Analysis of factors affecting crestal bone loss around the implants

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• Abstract

Purpose : To determine whether peri-implant crestal bone loss could be affected by systemic disease, primary ISQ value, implantation method (submerged vs. non-submerged), surface treatment, and bone density

Materials and methods : Patients who underwent fixture installation from June 24, 2005 to October 23, 2008 at Seoul National University Bundang Hospital were evaluated. A total of 157 patients (male: 52, female: 85) had 346 fixtures installed. Among them, 49 patients had periapical radiographs taken 1 year after prostheses were first set. A total of 97 fixtures were implanted. In particular, 30 fixtures were installed in patients with systemic diseases such as diabetes mellitus, cardiovascular disease, hypertension, and liver disease. The immediate stability of implants was measured with Osstell™. Implant surface treatment was classified into two groups (RBM, Cellnest (Anodized)), and bone density, into four groups (D1~D4). The bone resorption on the mesial and distal areas of fixtures was measured with periapical radiographs using the paralleling technique, and the mean value was calculated. The length determination program in IMPAX (AGFA, Belgium) was used.

Results : At least 332 out of 346 (96%) installed GS Ⅱ implants were successfully osseointegrated 1 year after prostheses were first set. The mean value of the bone resorption of the installed GS Ⅱ implants was 0.44mm. The minimum value was 0mm, and the maximum value, 2.85mm. There was a statistically significant difference between the implantation methods (submerged, non-submerged) with regard to the amount of alveolar bone loss 1 year after prostheses were first set ($p<0.05$). Non-submerged implants showed less crestal bone loss. Note, however, that other variables had no correlation with crestal bone loss ($p>0.05$).

Conclusion : There was a statistically significant difference between the 1-stage method and 2-stage method with regard to the amount of alveolar bone loss 1 year after prostheses were first set. Systemic disease, primary ISQ value, surface treatment, and bone density were not associated with alveolar bone loss. Other variables were assumed to have a correlation with alveolar bone loss.

• Keywords : crestal bone loss, implant

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Introduction

Upon placement, an implant has to be maintained in stable state without external force for a fixed period of time to allow the peripheral osteocyte and veins to form the bone and integrate with the surface of the implant. Prosthetic restoration takes place after successful osseointegration; resorption will proceed gradually over time after the prostheses begin to function. In 1986, Albrektsson, et al, suggested the standard for successful implant, i.e., 1.5mm or less bone loss in the first year after implant placement and 0.2mm or less vertical bone loss a year later[1].

There are many elements that can accelerate the resorption of alveolar bone, and they can be categorized into systemic factors such as whether the patient has systemic disease and local factors such as surface treatment of implant, obesity, and inflammation around the implant.

The initial failure of implant is generally accepted to be caused mainly by the "failure of close contact between bone and implant." Likewise, both systemic factors and local factors can interrupt primary cell reaction[2,3]. On the other hand, the post-failure of implant and bone resorption are related to overload or inflammation around the implant due to microbial infection[4].

The primary placement of implant can be divided into one-stage surgery and two-stage surgery. In the past, it was considered natural that the top area of the implant be covered with soft tissue during osseointegration to minimize the infection, the apical proliferation of the epithelium. So two-stage surgery was general. Symptoms such as infection, mobility, and resorption were considered to have been caused by the exposure of the implant inside the oral cavity. Note, however, that recent studies reported no large difference between one-stage surgery and two-stage surgery[5-9].

This study performed a comparative analysis on bone resorption 1 year after prostheses placement for Osstem GSⅡ (Osstem, Korea) Implant to examine the post-resorption of bones around the implant and correlations between a number of elements.

Materials and Methods

Patients who went through the Osstem GSⅡ Implant (Osstem, Korea) placement surgery from June 2005 to October 2008 were surveyed. There were a total of 157 patients (72 males, 85 females), and a total of 346 implants were placed. At least 49 patients had periapical radiograph 1 year after prostheses placement (28 males, 21 females), with a total of 97 implants placed. The survey on the survival rate targeted all patients, and the resorption of the alveolar bone was measured for patients whose periapical radiograph remained 1 year after prostheses placement.

A total of 30 implants were placed in patients with systemic disease. Diseases were classified into diabetes, cardiovascular disease, high blood pressure, and liver disease. The initial stability during placement was measured with Osstell Mentor™ and was categorized into 10 steps from the minimum value of 30. Surface treatment was divided into two categories: RBM and CellNest (Anodized). Bone substance was measured based on the feel of the surgeon and categorized into D1~D4. A total of 62 implants were placed in 1-stage surgery (non-submerged), and at least 35 implants, in two-stage surgery (submerged).

To measure bone resorption, the distance between the first screw thread to the very top of the resorbed alveolar crest as represented in the parallel periapical radiograph was measured; alveolar bone resorption on the mesial and distal sides was measured with the distance measurement program of IMPAX (Agfa, Belgium), with the average recorded (Fig. 1).

