The long-term clinical stability of implants placed with ridge splitting technique

[1]Department of Periodontology, National health insurance corporation, Ilsan hospital, Goyang, Korea
[2] Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry, Seoul, Korea
Jae-Min Yoon[1], Young-taek Kim[1], Yong-ju Jang[2], Jung-chul Park[2], Seong-ho Choi[2], Kyoo-sung Cho[2], Chang-sung Kim[2]

INTRODUCTION

After the loss of teeth, the vertical and horizontal absorption of alveolar bone is in progress [1]. If a tooth is extracted due to severe periodontitis, physical trauma, or vertical root fracture or if the facial bone plate suffers a traumatic injury during extraction, the apparent absorption of alveolar bone occurs horizontally and vertically, making ideal implant placement impossible [2]. When the implant cannot be placed in an ideal location due to absorption of alveolar bone, there will be a the negative effect on emergence profile, bucco-palatal relationship, and embrasure space, which can affect the future of implant-supported restorations in esthetics and function [2-3].

There must be at least 1mm bone surrounding the implant for a favorable clinical outcome [4]. Therefore, the evaluation of the residual ridge dimension must be performed through preoperative clinical and radiographic examination. If there is lack of the width of the residual ridge for implant placement, the clinicians should determine the surgical procedures to overcome the insufficient ridge dimension before implant surgery [5].

There are several procedures that have been suggested for lateral augmentation of the residual ridge, for example guided bone regeneration (GBR), onlays of bone grafting material, and distraction osteogenesis. These methods have several drawbacks. The drawbacks of GBR procedures are membrane collapse, membrane exposure, increased treatment cost to the use of membrane and delayed implant treatment time [6-9]. The drawbacks of bone grafting are a morbidity of the autogenous bone donor site, absorption of graft materials and delayed treatment time [8]. Use of distraction osteogenesis for lateral bone augmentation, which requires a device to improve bone defects, is faced with unavoidable elevated treatment cost a limited area on which to apply this technique.

In addition to these methods, ridge splitting is used for expansion of insufficient width of residual ridge. Crestal osteotomy is performed first on the residual ridge crest for ridge splitting by surgical blade, hand instrument, microsaw[10], or ultrasonic device[9]. After crestal osteotomy, the ridge expansion is performed with an osteotome, bone chisel, and bone spreader. When the width of ridge is properly expanded, implant placement is done simultaneously. Generally, the type of implant used with ridge splitting technique is a submerged implant. Ridge splitting was firstly introduced by Tatum (1986)[11]. Subsequently, the clinical application of modified ridge splitting techniques have been reported by many researchers [9-10, 12-15]. Therefore, the ridge splitting technique has been mentioned as a ridge expansion, bone spreading, osteotome technique [5].

The ridge splitting technique, unlike the GBR and bone graft procedures, enables implant placement simultaneously, thereby shortening treatment time [5]. The healing between separated bone plates is similar to that of a bone fracture, so additional bone grafts or barrier membrane applications on furrows is not always necessary when the ridge splitting technique is applied [13, 16].

The evaluation of vertical and horizontal bone change around the implant is regarded as an important measure

Corresponding author: **Dr. Chang- Sung Kim**
Department of Periodontology, Research Institute for Periodontal Regeneration, College of Dentistry, Yonsei University, 134 Shinchon-Dong, Seodaemun-gu, Seoul 120-752, South Korea.
Tel: +82-2 2228-3186, Fax: +82-2-392-0398. Email: dentall@yuhs.ac

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of implant success [17-18]. The success criteria of the Brånemark implant was suggested to be that marginal bone loss is less than 1mm at the 1st year after implant installation and thereafter less than 0.2 mm marginal bone resorption annually [19]. With regard to ITI implant (non-submerged implant), marginal bone resorption in the first year after placement was reported as 0.8 mm on average [20]. However, reports about long-term marginal bone change around implants placed with the ridge splitting technique have been limited.

The purpose of this study is to evaluate the long-term clinical stability of the ridge splitting technique, through the investigation of the survival rate and marginal bone loss of implants.

