Original Article

Radiographic Comparison of Crestal Bone Loss Around Two Implant Systems with Different Surface Roughness: A Retrospective Study

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Abstract

Background and Aim: This retrospective study aimed to investigate the effects of surface roughness and implant body design on the amount of crestal bone loss around implant.

Materials and Methods: In this retrospective study, dental records of 87 patients who received 139 implants were evaluated. The ITI group received 63 implants with moderate roughness, while the DIO group received 76 implants with hybrid roughness. Radiographs were taken immediately after implant placement, on the day of loading of the prosthesis, and 1 and 2 years after loading by using the parallel method. The Mann-Whitney U test was used to compare bone loss in the two groups at different time points, and the Wilcoxon test was used to evaluate the intra-group variations during a period of 1-2 years after applying the force (P=0.05).

Results: Radiographic records of 23 implants (16%) were unavailable during the second year. The ITI group had more bone loss at all three time points. Marginal bone loss in the ITI group during the second year was 0.65±0.44 mm and was significantly more than that in the DIO group (0.28±0.16 mm; P<0.05). The mean bone loss during the time interval of the first to the second year was significantly less than the bone loss during the time interval of loading to the first year (P<0.05) in both groups.

Conclusion: Based on the failure criteria, none of the implants failed after 2 years of loading. Implants with hybrid surface roughness were superior in preserving the marginal bone around implants against occlusal forces.

Key Words: Dental Implants, Alveolar Bone Loss, Radiography, Dental

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Introduction

Nowadays, implant treatments are highly regarded due to the high demand for them and their extensive use. Different parameters such as lack of implant motion, lack of radiolucency around the implant, marginal bone loss <1.5 mm in the first year and 0.2 mm in the subsequent years, absence of persistent symptoms like pain, infection, neuropathy, paresthesia, or invasion to the mandibular canal are evaluated to determine the success of implants [1]. Implant loosening and bone loss

around implants are the two main diagnostic factors evaluated to assess the success of implant treatment [1,2]. Maximum marginal bone loss and maximum failures occur during the first year after implant loading [1].

In most clinical studies, radiographic evaluation is used to assess marginal bone loss, which is a noninvasive method and can be applied to different situations. However, one limitation of two-dimensional (2D) radiography is providing a 2D image of a three-dimensional (3D) structure. Nevertheless, this technique can be used for evaluation of bone changes over time [3].

Different factors affect osseointegration including implant design, implant surface properties, bone density, surgical considerations, and loading conditions [4]. However, the most important factors are the crest module design and implant surface topography [4]. Implant design refers to macro- and micro-structural properties of implant. Macro-structural properties of implants include factors such as crest module design, implant body design, thread design, and abutment-to-implant attachment, while micro-structural properties include implant surface properties such as surface roughness, type, and surface energy [5,6]. In order to improve the bone-implant interface and limit marginal bone loss, the design of implant body and its macro- and micro-structural properties have been continuously modified [7]. The design of the crest module part of most implants was derived from the machined flat Branmark system, and the reason for its desirability was preventing the formation of microbial plaque after being placed in the oral cavity following bone loss (1). However, several longitudinal studies have indicated that the polished design is not appropriate for bearing occlusal forces, and the bone is lost to the first screw thread after 1 year of loading [8,9]. Roughening of the implant surface increases the bone-implant contact and results in higher success of implants with average roughness compared with those with low roughness [10,11]. Certain studies have reported less bone loss around implants with average roughness than around those with low roughness [12,13], while other studies have failed to confirm the effect of surface roughness on bone loss [14,15]. A recent systematic review concluded that an implant with minimum roughness showed less bone loss in a 5-year study [16]. In addition, a 5-year clinical study compared 42 implants with average roughness with 42 implants with minimum roughness and indicated that soft tissue inflammation around implants with radiographic bone loss >2.5 mm was significantly more than that around implants with average roughness [17]. By using hybrid implants with minimum surface roughness in the crest module and average roughness in the body, we can benefit from the advantage of minimum surface roughness without endangering osseointegration [18]. Considering the existing controversy regarding the effect of surface roughness on marginal bone conservation, additional studies are warranted in this area. Accordingly, this retrospective study aimed to investigate the effects of surface roughness and implant body design on the amount of crestal bone loss around two different implant systems.