SPSS 12.O (LEAD Technology, USA) was used for statistical calculation. The Kruskal-Wallis method was used to measure change in bone resorption due to systemic disease and initial stability, and the Mann-Whitney method, to measure change in bone resorption due to surface treatment. Independent T-test was utilized to measure the difference between one-stage surgery and two-stage surgery,

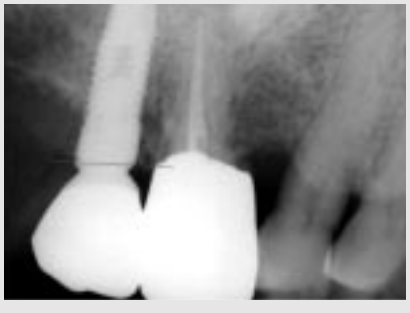

Fig 1. Method of measuring crestal bone loss. On the mesial and distal sides, the resorption volume of the implant fixture top and the first bone contact area was measured. The average was then calculated.

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Table 1. Systemic disease and crestal bone loss (Kruskal-Wallis) (p = 0.263)

Systemic Disease	n	Bone Loss (mm)	S.D.
None	67	.42	.53
Liver disease	2	0	0
Cardiovascular disease	16	.32	.31
Diabetes mellitus	10	.62	.84
Hypertension	2	1.58	1.80

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with the statistical significance of the difference in bone resorption due to the change in bone substance verified through ANOVA. Note, however, that the post-hoc test was not performed since it did not have statistical significance. The test was considered to have statistical significance in case the P value was smaller than 0.05.

Results

At least 332 out of the 346 GS Ⅱ implants (96%) placed survived 1 year after prostheses placement.

Alveolar bone resorption was measured to be a minimum of 0mm to a maximum of 2.85mm and 0.44mm on the average 1 year after prostheses placement.

There was no significant difference in bone resorption between systemic patient groups. Patients without any disease (n=67) showed 0.42mm (s.d.=0.53) of bone resorption on the average, whereas patients with liver disease (n=2) recorded 0mm. Patients with cardiovascular disease (n=16) exhibited 0.32mm (s.d.=0.31) of bone resorption, diabetics (n=10) recorded 0.62mm (s.d.=0.84), and hypertensives (n=2) showed 1.58mm (s.d.=1.80). Hypertensives showed a relatively large difference compared to other groups, but such was not statistically significant due to the small number of patients (p = 0.263). (Table 1)

Table 2. ISQ value (measured at 1st surgery) and crestal bone loss (Kruskal?Wallis) (P = 0.122)

ISQ (1st surgery)	n	Bone Loss (mm)	S.D.
30~39	6	.43	.74
40~49	4	1.28	1.08
50~59	9	.49	.49
60~69	26	.49	.58
70~79	32	.43	.60
80~89	18	.23	.26

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ISQ during placement was categorized into 30~39(n=6), 40~49(n=4), 50~59(n=9), 60~69(n=26), 70~79(n=32), and 80~89(n=18); resorption decreased when ISQ increased excluding the 30~39 sections, but the difference was not statistically significant (p value = 0.122). (Table 2)

Bone resorption due to implant surface treatment did not show any statistically significant difference 1 year after prostheses placement (p value = 0.555). (Table 3)

Bone resorption due to the difference in placement method (one-stage surgery, two-stage surgery) showed a statistically significant difference 1 year after prostheses placement, with the one-stage surgery exhibiting less resorption (p value = 0.016). (Table 4)

Bone resorption due to the difference in bone substance as felt by the surgeon 1 year after prostheses placement did now show any statistically significant difference (p value = 0.636). (Table 5)

Table 3. Surface treatment and crestal bone loss (Mann-Whitney) (P = 0.555)

Surface Treatment	n	Bone Loss (mm)	S.D.
RBM	87	.46	.60
Anodized (Cellnest)	8	.31	.37

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Table 4. Implantation method and crestal bone loss (T-test) (P = 0.016*)

Implantation Method	n	Bone Loss (mm)	S.D.
1-stage	35	.28	.28
2-stage	62	.53	.69

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Table 5. Bone density and crestal bone loss (ANOVA) (P-value = 0.636)

Bone Quality	n	Bone Loss (mm)	S.D.
D1	12	.25	.33
D2	28	.45	.58
D3	24	.43	.64
D4	33	.51	.63

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Discussion

Bone resorption is known to take place mainly during the first year after prosthesis placement, decreasing considerably after the prosthesis is stabilized[10]. There is no precise known cause for initial bone resorption around the implant, but some studies suggested that it could be caused by the interruption of blood circulation due to the external injury made during surgery[11, 12]. Moreover, some studies cited other possible causes such as overload, biological width, and crest module[13]. Other studies reported that bone resorption around the implant was caused by the gap between the implant and the abutment[14] and suggested a technique such as platform switching based on the study results. Bone loss within the first year of placement of the top prosthesis can be caused by the combination of local or systemic factors, although the cause is not precisely known in many cases.

