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# Survival rate and marginal bone change of INNO implants placed in augmented extraction sockets

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*Background:* The alveolar ridge undergoes reabsorption and atrophy subsequent to tooth removal and thus exhibits a wide range of dimensional changes. Preservation of the alveolar crest after tooth extraction is essential to enhance the surgical site before implant fixture placement. The aim of this clinical study is to investigate and compare the need for additional augmentation procedures at implant insertion, as well as the success rate and marginal bone loss for implants placed in the grafted sites versus those placed in naturally healed sites.
*Methods:* Twenty patients with hopeless tooth were allocated to: 1) a test group, receiving extraction and grafting synthetic bone. After 4 months of healing, implants were inserted in each of the sites. and 2) a control group, receiving extraction without any graft and having intact crestal bone. The implants were submerged and loaded at conventional loading time with metal–ceramic rehabilitation. The follow-up included evaluation of implant diameter and length, the need for additional augmentation procedures at implant placement, implant failure, and marginal bone level changes. All patients were followed in 1 year.
*Results:* The implant success rate at the 1-year follow-up visit reached 100% for both groups. No statistically significant differences were detected for marginal bone changes between the two groups.
*Conclusions:* It was concluded that implants placed into grafted extraction sockets exhibited a clinical performance similar to implants placed into non-grafted sites in terms of implant survival and marginal bone loss. However, grafted sites allowed implant placed in the normal position of ridge when compared to naturally healed sites.

*Key Words:*
Alveolar bone loss; bone substitutes; dental implants; survival rate.

The range of indications for implant dentistry has been broadened from fully- to partially-edentulous jaws. The replacement of a missing single tooth has become a frequent procedure with predictable outcomes.[1] The long- term stability of implants depends on the quality and quantity of the available alveolar bone. Limited loss of alveolar ridge height and width to a minimum provides a better site for placing dental implants. Moreover, the outcome of implant therapy is no longer evaluated in terms of implant survival alone but by favorable esthetic and functional results as well.[2] Such issues depend not only on the correct positioning of the implant to ensure an appropriate alignment of the restoration and an adequate emergence profile,[2] but also on the amount of bone available at the implant site to allow maximal support and stability of surrounding hard and soft tissue.[3,4]

It is well documented[5,6] that alveolar ridges exhibit resorptive changes after tooth removal. Alveolar bone loss can occur as a result of iatrogenic trauma while extracting teeth or natural post-extraction socket healing. The alveolar process is a tooth dependent tissue that develops in conjunction with tooth eruption. Subsequent to tooth extraction, the alveolar ridge undergoes reabsorption and atrophy, exhibiting a wide range of dimensional changes.[5,6] Although bone fill in the socket will continue for several months, it does not reach the level of adjacent teeth.[5-7] The reabsorbed ridges do not allow for appropriate pontic fabrication when conventional fixed prostheses are considered, nor do they permit the placement of endosseous implants in a favorable prosthetic position. Because ridge dimensions are so critical, preservation of the alveolar crest after tooth extraction is essential to maintain the vertical and horizontal dimensions of the alveolar ridge. Several studies have proposed various ridge-preservation approaches, including placement of different grafting materials and/ or use of occlusive membranes to avoid the tendency for soft-tissue invagination and the formation of fibrous tissue in the coronal portion of the alveolus.[8-12] Site preservation through socket grafting is a predictable procedure to enhance the surgical site before implant fixture placement. Bone substitutes have been used in attempts to avoid alveolar ridge resorption after tooth removal.[13,14] Although the use of autogenous bone is, in nearly all cases, the gold standard in bone augmentation,[8] it may be considered unreasonable to harvest autogenous bone to fill the above limited bone deficiency. Many authors have assessed the reliability of using either allografts or xenografts for such purposes, which prevent the need for an additional surgical site for bone collection.[10,13-15]

A comprehensive systematic review found that implants placed in augmented edentulous sites had a survival rate similar to implants placed in native bone.[16] In a retrospective analysis, Urban et al.[17] reported a 100% cumulative survival rate 6 years after loading, in 36 sites regenerated with titanium reinforced membranes and particulated autogenous bone graft. They reported an overall mean crestal bone remodeling of 1.01 mm measured from the implant abutment junction. Similarly, a 1.32 mm marginal bone remodeling was reported in a previous study[18] on 32 vertically augmented sites with autogenous bone chips and titanium-reinforced membranes. The authors concluded that vertically augmented bone using guided bone regeneration (GBR) techniques responds to implant placement in the same way as native, non-regenerated bone.[18] In a retrospective study by Benić et al.,[19] the GBR procedure involved grafting with a xenogenic bone substitute covered with a bio-resorbable collagen. The level of the marginal bone below the shoulder of the implant at the 5-year follow-up examination was 1.3 mm for the GBR group and 1.6 mm for the control group. These results demonstrated that bone regenerated by GBR in peri-implant bone defects remains as stable over time as pristine peri-implant bone. Although the cumulative survival rate was lower for the implants placed into native bone (94.1% versus 100% for the GBR group), this difference was not statistically significant.