Materials and Methods

This retrospective study evaluated patients referred to a private clinic in Tehran during 2014-2016 and received dental implants. The patients were examined in terms of inclusion and exclusion criteria. In one group, ITI implants (ITI Bone level, Strumann, Basal, Switzerland) and in the second group, DIO implants (DIO UF, Dio CO., Busan, South Korea) were evaluated. Both implant types have sandblasted surface, acid-etched surface, and V-shaped screw thread. ITI implants have a body with parallel walls and a surface with average roughness (Ra = 2.5-3 μm). Implants of the DIO system have a hybrid form. In other words, the crest module has a minimum surface roughness (Ra = 0-1.5 μm), while the body and apex have average surface roughness (Ra=2-2.5 μm). In terms of body design, the body walls of this system are conical (Figure 1). The inclusion criteria included single implants, serial radiographs with at least 1 year of follow-up in

Figure 1. Comparing the shape and surface roughness of implants

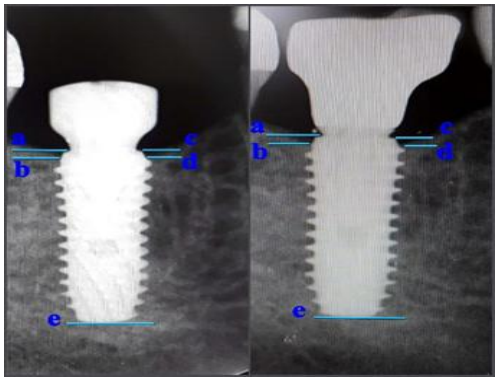

Figure 2. Point coordinates for measuring bone loss:(a) implant shoulder in the mesial, (c) implant shoulder in the distal, (b) the first contact of bone with the implant in the mesial, and (d) the first contact of bone with the implant in the distal

the file and age of over 18 years. The exclusion criteria included parafunctional habits such as bruxism, alcohol addiction, smoking for more than 10 times a day, need for bone grafting for implant placement, history of head and neck radiotherapy, and systemic diseases (uncontrolled diabetes mellitus, metabolic and hematologic disorders, uncontrolled periodontal disease, and history of infectious endocarditis).

Patients meeting the inclusion criteria were classified into two groups based on the type of implant system used. All implants were placed by two expert surgeons using the two-step method according to the manufacturer's protocol. Digital oral radiographs of patients were evaluated. Radiographs present in dental record files had been taken immediately after implantation, immediately after loading, and 1 and 2 years after loading using the parallel technique. The radiographs had been taken by Soredex X-ray machine (Soredex d, Kavo Dental, Helsinki, Finland) and the images were processed and viewed by appropriate software (Scanora, Astra version 5.0.2, Soredex, Finland). All radiographs were taken by one person using the same method. Coordinates of the implant shoulder point at the mesial (point a) and distal (point c) as well as the coordinates of the first point of bone to implant contact in the mesial (point b) and distal (point d) were determined to evaluate bone height changes (Figure 2).

The ab distance represented bone height in the mesial and the cd distance represented bone height in the distal of implant. Measurements were made with an accuracy of 0.01 mm using an appropriate software (Scanora, Astra version 5.0.2, Soredex, Finland). In order to normalize the data obtained from all images, the distance from the point a (implant shoulder) to point e (the most apical area of the implant) was calculated (Figure 2). By using the following formula, the length of the implant and the implant size on the image (the ae distance), the probable magnification of bone loss in the image at the mesial (ab) and distal (cd) was corrected.

Measurements were repeated at every follow-up. The mean value of mesial and distal bone loss was calculated. All evaluations were performed by one person to minimize the potential mistakes of the observer. All evaluations were made two times to increase the precision. Painful, infectious, or loose implants as well as bone loss of more than half of the implant length were considered as treatment failure.

Statistical analysis

The SPSS version 22 (SPSS, Chicago, IL) was used for data analysis. Normality of data was evaluated using the Kolmogorov-Smirnov test, and since data were not normally distributed,

the Mann-Whitney U test was used to compare bone loss between the two groups at different time intervals. In addition, the Wilcoxon test was used to evaluate the changes in one group during the period of loading and 1 and 2 years after implantation.

Results

Overall, radiographs of 87 patients with 139 implants were evaluated. Of these patients, 48 (55.1%) were females and 39 (44.9%) were males. The youngest patient that received implant was 18 years, and the oldest was 67 years. The mean age of patients was 45.76 years. Fifty-nine fixtures (42%) were placed in the maxilla and 80 fixtures (58%) were placed in the mandible. The ITI group included 63 (46%) implants and the DIO group included 76 (54%) implants. None of the patients required any bone graft during surgery. A total of 23 implants [16% (11 implants in ITI group, 12 implants in DIO group)] placed in 11 patients (10 implants in the mandible, 13 implants in the maxilla) had no radiograph at the second year. Bone loss in each group at the loading time as well as the first and second years is shown in Table 1. Bone loss in both groups at different times was analyzed using the Mann-Whitney U test. Significant differences were observed between the two groups and within each group ($P<0.05$). The ITI group had more bone loss during all three time intervals. In both groups, the mean bone loss during the first to the second year was significantly less than that during the first year to loading time interval ($P<0.05$). The mean bone loss in the ITI group was 0.19±0.21 mm at the time interval of loading until the first year of study and 0.12±0.11 mm from the first year to the second year. The mean bone loss in the DIO group was 0.12±0.14 mm at the time interval of loading until the first year of study and 0.05±0.06 mm from the first year to the second year. Based on failure criteria, none of the implants failed at 2 years after loading.