In this study, whether or not the patient had systemic disease did not appear to have influenced bone resorption 1 year after prosthesis placement. Other studies that examined the relationship between systemic diseases and implant success rate and bone resorption found statistically significant difference in the rate of occurrence of complications between patients with systemic disease and healthy patients and reported that the rate of occurrence of complications was especially high in hypertension, cerebrovascular disease, and psychiatric disease groups. Note, however, that there was no significant difference in bone resorption 1, 2, or 3 years after the surgery between patients with systemic disease and healthy patients[15].

There was no study that examined the relationship between cardiovascular disease and implant failure[16]. Moy, et al reported that implant placement was not a clear contraindication for patients with cardiovascular disease[17]. For cerebrovascular disease, the person is only considered a patient 6~12 months after the initial treatment period; the patient should not receive any stress including surgical operations within 3~6 months of the stabilization period. Otherwise, ischemic complications may occur. Furthermore, some studies reported that the normal removal of implant was closely related to the mental factor, although there were no biological evidences supporting the finding that more implant failures are found in mental patients.

Osstell™ is used to measure the stability of the implant; it is called resonance frequency analyzer. As the principle of operating this device, it applies vibration to the bone-implant interface and measures the rebound. The measured value is called ISQ (implant stability quotient). When the interface grows, ISQ decreases[18]. The initial stability did not have a significant relationship with bone resorption 1 year after prosthesis placement, but bone resorption appeared to be less given higher initial ISQ excluding the ISQ 30~39 sections.

The surface treatment of the implant is known to have an impact on the cell reaction speed. The anodizing surface makes a porous crater-like surface structure by electrochemically anodizing the metal substrate on the titanium surface. RBM (resorbable blasting media) creates a rough surface by spraying materials that can be absorbed inside the body such as HA (Hydroxyapatite: Ca10(PO4)6(OH2)) powder on to the titanium surface; it was developed to resolve the problem of aluminum oxide. Used to be applied as spray material, aluminum oxide can have a negative impact on osseointegration in case it is not completely eliminated. The study that examined the association between surface treatment and wettability reported less wettability and implant removal torque obtained given greater surface contact angle of moisture. On the other hand, better wettability and removal torque were obtained with smaller surface contact angle. Some studies reported that the anodized surface had the best wettability, and the machined surface, the worst[19]. Moreover, some studies reported a significant difference in bone resorption around the implant after functioning between the implant with machined surface and implant with anodized surface and claimed more bone resorption was found with the machined surface implant[20]. We could not find any articles that had been studied the significant difference in bone resorption between the anodized implant and RBM-treated implant.

In this study, the one-stage surgery and two-stage surgery showed significant differences in crestal bone resorption, with less bone resorption observed in the one-stage surgery. Other studies that surveyed the success rate of implants did not find huge differences in the changes taking place in the peripheral bones after the application of two surgery methods[21, 22]; neither did they find significant differences in the resorption of alveolar crestal bone[23]. The implant placement is divided into the one-stage surgery and two-stage surgery according to exposure. One-stage surgery is popularly applied since it does not require additional

surgery, requiring short recovery period and having little difference in the success rate compared with the two-stage surgery. Note, however that some studies claimed that one-stage surgery and two-stage surgery had similar success rates, although two-stage surgery tended to show lower failure rate, more so with completely edentulous patients. Accordingly, studies recommended one-stage surgery, which involved less surgery and fast recovery for partially edentulous patients who are less affected by the additional external force, and two-stage surgery, for completely edentulous patients who are likely affected by external force or patients who did not achieve initial stability[24].

This study did not show significant difference in bone resorption due to the bone substance identified by the surgeon (Lekholm & Zarb, 1985) 1 year after prostheses placement. Bone quality and quantity are two important elements in establishing an appropriate treatment plan and obtaining sufficient surface contact. According to studies, the weight applied to the implant is an important element in crestal bone loss[25-28]; the weight on the implant can be distributed through sufficient surface contact. Some studies reported that placing an implant with a special design that allows sufficient surface contact in inferior bone substance such as D4 will help prevent alveolar bone resorption and reduce failures[29].

One of the limitations of this study was that it could not standardize the variables influencing bone resorption. In other words, long-term, more systematic studies must be conducted on the elements influencing the resorption of the bone around the implant after standardizing a number of variables such as the type of surgical methods, bone graft material, type of bio-materials such as barrier membrane, type of upper prostheses, and condition of antagonist teeth.

Conclusion

This study did not find statistically significant difference in the peripheral bone resorption of the implant 1 year after prostheses placement due to the existence of systemic disease, initial fixed value, and surface treatment. Likewise, statistically significant difference in bone resorption due to the placement method (one-stage surgery, two-stage surgery) was found, with one-stage surgery showing less resorption.

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