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Radiographic comparison of the crestal bone loss in the bone-level and tissue-level implants in implant-supported mandibular overdentures

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ABSTRACT

Introduction: To preserve the peri-implant bone level during implant restorations, multiple variations have been made in the implant-abutment connections and bone level, and tissue level implants have been placed at the bone or tissue levels to restore the function of the lost teeth. This study compared the radiographic amount of crestal bone loss in bone-level and tissue-level implants in the implants supported mandibular overdentures.

Materials and Methods: This study included 40 patients receiving bone-level and tissue-level implants with mandibular overdentures. A total number of 120 implants were placed by an experienced surgeon in a one-stage surgery. Panoramic images of patients immediately after surgery and at least one year after prosthetic loading were assessed. Bone loss values (distance between implant shoulder to proximal bone) were assessed in the bone-level and tissue-level implants on the radiographs using digital caliper on the surrounding areas of implants, including mesial and distal aspects. The data were subjected to a Student t-test.

Results: The mean of Mesial Bone Loss (MBL) of the right canine was reported 0.74mm. The mean amount of Distal Bone Loss (DBL) of the right canine was 0.78mm, the mean of DBL of the first incisal was 0.75mm. The mean of MBL of the first incisal was 0.77mm, the mean of DBL of the left canine was 0.76mm. The mean of MBL of the left canine was 0.78mm. Distal and mesial bone loss in the canine and first incisor bone-level implants were slightly higher than respective tissue-level implants, but no statistically significant differences were noted in this regard.

Conclusion: According to the results of this study, both bone-level and tissue-level implants can be successfully used for supporting mandibular overdentures. Since the amount of cervical bone loss was clinically acceptable in both groups (in a period of one to four years with an average of 2.1 years). This study recommends that clinicians choose the type of implant according to clinical need and judgement.

Keywords: Crestal bone loss; Bone-level implant; Tissue-level implant; Implant-supported overdentures.

Introduction

Since the introduction of osteointegrated implants to replace missing teeth, options for treating patients with partial or complete edentulous areas have increased dramatically [1,2]. There are currently two categories of dental implants: tissue-level and bone-level implants [1,2]. The most critical factor affecting the success rate of the treatment is to maintain bone support [3]. Therefore, bone tissue at the implant site is a critical factor Alveolar bone resorption is associated with factors such as the initial thickness of the buccal plate 5, the vertical position of the implant [5-7], and bacteria existence in the micro-gaps of the abutment-implant junction [8].

Due to the need for biological width, as the distance between the alveolar bone crest and the abutment-implant junction micro-gaps decreases, the rate of inflammation increases. Biological width includes the continuous thickness of the gingiva around the tooth. This thickness can also be seen in the areas around the implant [9]. Therefore, biological width is thought to be essential in order to protect the bone from the contaminated environment of the mouth. If the biological width is exceeded, the bone will naturally resorb to an approximate width of 2mm to create a distance of 2mm for the biological width. Tissue-level implants with a micro-gap of 2-3mm from the alveolar bone may provide this biological width.

On the other hand, bone-level implants are usually used to provide esthetics in the anterior area [10]. These implants are prone to severe bone resorption due to the vertical proximity of the micro-gap to the bone. However, the type of abutment connection may provide a horizontal distance to the micro-gap. Although in platform-switching implants, bone loss around the implant has been reported to be less than in platform matching implants [11-15]. Besides, the other advantages of platform-switching are the biomechanical characteristics, which move the stress focus area away from the cervical bone. Bone-level and tissue-level implants result in different amounts of crown height space, which can also affect the magnitude of contouring forces [14-15].

The benefits of mandibular overdentures in patients with complete edentulous include increased stability and improved nutrition and phonetics. On the other hand, the number of ideal implants for overdenture has not been clearly defined in elderly toothless people with severe mandibular atrophy [2]. Despite the economic and social issues, in recent years the use of overdentures based on two or more implants has been approved as a treatment option to improve patient satisfaction and performance. This treatment was first introduced in 1980 by Branemark. Evidence about the biological success and patient satisfaction with this type of treatment has led some researchers to recommend the use of an overdenture based on mandibular implants as the first treatment choice in any edentulous patient [2]. The aim of this study is to compare the rate of cervical bone loss in bone-level and tissue-level implants in mandibular overdenture treatments.