MATERIALS AND METHODS

Inclusion criteria and demographics

From October 2000 to July 2004, the patients who underwent implant placement at the Department of Periodontology, College of Dentistry, Yonsei University, were selected. The inclusion criteria were as followed: (1) ridge splitting technique was performed to place implants; (2) a minimum follow-up period of 1 year after implant placement; (3) a prosthetic procedure was done on the implants; (4) graft material, type of implant used, occurrence of complication during procedure were clearly recorded. According to inclusion criteria, the total number of patients was 20 (7 males and 13 females) with 34 implants placed (Table 1).

■ Table 1. Demographic description.

Subjects	20 patients (34 implants)
Gender	Male:Female = 7:13
Mean age (years)	33 (range: 17~62)
Mean follow up period (years)	4.2±2.1

Brånemark MKIII® (Nobel Biocare, Goteborg, Sweden), ITI® (Straumann Dental Implants; Institute Straumann AG, Waldenberg, Switzerland), Replace® (Nobel Biocare, Goteborg, Sweden), and 3i Osseotite® (Implant innovations, Palm Beach Gardens, FL, USA) were used in this study. Twenty, eight, four and two implants of those types were placed, respectively. ITI® implants were placed with a non-submerged approach. The other system implants were placed with a submerged approach. A second surgery was performed on submerged implants for healing abutment connection after average of 5.3±3.7 months of healing period. A prosthetic procedure was performed at an average of 7.9±3.0 months after placement. The average follow-up period was 4.2±2.1 years.

The mean diameter of the implants placed in this study was 3.95 ± 0.37 mm (3.3 mm~5.0 mm). A 4 mm diameter implant (n=18) was used most frequently. The mean length of the implants placed in this study was 11.87±1.26 mm (8.5 mm~13 mm). A 12mm long implant (n=18) was used most frequently (Table 2).

■ Table 2. Distribution of implant diameter and length.

Diameter (mm)	No. of implant	Length (mm)	No. of implant
3.3	4	8.5	1
3.5	3	10	6
4.0	18	11.5	8
4.1	6	12	15
4.3	1	13	5
4.8	1		
5.0	1		

The distribution of implants was as follows: (1) 18 implants were placed at the maxilla (13 implants were placed in the anterior region and 5 implants in the posterior region). (2) 16 implants were placed at the mandible (8 implants were placed in the anterior region

■ Table 3. Site distribution of the ridge splitting technique according to jaw.

Mx	Right	Left	Mn	Right	Left
Central incisor	2	2	Central incisor	1	3
Lateral incisor	4	3	Lateral incisor	2	1
Canine	1	1	Canine		1
1st premolar	1	1	1st premolar	2	1
2ndpremolar	1	2	2ndpremolar	1	1
1st molar			1st molar	1	1
2nd molar			2nd molar		1

■ Table 4. Complications during procedures.

Distribution (tooth number)	Complication	Type ofImplant system	Treatment modality for managing complications
#11	Buccal fenestration	Replace®	Bone graft
#11	Buccal fenestration	Brånemark MK Ⅲ®	Bone graft
#15	Buccal dehiscence	3i Osseotite®	Bone graft
#25	Buccal dehiscence	3i Osseotite®	Bone graft
#22	Buccal bone plate fracture	Brånemark MK Ⅲ®	GBR

and 8 implants in the posterior region). Overall, the number of implants placed in the anterior region was larger than in posterior region (21 out of 34 implants) (Table 3).

In this study, complications during procedures occurred with 5 implants. Dehiscence occurred with 2 implants, penestration with 2 implants, buccal bone plate fracture with 1 implant (Table 4).