The aim of this retrospective clinical study is to test the hypothesis that there is no difference in success rate, bone tissue remodeling, and need

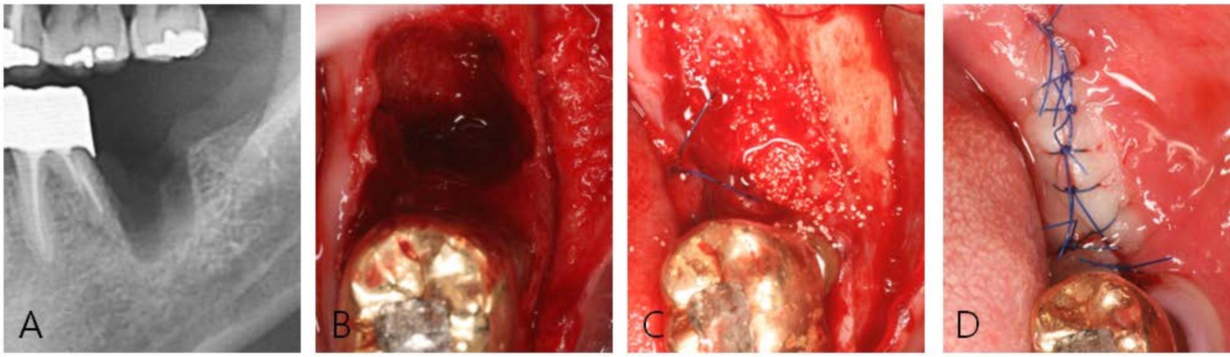



**Figure 1** Socket preservation. A: preoperative panoramic X-ray view, B: extraction socket, C: socket prevervation with bone graft, D: primary closure with coronally advanced flap

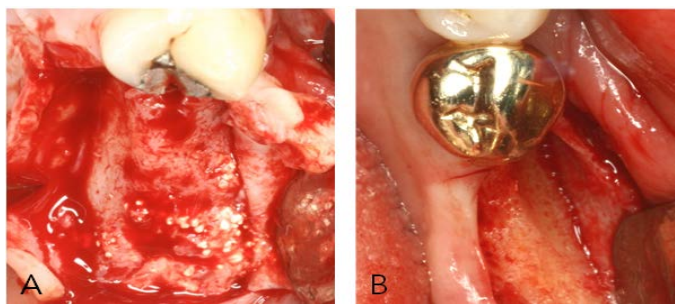
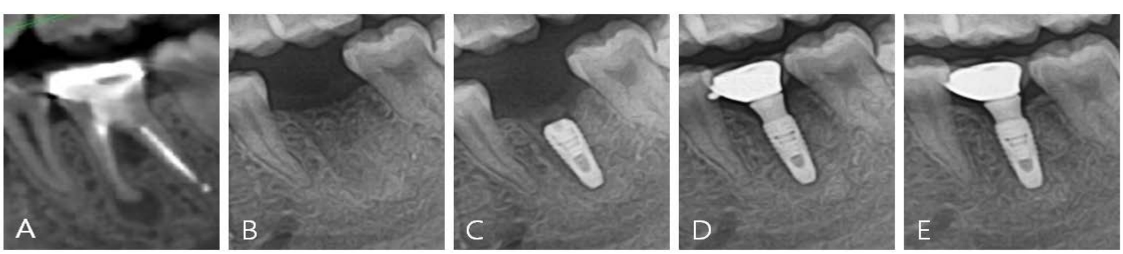



**Figure 2** Comparison of the socket preservation ridge and the healed ridge. A: the sockets on 4 months after graft with the limited buccal bone loss, B: the edentulous healed ridge with the decreased buccal bone width.




**Fiqure 3** Panoramic X-rays A: before surgery, B: socket preservation, C: implant placement, D: restoration, E: 12 months after loading

for augmentation procedures for implants placed in grafted sites versus implants placed in naturally healed sites. In the preliminary report,[15] the ridge-preservation approach using synthetic bone in combination with a rhBMP-2 solution significantly limited the reabsorption of hard-tissue ridge after tooth extraction compared to the synthetic bone without rhBMP-2 solution.