Materials and Methods

This research is a retrospective cohort trial performed on forty patients that received implants for 3-implant-retained mandibular overdentures, especially patients with one of these four types of attachments: (i) Ball & Bar, (ii) Locator, (iii) Ball, and (iv) Kerator Attachments. Also, this research is limited to two types of maxillary prosthesis, including complete maxillary denture or implant-retained maxillary overdenture. Patients are selected from referral patients to the implant department of dental school, which has the criteria for inclusion in the research.

The criteria for patient selection

The selected patients did not have a systemic disease that causes any contraindication to implant treatments and had not received any kind of guided bone regeneration. Also, they did not have a history of smoking.

Procedure of surgery

The selected patients for implant therapy with mandibular overdenture received sixty bone-level implants and sixty tissue-level from Straumann (Basel, Switzerland), DIO (Busan, Korea), Schilli Implantology Circle “SIC (Basel, Switzerland), and Dentium (Seoul, Korea) brands. A single surgeon who has more than five years of experience and has conducted more than 500 implant surgeries performed the surgical procedures. Implants were placed in a one-stage procedure, and they were assessed at least one year after prosthetic loading. Panoramic images were taken before and after implant insertion.

Data analysis

To determine the amount of bone in bone-level and tissue-level implants on a panoramic radiograph, we used a digital caliper (Adobe Photoshop CC 2015 from Adobe INC Company) around implants. The distance between the shoulder and the proximal bone on both mesial and distal surfaces of each implant was measured twice and compared. The average of the two measurements was used for statistical analysis. The dimensional deviation was measured by comparing the dimensions of the implant in radiograph and actual height using the following equation:

$$X=B\times(C/A)$$

Where A is the length of the implant on the radiograph, B is the actual length of the implant. C is the distance between the coronal part of the implant neck and the coronal part of the bone junction around implants in a radiograph. X is the actual distance between the implant shoulder and the coronal part of the bone-implant junction, respectively. The brand of implants, age, gender, gingival biotype of patients, presence of keratinized tissue around implants, and medical history of the patients were collected from examination files. Data were analyzed with SPSS software (Statistical Package for Social Sciences) version [25]. The rate of bone resorption and the width of the attached gingiva in the distal and mesial surfaces of all implants were statistically assessed using student t-test software. To evaluate the effects of the variables such as age, gender, implant brans and type of attachment, etc on bone resorption around the bone-level and tissue-level implants regression test was used. In this study, the first type error rate (α) was equal to 0.05.

Results

The results obtained during the measurement of bone loss in bone level implants are presented in table 1: 120 measurements were taken at least one year after loading. The amounts of bone loss in tissue-level implants were less than the bone-level implants. There were no statistically significant differences between the means of both measures ($P<0.05$) as presented in table 2. The results obtained during the measurement of attached gingiva in tissue-level implants are presented in table 3. The results obtained during the measurement of attached gingiva in bone level implants are presented table 4. The results of the attached gingiva of the bone-level implants were better than the tissue-level implants. There were no statistically significant differences between the mean amounts of both measures ($P<0.05$), table 5.

Discussion

Bone remodeling around dental implants has been reported in many previous researches [16-22]. Most studies have focused on the type of implants (one-component or two-component) or the type of abutment. However, in the present study, the rate of bone loss around bone-level and tissue-level implants was measured and reported. The amount of bone loss obtained in the present study after at least one year (in a period of one to four years) in both groups are within the range of previously reported data in the literature [16,17]. There are no significant differences between the amount of bone loss around bone-level and tissue-level implants in the present study. Although bone loss values are slightly higher in the bone-level group than tissue-level implants, they are not statistically or clinically significant. It should be noted that the highest amount of bone loss analysis was related to the fourth year of follow-up (Tables 6, 7, 8 and 9). In summary, the results of this retrospective study indicate the occurrence of acceptable bone loss in both groups of implants, and both of them had stable results and acceptable bone reactions. Lago et al. showed that tissue-level implants with platform matching design and bone-level implants with platform switching design have significant differences in the rate of crestal bone loss at one year, one to three years and also at the beginning [18]. In a recent study, periapical radiographs were used to determine changes in the crestal bone levels around the implant at different time intervals, which was different from the panoramic radiographs in the present study. In addition, Caetano et al. studied the crestal bone changes in both tissue-level and bone-level implant designs and showed that the mean marginal bone changes in the distal region were not significantly different between the two groups, but tissue-level implants had more bone loss at the mesial surface than bone-level implants [19]. In the present study, the rate of bone loss in tissue-level implants was slightly lower than in bone-level implants, which differs from the results of Caetano's research.