Surgical procedure

In all patients, prophylactic antibiotics were given before surgery. Local anesthesia was achieved by infiltrating lidocaine 2% containing 1:100,000 epinephrine. A soft tissue incision was made to create a full and partial-thickness flap in the surgical sites (Fig. 2A). If necessary, an anterior and posterior vertical releasing incision was made. Crestal osteotomy was performed at residual ridge with various surgical instruments, for example an oscillating surgical bur, rotary instrument, a guide drill and a number 15 surgical blade (Figs. 1A and 2B). In some cases, vertical osteotomy at the adjacent remaining tooth area was made in order to facilitate the expansion of the residual ridge and to prevent the fracture of the buccal bone plate during expansion. A bone chisel (Stoma®, Germany), bone spreader (Meisinger®, USA), and osteotome (3i®, Implant Innovations, Palm Beach Garden, FL, USA) were applied sequentially to expand the residual ridge through the induction of a green stick fracture of the buccal bone plate (Figs. 1B and 2C). After the residual ridge was expanded appropriately, osteotomy for the implant placement was done with drills and an osteotome. Then, implants were placed (Figs. 1C and 2D). If complications, like dehiscence, penestration, and bone fracture, occurred at the surgical area during implant placement, GBR and bone graft were applied to cope with the complications. The flap was replaced and sutured in a tension free state (Fig. 1D). Stitches were removed after 10~14 days postoperative (Fig. 2E). Patients were asked to rinse with chlorhexidine 0.12% three times daily for 2 weeks postoperative. In submerged implants, a few months healing period was allowed prior to the second surgery.

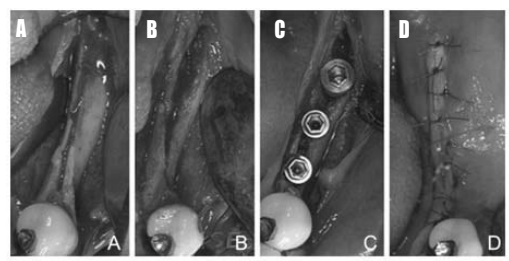

Fig. 1. Submerged implants were placed at #35, 36, 37.
(A) After crestal osteotomy.
(B) After Ridge expansion was performed.
(C) Implants were placed into expanded ridge.
(D) After suturing.

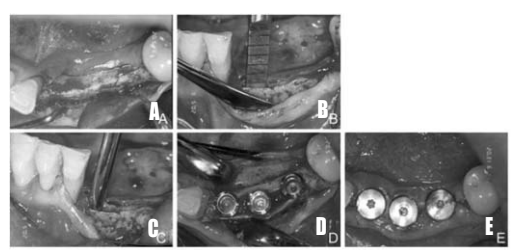

Fig. 2. Non-submerged implants were placed at #32, 33, 34.
(A) Flap was opened.
(B) Crestal osteotomy with bone chisel.
(C) Ridge widening with bone spreader.
(D) Implant was placed.
(E) After stitches were removed.

Analysis methods

Measuring of marginal bone loss

Implant marginal bone loss around the implant was evaluated using periapical radiographs that were taken on the day of the implant placement and on the follow-up visit. The distance from a reference point at the implant to the most coronal point where the marginal bone contacts the implant was measure. Measurements were made mesially and distally of each implant. In order to calibrate dimensional magnitude, the apparent dimension of each implant was measured in the radiograph and compared with the real implant length [21]. For submerged implants, the fixture-abutment junction, plat-top of implant, was used as the reference point [22]. For ITI® implants, the margin of rough surface was used as the reference [23] (Fig. 6). ITI® implants were inserted with the margin between the rough and smooth surface level with the alveolar crest. However, this margin was not discernible on radiographs. Measurement was performed at the shoulder of implant. The margin between the rough and smooth surface was situated 2.8 mm from the shoulder of the implant (1.8 mm for the standard plus ITI®implants). Therefore, the marginal bone loss of ITI® implants was determined by subtracting the distance of the smooth surface (2.8 mm or 1.8 mm) from the calibrated measurements.

The periapical radiographs were converted to JPEG image files using the PACS system of the dental hospital of Yonsei University to measure the distance from the reference point of the implant to the first visible marginal bone contact on computer monitor (Fig. 3). The marginal bone loss was measured in 0.1 mm increments.

