times every week.

3.4. Statistical analysis

The data were analyzed by statistical software SPSS version 22.0 (SPSS, Chicago, IL, USA). Normality test was done by Shapiro-Wilk test. The difference in the peri-implant bone levels between the customized titanium abutment and the healing abutment group was assessed by using the independent t-test (normal distribution) or Mann Whitney U test (non-normal distribution). Statistical significance was set at *p*-value < 0.05. The intraclass correlation coefficient (ICC) was performed and calculated with the mean of 0.9, which is considered excellent reliability according to the study of Terry K. Koo and Mae Y. Li (Koo & Li, 2016)

4. Results and Discussion

4.1 Results

The inclusion criteria were met by a total of 14 patients (6 men and 8 women). At the time of implant placement, the average age was 52.43±7.26 years (range 38–61 years). A diabetic and a smoker were not among the patients. A total of 14 dentium implants were placed in healed sites, with a mean insertion torque of 45±4.39 in both groups then each group was connected with 7 customized titanium abutments and 7 healing abutments groups respectively, immediately after implant placement.

Table 1 Demographic data

Variables		Subjects (n=14)
Age (years)		52.43±7.26
Gender		
- Male		6 (42.86%)
- Female		8 (57.14%)
Insertion torque		45±4.39
Abutment		
- Healing abutment	7 (50%)	7
- Customized titanium abutment		(50%)

Table 2 The level of the crestal bone compared to gender and age following dates

Subject	Age	Gender	T0	T1	T3	T6
1	55	M	3.5	3.45	3.4	3.35
2	58	F	0.8	0.6	0.2	0.2
3	46	F	2.3	1.6	1.5	1.25
4	52	F	4.3	2.3	0.9	0.65
5	60	M	5.1	2.5	2.8	2.35
6	58	F	1.7	1.65	1.6	1.6
7	61	M	2.35	2.1	2.05	1.15
8	54	F	1.25	1.1	1.05	0.7
9	58	M	3.4	3.25	3.25	3.05
10	52	F	2.5	1.55	1.2	1.4
11	31	M	2.45	2.35	2.65	2.1
12	38	M	2.6	2.35	2.55	2.4
13	54	F	3.15	2.4	2.1	1.9
14	57	F	2.4	2.15	2.55	2.65

Subjects 1-7 were in the control group and Subjects 8-14 were in the test group.

Table 2 shows the association between implant placement depth and crestal bone level. However, crestal bone loss is not influenced by gender and age.

The average bone height between the abutment (DIB) was shown on the periapical radiograph. All of the data had a normal distribution. The highest bone height was found in the healing abutment group, which was around 2.864 ± 1.51 mm at the time of implant placement. In contrast, after 6-month of follow-up, the healing abutment group demonstrated the lowest bone height, which was around 1.507 ± 1.060 mm. From the time of implant placement until 1-month and 6-month periods, both groups showed slight marginal bone loss; however, there were no statistically significant differences between them at any time. Table 3 shows the results.

Table 3 Mean of bone height of each group (mm)

Group	Healing abutment	Customized titanium abutment	$P<0.05$
T0	2.864 ± 1.51	2.535 ± 0.68	0.609
T1	2.028 ± 0.88	2.164 ± 0.68	0.754
T3	1.778 ± 1.089	2.192 ± 0.804	0.435
T6	1.507 ± 1.060	2.028 ± 0.790	0.318

Baseline (T0), 1-month (T1), 3-month (T3), and 6-month (T6).

4.2 Discussion

This prospective clinical study aimed to assess and compare the effect of different abutments on marginal bone loss in posterior teeth during six months period. Two types of abutments were used in this study including a healing abutment and a customized titanium abutment (Definite abutment). The results demonstrated that the osseointegration of all dental implants was in good condition. There were no significant differences in bone height between the two types of abutments after 6-month of follow-up. Therefore, the null hypothesis was accepted. A similar result was found in a study by Koutouzis in 2013 (Koutouzis et al., 2013), which was not statistically significant in both groups. However, in their study, they used a bone level implant and bone loss at the platform while, in this study, a subcrestal implant was utilized to be able to get the measurement of bone remodeling both from the implant platform and the crestal bone level. Results showed that none of the specimens had a bone loss at the implant platform. Bone remodeling at the crestal bone has been found in both healing and customized titanium abutment groups, which were 1.507 ± 1.060 and 2.028 ± 0.790, respectively.

Thick and thin tissue biotype has been reported for crestal bone remodeling after abutment delivery. According to a prospective study by Linkevicius et al. (Linkevicius et al., 2015), a thick biotype preserves crestal bone stability while a thin tissue biotype is associated with increased crestal bone loss due to biologic width formation. A subcrestal placement of the implant is recommended for a thin biotype. The reason for this is the intention to compensate the space for re-establishing the biological width to prevent the crestal bone loss around the implant (Palacios-Garzón et al., 2019). In that study, they used supracrestal implant placement intending to avoid the micro-gap interphase between bone and implant. However, supracrestal technique is not recommended in patients with thin tissue biotypes. However, other studies (Linkevicius et al., 2010) found that the implants with platform switching did not preserve crestal bone better than platform matching implant-abutment connection if the thin biotype was present.

The effect of abutment disconnection and reconnection on peri-implant tissues is remained unclear based on several experimental studies. (Abrahamsson et al., 1997; Abrahamsson et al., 2003; Ericsson & Lindhe, 1993). A five-time abutment disconnection and reconnection were shown in an animal study to possibly damage the mucosal barrier (Abrahamsson et al., 1997), resulting in a more apically migration of epithelium and connective tissue causing increased marginal bone resorption. In this study, abutments were disconnected and reconnected only twice, which were during the impression procedure and the final restoration delivery. Thus, it might have less effect on the clinical outcome of bone remodeling around the implant placement.

Moreover, the current study showed the association between implant placement depth and crestal bone level. Also, the study revealed full coverage of the bone around the implant platform when the fixture was placed 2 mm subcrestally. Another study(de Siqueira et al., 2020) demonstrated that placing an implant at different depths does not affect crestal bone level. However, the relation between implant placement depth and crestal bone level changes in this study was suspected to be caused by the difference in tissue biotype. In addition, the crestal bone loss is not influenced by gender and age while other studies found that gender and age affected crestal bone loss, especially in old females (50-60 years old) during 3 years of follow-up (Negri et al., 2014). The reason could be that this study had a short period of observation and the sample size was relatively small as compared to the study by Negri et al. To validate the findings of the current study, further prospective clinical studies with a longer duration and a larger sample size are needed.

5. Conclusion

Within the limit of this study, installation of customized titanium abutment at the time of implant surgery is suggested with the result of digital precision of implant positioning and abutment design. The crestal bone loss from one abutment-one time showed comparable crestal bone remodeling to a conventional technique. However, a further longitudinal human study of bone remodeling in this concept is needed.

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