In another study, Van Eekeren et al. showed that bone-level implants had more crestal bone changes after one year compared to tissue-level implants [20], which was also evident in the present study. On the other hand, Kumar et al. evaluated the rate of marginal bone loss in tissue-level implants and bone-level implants. No significant differences were observed between the two groups in the periods of 6-12 months. Minor differences in bone loss in bone-level implants compared to tissue-level implants in other periods were not clinically significant [21]. Vouros et al. compared the clinical and radiographic outcomes of bone-level and tissue-level implants and showed no significant differences in bone loss and survival rates of any of the two groups of dental implants during the short-term evaluation period (one to three years). They concluded that both implant systems have adequate conditions to replace missing teeth [22].

Various reasons have been found responsible for bone resorption around implants, including surgical trauma [23], biological width formation [24], inflammation and micromovement in the micro-gap between implant and abutment [25,26] and the effects of occlusal forces [27]. In the present study, it seems that the most important factors are related to surgical trauma and the formation of biological width. To show the effects of plaque accumulation, micro-movement and their subsequent inflammation and occlusal forces, a longer follow-up period is required. In addition, heat from drilling [28] and pressure in the crest area during implant placement [29] are other factors associated with bone resorption. The rate of bone loss after the implant treatments after one year (period of osteointegration) should not be more than 1.5mm, and in follow-up periods after the first year, the amount of marginal bone loss should not exceed more than 0.1mm per year [6,30]. Considering the fact that the rate of bone resorption one year following implantation in both bone and tissue level implants has been within the normal range, it can be concluded that treatment with both these systems has been successful. However, further studies in terms of follow-up time and clinical indicators such as plaque index, bleeding and gingiva index are needed to reach a definitive conclusion.

The critical time for implant survival usually begins at the time of implant placement and lasts up to one year after occlusive forces are applied. Therefore, after the end of the first year, the success or failure of the implant can be judged to a large extent [31]. In a general view, the differences among the results of various studies in terms of the success rate of implants and the health status of the soft and hard tissues around them, including the rate of bone resorption, can be attributed to numerous factors, including the type and shape of implants, the surgeon's experience, the number of cases examined, patient's oral hygiene, the duration of implant function, the type of bone, and the different criteria for examining implants. The main limitation of the present study is its retrospective nature; as a result, it was not possible to randomize the study groups. The radiographic assessment of bone changes from panoramic images in adobe photoshop software made it possible to perform accurate and valid measurements on standard radiographs in this study. On the other hand, not all patients participated in follow-up examinations, which is another study limitation. However, it can be concluded that both implant systems in the present study have relatively similar results in terms of bone loss in the mesial or distal regions of the canine and incisor teeth, and both groups are clinically successful with an acceptable range of bone loss. The decision to use tissue-level and bone-level implants should be based on factors such as aesthetics, crown length, etc [32].

None of the variables of age, implant brand, implant type, maxillary prosthesis, attachment type and gingival biotype had significant effects in predicting the amount of distal and mesial bone loss in the canine and first incisors implants in the present study. Patient's satisfaction in the tissue-level group was slightly higher than the bone-level group (mean 9.23 vs. 8.73 of ten). In the study of Chappuis, there were no significant differences in terms of patient satisfaction between the two groups [33]. In conclusion, according to the results of this study and previous researches, both bone level and tissue level implants can be used in mandibular overdenture treatments with acceptable success. Case selection and case-specific treatment plan will increase the success of treatment.

Table 1. Measurement of crestal bone loss in 20 patients with tissue-level implants.