## MATERIALS AND METHODS

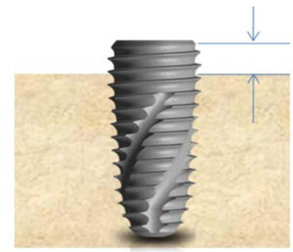
A retrospective clinical study was made in the Aneui implant clinic, Hamyang, Korea between June 2011 and December2013. The patient inclusion criteria were: 1) patients with single missing teeth programmed for restoration with dental implants; 2) partially edentulous patients with free extremities programmed for restoration with dental implants; 3) patients requiring dental implant restoration of the entire dental arch; and 4) patients with sufficient bone width (minimum 6.75 mm)and height (minimum 8.5 mm). The exclusion criteria were: 1) patients with systemic diseases contraindicating any type of surgery; 2) patients receiving or who have received bisphosphonates; 3) patients with active disease of the implant bed (e.g., residual cysts); and 4) patients with bone atrophy requiring bone regeneration in both width and height.

## Surgical techniques

INNO® dental implant (Cowellmedi Co. Ltd, Pusan, Korea) were placed using the same surgical protocol in all cases. Anesthesia was provided in the form of 2% lidocaine with epinephrine 1:100,000. A crestal incision was made with the raising of a full thickness mucoperiosteal flap. The space of extraction socket was filled with CowellBMP® bone graft (Cowellmedi, Pusan, Korea) which are composed of the rhBMP-2 and HA/TCP biphasic particles. Suturing was carried out with 4/0 silk for the primary closure of flap (Figure 1). All implants in the test group were placed on 4 months after socket preservation and loaded in the conventional healing period after implant placement and implants which have the healed ridge were placed without bone graft in control group(Figure 2). The drill speed was reduced from 1200 to 60 rpm as the drill diameter was increased in order to reduce heating of the bone at the implant site. Drilling was carried out under irrigation with saline solution, and the implant was placed with a 25 rpm and 45N of torque. Panoramic X-rays (Vatec, Anseong, Korea) were made at the appointment of before surgery, after socket preservation and implant placement and restoration and 12 months after loading (Figure 3).

*Image analysis*

Panoramic X-rays were analyzed with Easydent viewer



**Fiqure 4** Reference points on the top of implant surface and the first contact point with bone at the mesial and

version 4.5 software (Vatec, Anseong, Korea). Two reference points were marked on the top of implant surface and the first contact point with bone at the mesial and distal side of implant. The measurement between two points was calculated to average value. The differences between the values of the first measurement (after implant placement) and those of the second (12 months after loading) were used to establish marginal bone loss (Figure 4).

*Statistical analysis*

The data were processed using the SPSS version 17.0 statistical package (SPSS Inc., Chicago, IL, USA) for Microsoft Windows. The Student t-test was used for the comparative analysis.

## RESULTS

The mean age of the patients was 58.5 years with a range from 25 to 73 years. The average loading time was 13.4 months and the shortest time period was 10 months with 8 patients. A total 40 dental implants were evaluated n 40 patients (21 females and 19 males). 20 Implants of control were placed in premolar (3 implants), molar (2 implants), $2^{nd}$ molar (8 implants) at maxilla and in premolar (0 implants), molar (2

Table 1 Tooth Position of implant placement

| Group | Premolar | $1^{st}$ molare | $2^{nd}$ molar | Total |
|---|---|---|---|---|
| Maxilla control | 3 | 2 | 8 | 13 |
| Mandible control | 0 | 2 | 5 | 7 |
| Maxilla test | 4 | 1 | 7 | 12 |
| Mandible test | 0 | 3 | 5 | 8 |
| Total | | | | |

## Table 2 Distribution of implant lengths

| Group | 8 mm | 10 mm | 12 mm | Total |
|---|---|---|---|---|
| Control | 8 | 5 | 7 | 20 |
| Test | 1 | 8 | 11 | 20 |
| Total | 9 | 13 | 18 | 40 |

## Table 3 Distribution of implant diameters

| Group | 4 mm | 4.5 mm | 5 mm | Total |
|---|---|---|---|---|
| Control | 4 | 13 | 3 | 20 |
| Test | 0 | 11 | 9 | 20 |
| Total | 4 | 24 | 12 | 40 |

Radiographic evaluation indicated that all implants were successfully osseointegrated. There were no significant differences in mean marginal bone loss between the test group and control group at 1 year after loading. (Table 4).

## Table 4 Marginal bone change (mm) on 1 year after loading

| Group | 1 Year After Loading |
|---|---|
| | Mean ± SD |
| Control | 0. 36±0. 24 |
| Test | 0. 14±0. 09 |
| *P* | 0.19 |

implants), 2nd molar (5 implants) at mandible. 20 Implants of test group group were placed in premolar (4 implants), molar (1 implants), 2nd molar (7 implants) at maxilla and in premolar (0 implants), molar (3 implants), 2nd molar (5 implants) at mandible. The short 8 mm implant ( 9 implants) and the longer 10 mm (13 implants) and 12 mm implants (18 implants) of diameter 4 mm (4 implants), 4.5 mm (24 implants), 5 mm (12 implants) were placed in the healed ridge (20 implants) and the socket preservation site (20 implants) (Table 1, 2, 3).