Discussion

The results of this study indicated that bone loss in the DIO group was significantly less than that in the ITI group ($P<0.05$). Implants used in this study were different in terms of macro-structural properties. Implants in the DIO group were conical, while they were cylindrical in the ITI group. The cylindrical form of the implant body is designed to increase the initial stability of implant [19]. Initial stability is typically measured by the force required to place the implant [19]. According to Grandi et al, [20] high force in implant placement has no effect on osseointegration or bone loss prevention in two implants with identical design, and it also seems ineffective on crestal bone loss. As a result, the difference in bone surface cannot be justified by the force exerted on the bone while placing an implant. Bashutski et al. [21] stated that if excessive force is applied while placing an implant, the area with denser bone will be at higher risk of necrosis. Thus, if compressive force is applied to the dense cortical bone, the probability of bone loss would be greater.

In addition, implants used in this study were different in terms of micro-structural properties. The ITI group had moderate surface roughness while the DIO group had the hybrid form. Rough implants were introduced to improve initial bone loss after implantation and result in faster osseointegration and better bone-to-implant contact. Such a feature has been confirmed in several animal and clinical studies [10-14]; on the other hand, the negative effect of surface roughness on plaque formation should be taken into account [22-24]. In an implant with hybrid surface, the moderate roughness of the body increases the osseointegration while the minimum roughness of the crest minimizes peri-implantitis [18]. In a 5-year clinical trial, two groups of implants with different surface roughness were compared; wherein, implants with minimum roughness had more desirable clinical symptoms and had significantly better performance in preserving the marginal bone [17]. A systematic review indicated that gingivitis around surfaces with minimum roughness was at least 20% lower in comparison with surfaces with higher roughness during 3 years [25]. Another recent systematic review on retrospective and

Table 1. Measuring bone loss at different time intervals

Group	Loading N=139	One year after loading N=139	Two years after loading N=116	
	Mean± SD	Mean ± SD	Mean ± SD	
ITI (N=63)	0.28 ± 0.36*	0.48 ± 0.38*	(N= 52)	0.65 ± 0.44*
DIO (N=76)	0.12 ± 0.15*	0.25 ± 0.17*	(N= 64)	0.28 ± 0.16*

***P<0.05**

SD: Standard deviation

prospective studies with follow-ups of >5 years concluded that bone loss around implants with minimum surface roughness was significantly less than that around implants with moderate surface roughness. The results of this study indicated that vertical bone loss of >2 mm in marginal bone was 14% around implants with minimum surface roughness while it was 18% to 20% around implants with moderate surface roughness [16]. A 5-year clinical study reported a mean bone loss of 0.5 mm for implants with moderate surface roughness and 0.2 mm for implants with minimum surface roughness [26]. In a study conducted by Glibert et al. [18] aimed at evaluating implants with hybrid surface and moderate roughness in toothless patients, the follow-up radiographs were taken 3 and 12 months after placing the prosthesis, and bone loss was studied in two groups. As a result, implants with hybrid surface showed better performance, implying that hybrid implants were more suitable for implant-based treatments [18]. The results of the present study are in line with those of the aforementioned studies.

However, in a 6-year retrospective study, Polizzi et al. [13] evaluated the Branemark system (minimum roughness) and Nobel Biocare (moderate roughness) and observed less bone loss in the Nobel group [27]. However, they included patients with systemic disease and gingivitis, as well as smoker patients in their study, and this could explain the difference in the results of this study and those of our study.

In a systematic review, Bateli et al. [28] could not determine a particular form of crest module design for prevention of marginal bone loss at 5 years. However, there is high level of disagreement on this issue, and additional long-term clinical studies are needed to clarify it.

One of the major limitations of the present study was the short duration of follow-ups. Also, we lost 16% of the samples in the second year of follow-up. Longer duration of follow-up is needed to evaluate the effects of long-term occlusal forces on crestal bone loss around implants with different types of roughness.

Conclusion

Bone loss in the two groups was clinically acceptable at a 2-year interval, but the results of the present study indicated that the crest design with hybrid roughness resulted in lower marginal bone loss in comparison with implants with moderate roughness. In both groups, the mean bone loss during the first to the second year was significantly less than that during the first year to loading time interval.

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