Variable	*Number*	*Mazimum*	*Minimum*	*Standard deviation*	*Mean*
Distal bone loss around right canine area	*20*	*1.32*	*0.14*	*0.35*	*0.65*
Mesial bone loss around right canine area	*20*	*1.38*	*0.12*	*0.34*	*0.62*
Distal bone loss around first canine area	*20*	*1.34*	*0.11*	*0.35*	*0.69*
Mesial bone loss around first canine area	*20*	*1.24*	*0.12*	*0.34*	*0.7*
Distal bone loss around left canine area	*20*	*1.12*	*0.13*	*0.3*	*0.62*
Mesial bone loss around left canine area	*20*	*1.14*	*0.12*	*0.3*	*0.62*

Table 2. Measurement of crestal bone loss in 20 patients with tissue-level implants.

Variable	Number	Maximum	Minimum	Standard deviation	Mean
Implant Attach gingiva of right canine area	20	5	0	0.26	1.89
Implant Attach gingiva of first canine area	20	3	0	1.03	1.38
Implant Attach gingiva of right canine area	20	4.5	0.25	1.21	1.65

Table 3. Measurement of crestal bone loss in 20 patients with bone-level implants.

Variable	Number	Maximum	Minimum	Standard deviation	Mean
Distal bone loss around right canine area	20	2.71	0.11	0.57	0.78
Mesial bone loss around right canine area	20	1.65	0.11	0.44	0.74
Distal bone loss around first canine area	20	1.68	0.12	0.47	0.75
Mesial bone loss around first canine area	20	1.76	0.15	0.46	0.77
Distal bone loss around left canine area	20	2.35	0.12	0.56	0.76
Mesial bone loss around left canine area	20	1.87	0.11	0.47	0.78

Table 4. Amount of attached gingiva in 20 patients with bone-level implants.

Variable	Number	Maximum	Minimum	Standard deviation	Mean
Implant Attach gingiva of right canine area	20	4	0	1.26	2.11
Implant Attach gingiva of incisal area	20	4	0	1.24	1.75
Implant Attach gingiva of right canine area	20	3	0	1.03	2.2

Table 5. Mean, standard deviation and standard error of variables in patients with bone-level and tissue level implants.

Variable	Type of implant	Mean	Standard deviation	Standard error	P-value
Distal bone loss around right canine area	Tissue-level:	0.65	0.35	0.08	0.41
	Bone-level:	0.78	0.57	0.13	
Mesial bone loss around right canine area	Tissue-level:	0.62	0.34	0.08	0.34
	Bone-level:	0.74	0.44	0.09	
Distal bone loss around incisal canine area	Tissue-level:	0.69	0.35	0.08	0.65
	Bone-level:	0.75	0.47	0.1	
Mesial bone loss around first incisal area	Tissue-level:	0.7	0.34	0.08	0.63
	Bone-level:	0.77	0.46	0.1	
Distal bone loss around left canine area	Tissue-level:	0.62	0.29	0.07	0.33
	Bone-level:	0.76	0.56	0.12	

Variable	Type of implant	Mean	Standard deviation	Standard error	P-value
Mesial bone loss around left canine area	*Tissue-level:*	*0.62*	*0.29*	*0.07*	*0.21*
	Bone-level:	*0.78*	*0.47*	*0.11*	
Implant Attach gingiva of right canine area	*Tissue-level:*	*1.89*	*1.26*	*0.28*	*0.58*
	Bone-level:	*2.11*	*1.26*	*0.28*	
Implant Attach gingiva of first incisal area	*Tissue-level:*	*1.38*	*1.03*	*0.23*	*0.31*
	Bone-level:	*1.75*	*1.24*	*0.28*	
Implant Attach gingiva of left canine area	*Tissue-level:*	*1.65*	*1.21*	*0.27*	*0.13*
	Bone-level:	*2.2*	*1.03*	*0.23*	

Table 6. The minimum, the maximum, mean, standard deviation of bone changes in bone-level and tissue-level implants after the first year.

Variable	Number	Maximum	Minimum	Mean	Standard deviation
Distal bone loss around right canine area	*9*	*0.14*	*0.92*	*0.45*	*0.22*
Mesial bone loss around right canine area	*9*	*0.12*	*1.12*	*0.47*	*0.29*
Distal bone loss around first incisal area	*9*	*0.11*	*0.92*	*0.42*	*0.25*
Mesial bone loss around left canine area	*9*	*0.12*	*0.88*	*0.43*	*0.23*
Distal bone loss around left canine area	*9*	*0.13*	*0.95*	*0.41*	*0.23*
Mesial bone loss around left canine area	*9*	*0.12*	*1.03*	*0.41*	*0.27*
Implant Attach gingiva of right canine area	*9*	*0.25*	*5*	*1.72*	*1.59*
Implant Attach gingiva of left incisal area	*9*	*0*	*3*	*1.41*	*1.13*
Implant Attach gingiva of left canine area	*9*	*0*	*4.5*	*1.16*	*1.52*

Table 7. The minimum, the maximum, mean, standard deviation of bone changes in bone-level and tissue-level implants after the second year.