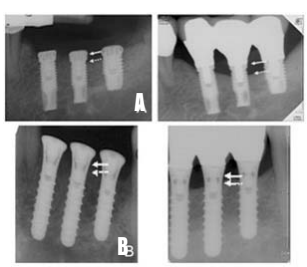

Fig. 3. Periapical radiographs of implants.
(A) Submerged implant (Left: the day of surgery, Right: 6.4 years after implant placement). Marginal bone loss of distal side of #36 implant was 1.41 mm.
(B) Non-submerged implant. Marginal bone loss of distal side of #33 implant was not occurred (Left: the day of surgery, Right: 7 years after implant placement). (arrow: reference point, dotted arrow: most coronal point of bone to implant contact).

Evaluation of implant survival rate

In this study, the criteria for implant survival were used as proposed by Buser et al. (1990) 24). The criteria are as followed: (1) Absence of persistent subjective complaints, such as pain, foreign body sensation, or dysanaesthesia; (2) Absence of a recurrent peri-implant infection with suppuration; (3) Absence of mobility; and (4) Absence of a continuous radiolucency around the implant.

Statistical evaluation

For statistical evaluation, the paired T-test was performed using the EXEL program (Microsoft®, USA): (1) between non-submerged implants and submerged implants; and (2) between implants that had complications during the procedure and implants that had no complications. A P-value < 0.05 was considered to be statistically significant.

For review of implant survival rate, the Keplan-Meier survival analysis was assessed.

RESULTS

Marginal bone loss of implants

The mean marginal bone loss of implants in this study was 1.57±1.44 mm at the mesial side and 1.42±1.48 mm at the distal side. In the non-submerged ITI® implants (n=8), the mean marginal bone loss was 1.17 ±0.76 mm and 0.70±0.82 mm on the mesial and the distal sides, respectively. In the submerged implants (n=26) the loss was 1.74±1.40 mm and 1.59±1.41 mm on the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant (P>0.05) (Table 5). In complicated implants (n=5), the mean marginal bone loss was 1.73±1.24 mm and 1.90±1.22 mm on the mesial and the distal sides, respectively. In non-complicated implants, the mean marginal bone loss was 1.57±1.31 mm and 1.26 ±1.35 mm on the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant (P>0.05) (Table 6).

Survival rate of implants

The implant survival rate during an average follow-up period of 4.2±2.1 years was 100% regardless of the implant system and complications (Table 7).

DISCUSSION

The ridge splitting technique is a useful approach for implant placement in sites where the width of the residual ridge is insufficient due to progressed bone resorption. Since first reported in 1986 by Tatum [11], various modified procedures have been reported. Simion et al. (1992) reported the split crest technique in 5 patients [12]. They were able to gain 1~4 mm of the alveolar ridge width by a split-ridge crest technique and guided tissue regeneration at the same time. Scipioni et al. (1994) reported the ridge expansion technique [13]. In that study, the ridge expansion technique involved a partial thickness flap, crestal and vertical osteotomy, and buccal displacement of the buccal cortical plate, including a portion of the underlying cancellous bone. Implants were placed in the expanded ridge and allowed to heal for 4~5 months. They installed 329 implants in 170 patients and found that the survival rate of implant over 5 years was 98.8%. But, they did not report the marginal bone loss around implants. Sethi et al. (2000) placed 449 implants in 150 patients in the narrow edentulous ridge of the maxilla by the ridge expansion technique [15]. After crestal osteotomy was done, they used an osteotome and D-shaped ridge expander for ridge expansion. The implants were followed up for 5 years after the placement. They found that the implant survival rate was 97%. Blus et al. (2006) used the piezosurgery for the ridge splitting [9]. They placed 220 implants in 57 patients and evaluated the implant survival rate with life table analysis. After 3 years of functional loading, the cumulative implant survival rate was 100%. In this study, 34 implants in 20 patients were placed with the ridge splitting technique. During an average follow-up period of 4.2 years, the cumulative survival rate was 100%. These results are similar to other previous studies.

The ridge splitting technique, unlike guided bone regeneration and bone graft, allows the implant to be placed at the same time. The placed implant with the ridge splitting technique is covered with a split ridge (dense bone plate), and the healing of the furrow between the split plates is similar to that of fractured bone [25]. If primary closure of the flap is obtained over the furrow, a bone graft into the furrow is not necessary. At least 3mm of the residual ridge is needed for the ridge splitting technique because cancellous bone must exist between cortical bone plates for bone expansion 5, [10]. To maintain the vitality of the separated buccal bone plate through the ridge splitting procedure, an adequate blood supply is essential. If the blood supply from buccal periosteal flap and endosteal blood supply to the split buccal bone plate are blocked at the same time, the resorption of the buccal bone plate may be unavoidable even though a bone graft is applied into the furrow area. Thus, for successful clinical outcomes, it is necessary to minimize the amount of full-thickness flap on the buccal side [26].

Using the development of osseointegration to judge the ridge splitting technique is not an appropriate method. If apical fixation of implant occurs, the osseointegration between ridge splitting and bone graft is same. Therefore, in order to evaluate the width expansion success, the assessment of marginal bone resorption is a proper measure [26].

The assessment of marginal bone dimension around implants placed by the osteotome technique, like ridge splitting or ridge expansion, has been performed [27]. They used Osseotite®, Frialit-2®, Tiolox®, and ITI® implant systems. The total number of patients was 22, with 22 implants placed in their study. During the healing period of 6 months after placement, the mean loss of marginal bone was 0.8 mm. Then 6 months after functional loading, the marginal bone around the implants were reduced on average by 1mm. In another study, evaluation of the marginal bone dimension of ITI® TE implants, which were placed with ridge splitting technique and the submerged approach, was performed. During the 6 months after functional loading, the mean loss of marginal bone was 2.0 mm [9]. Evaluation of the marginal bone stability using 3 different flap approaches for the ridge splitting technique was performed [26]. Full-thickness flap, partial-thickness flap, and osteoperiosteal flap were applied with ridge splitting technique for widening the narrow ridges. "Osteoperiosteal flap" was flap reflection was performed on the crestal area only. A total of 81 implants were placed, of which 4 lost osseointegration. 45 implants were placed with partial-thickness flap reflection, 12 implants with full-thickness flap, and 20 implants with osteoperiosteal flap. Bone sounding with a probe and explorer was used to assess marginal bone stability. The assessment was performed 2 years after placement. Buccal bone loss of 2 mm or more was seen in 11 implants, 10 implants of which used the full-thickness flap reflection and 1 implant used an osteoperiosteal flap reflection. These results show that marginal bone stability is influenced by blood supply on different flap approaches and suggests that full thickness flap should not be reflected when ridge splitting is done.

In this study, during an average 4.2 year observation period after implant placement, the mean marginal bone loss around the implants was 1.57 mm and 1.42 mm at the mesial and the distal sides, respectively. In another study, the marginal bone loss around ITI® and Brånemark implants was evaluated. Implants were typically placed in partially edentulous maxilla. For the Brånemark implants, the fixture-abutment junction (plat top of implant) was used as the reference point for measurement. After 3 years of functional loading, the mean marginal bone loss from reference point was 1.8 mm on ITI® implants and 1.3 mm on Brånemark implants [22]. The result was similar to this study.

The comparison of marginal bone loss between the non-submerged ITI® implant and submerged implants was performed in this study. In the non-submerged ITI® implants (n=8), the mean marginal bone loss was 1.17 mm and 0.70 mm at the mesial and the distal sides, respectively. In submerged implants (n=26), 1.74 mm and 1.59 mm at the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant. Commonly, a submerged implant is used with the ridge splitting technique. However, the results of this study showed that non-submerged implants placed with the ridge splitting technique did not have a disadvantage of absorption of marginal bone loss. These results mean that if the initial stability of the implant is achievable and a primary flap closure can be obtained, the ridge splitting technique may be applied with non-submerged implant placement.