Variable	Number	Maximum	Minimum	Mean	Standard deviation
Distal bone loss around right canine area	*17*	*0.11*	*2.71*	*0.79*	*0.59*
Mesial bone loss around right canine area	*17*	*0.11*	*1.65*	*0.68*	*0.39*
Distal bone loss around first incisal area	*17*	*0.12*	*1.45*	*0.75*	*0.36*
Mesial bone loss around left incisal area	*17*	*0.15*	*1.52*	*0.77*	*0.38*
Distal bone loss around left canine area	*17*	*0.12*	*2.35*	*0.75*	*0.5*
Mesial bone loss around left canine area	*17*	*0.11*	*1.63*	*0.71*	*0.36*
Implant Attach gingiva of right canine area	*17*	*0.5*	*4*	*2.23*	*1*
Implant Attach gingiva of left incisal area	*17*	*0*	*4*	*1.89*	*1.15*
Implant Attach gingiva of left canine area	*17*	*1*	*3*	*2.44*	*0.63*

Table 8. The minimum, the maximum, mean, standard deviation of bone changes in bone-level and tissue-level implants after the third year.

Variable	*Number*	*Maximum*	*Minimum*	*Mean*	*Standard deviation*
Distal bone loss around right canine area	*12*	*0.23*	*1.36*	*0.7*	*0.36*
Mesial bone loss around right canine area	*12*	*0.27*	*1.45*	*0.73*	*0.41*
Distal bone loss around first incisal area	*12*	*0.22*	*1.68*	*0.85*	*0.46*
Mesial bone loss around first incisal area	*12*	*0.28*	*1.76*	*0.88*	*0.45*
Distal bone loss around left canine area	*12*	*0.22*	*1.98*	*0.79*	*0.45*
Mesial bone loss around left canine area	*12*	*0.28*	*1.87*	*0.87*	*0.45*
Implant Attach gingiva of right canine area	*12*	*0*	*4*	*1.87*	*1.36*
Implant Attach gingiva of first incisal area	*12*	*0*	*4*	*1.25*	*1.15*
Implant Attach gingiva of left canine area	*12*	*0*	*3*	*1.77*	*1.1*

Table 9. The minimum, the maximum, mean, standard deviation of bone changes in bone-level and tissue-level implants after the fourth year.

Variable	*Number*	*Maximum*	*Minimum*	*Mean*	*Standard deviation*
Distal bone loss around right canine area	*2*	*1.1*	*1.24*	*1.17*	*0.09*
Mesial bone loss around right canine area	*2*	*0.9*	*1.38*	*1.14*	*0.33*
Distal bone loss around first incisal area	*2*	*0.52*	*1.34*	*0.93*	*0.57*
Mesial bone loss around first incisal area	*2*	*0.58*	*1.22*	*0.9*	*0.45*
Distal bone loss around left canine area	*2*	*0.82*	*0.9*	*0.86*	*0.05*
Mesial bone loss around left canine area	*2*	*0.84*	*0.94*	*0.85*	*0.12*
Implant Attach gingiva of right canine area	*2*	*1*	*3*	*2*	*0.41*
Implant Attach gingiva of first incisal area	*2*	*0.5*	*2*	*1.25*	*0.06*
Implant Attach gingiva of left canine area	*2*	*0.75*	*3*	*1.87*	*1.59*

Conclusions

Both bone-level and tissue-level implants can be successfully used for supporting mandibular overdentures. The amount of cervical bone loss was clinically acceptable in both groups (in a period of one to four years with an average of 2.1 years), the treatment success rate was 100%, and no treatment failure was observed. It is recommended that clinicians choose the type of implant according to their clinical needs and judgement.

Conflict of Interest

There is no conflict of interest to declare.

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