In this study, complications during implant placement occurred with 5 implants. Buccal dehiscence occurred with 2 implants, buccal bone fenestrations with 2 implants, and buccal bone fracture with 1 implant. The marginal bone loss of complicated implants was also investigated. In complicated implants, the mean marginal bone loss was 1.73 mm and 1.90 mm on the mesial and the distal sides, respectively. In non-complicated implants, the mean marginal bone loss was 1.57 mm and 1.26 mm on the mesial and the distal sides, respectively. The difference between complicated and non-complicated implants was not statistically significant. The reason may be that bone graft and barrier membrane were used to cope with complications.

Considering the results of this study, the ridge splitting technique is a predictable method to place implants at a narrow alveolar ridge. However, this study has the limitations that the number of implants investigated in this study is small, the follow-up period is not longer than other studies, and the study design is retrospective. Therefore, more researches are needed for evaluation the long-term stability of the ridge splitting technique.

Conclusion

1. During an average follow up period of 4.2years, the cumulative survival rate of implants placed with the ridge splitting technique was 100%.
2. The mean marginal bone loss of implants in this study was 1.57 ± 1.44mm at mesial side and 1.42 ± 1.48mm at distal side.
3. In non-submerged ITI® implants (n = 8), the mean marginal bone loss was 1.17±0.76mm and 0.70± 0.82mm on the mesial and the distal sides, respectively. In submerged implants (n = 26) the loss was 1.74± 1.40mm and 1.59±1.41mm on the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant ($p > 0.05$).
4. In complicated implants (n=5), the mean marginal bone was 1.73±1.24mm and 1.90±1.22mm on the mesial and the distal sides, respectively. In non-complicated implants, the mean marginal bone was 1.57 ±1.31mm and 1.26±1.35mm on the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant ($p > 0.05$).
5. Considering the results of this study, the ridge splitting technique is a predictable method to place implants at a narrow alveolar ridge.

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치조능 분리술을 이용해 식립된 임프란트의 장기간의 임상적 안정성

윤재민[1], 김영택[1], 장용주[2], 박정철[2], 최성호[2], 조규성[2], 김창성[2]

[1]국민건강보험공단 일산병원 치주과

[2]연세대학교 치과대학 치주과학 교실, 치주조직재생연구소

Purpose: The purpose of this study is to evaluate the clinical stability of implants placed with a ridge splitting technique through the investigation of the survival rate and marginal bone loss of implants.

Methods: 34 implants were placed in 20 patients with the ridge splitting technique. 8 out of 34 implants were placed with the non-submerged approach. 26 out of 34 implants were placed with the submerged approach. Guided bone regeneration (GBR) and bone graft were applied in 13 implants.

Results: A prosthetic procedure was performed on average 7.9 °æ 3.0 months after placement. The average follow up period was 4.2 °æ 2.1 years. During the follow up, the cumulative survival rate of implants was 100%. The mean marginal bone loss of implants was 1.57 °æ 1.44 mm at the mesial side and 1.42 °æ 1.48 mm at the distal side. In non-submerged implants, the mean marginal bone loss was 1.17 mm and 0.70 mm on the mesial and the distal sides, respectively. In submerged implants, the loss was 1.74 mm and 1.59 mm on the mesial and the distal sides, respectively. The difference between the two groups was not statistically significant ($P > 0.05$). Complications during implant placement surgery, buccal bone dehiscence, fenestration, and buccal bone plate fracture, occurred with 5 implants. In those implants, the mean marginal bone loss was 1.73 mm and 1.90 mm on mesial and distal sides, respectively. In implants without complications, the mean marginal bone loss was 1.57 mm and 1.26 mm on the mesial and the distal side, respectively. The difference between the two groups was not statistically significant ($P>0.05$).

Conclusions: Within limits of this study, considering the results of this study, the ridge splitting technique has a long-term clinical stability to place the implant at the narrow alveolar ridge. *[THE JOURNAL OF THE KOREAN ACADEMY OF IMPLANT DENTISTRY 2011;30(1):1-8]*

Keywords: Dental implant, Alveolar bone loss, Bone regeneration,Ridge splitting technique.