**DISCUSSION**

The preservation of the alveolar bone volume seems to be fundamental for proper esthetic rehabilitation. In the present study, 40 implants were inserted to replace hopeless. The height and the thickness of the buccal bone and the level of the alveolar peaks play a critical role, because the papilla size, the embrasure shape, and the emergence profile strictly depend on the anatomy of the underlying bone. After tooth extraction, the alveolar process is markedly reduced with respect to both height and width; the dimensional changes are more pronounced at the buccal than at lingual/palatal bone walls. This is not surprising because the buccal bone plate of the alveolar ridge is commonly thin and fragile.[7] Moreover, the space previously occupied by the tooth and its periodontal ligament will be replaced mainly by the trabecular bone and bone marrow.[23,24]

In the esthetic zone, where the buccal plate is often <1.5 to 2 mm thick, the pattern of bone reabsorption makes the placing of implants more difficult in a favorable prosthetic position without producing buccal bone defects. A patient with high esthetic demands, such as a high lip line or a thin biotype, which is prone to additional recession, represents a specific indication for ridge preservation.[25] In our previous study,[15] the ridge-preservation procedures using synthetic bone graft with rhBMP-2 reduced the bone dimensional changes after tooth extraction, thus allowing a more favorable implant position. This ridge-preservation approach significantly limited the resorption of the hard-tissue ridge after tooth extraction compared to extraction alone.

It is well documented[26-28] that BMP bone graft is a safe and effective without barrier membrane.

It was also found to promote bone formation and did not interfere with bone regeneration.[27] Lee et al.[27] and Park et al[28] did not detect any sign of inflammatory in- filtrate, necrosis, foreign-body reaction, or evidence of adverse reaction with the use of synthetic bone with BMP-2. Xenografts do not completely reabsorb, and they maintain their density over long periods, thus acting as a mineral reservoir necessary for new bone formation.[29] The incorporation of the synthetic bone particles in host bone creates a dense and hard tissue network, in which the graft particles, completely embedded in mineralized bone, provide support to dental implants.[30]

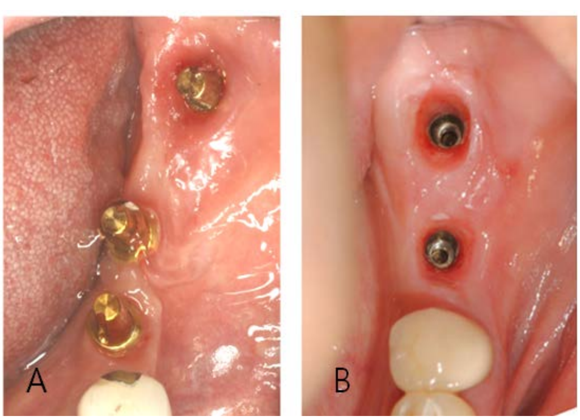
The results of the present study show that there were no differences in the survival rates between implants placed into augmented and non-augmented sites. These survival rates compare well with findings reported in previous studies including implants in pristine as well as regenerated bone.[31] According to a systematic review,[32] the survival rate of implants placed into sites with regenerated/augmented bone using barrier membranes varied from 79% to 100% with the majority of studies indicating >90% after 1 year of function.[32] The survival rates obtained in such a systematic review are similar to those generally reported for implants placed conventionally into sites without the need for bone augmentation. Survival rates of implants placed in vertically augmented bone with the GBR technique appeared similar to implants placed in native bone in a less recent clinical trial.[18]

Benić et al.[19] showed that implants placed with bone regeneration did not perform differently from implants placed into native bone in terms of implant survival: cumulative survival rates reached 100% for the GBR group and 94.1% for the control group without statistical significant difference. The 24-month follow-up showed 100% implant survival for implants placed in extraction sockets grafted with three different materials in a study by Crespi et al.[33] These results suggested that the early prognosis of such a treatment modality is not negatively influenced by grafting materials of different composition.

In the present investigation, the level of the marginal bone loss amounts to 0.036±0.024 mm for the control group and to 0.14±0.09 mm for the test group at the 1-year follow-up examination (Table 4). These results demonstrated that ridges regenerated with the use of synthetic bone in postextraction sockets remain as stable over time as native bone. The marginal bone levels in the present investigation were within the range of values reported previously in long-term studies documenting the outcome of implants placed in native bone.[34-36] In a study by Nickenig et al.,[37] bone loss for machined implants progressed from 0.5 m in the healing period to 0.8 and 1.1 mm at the 6- and 24-month follow-ups. Conversely, bone loss for the microthreaded implants progressed from 0.1 mm in the healing period to 0.4 and 0.5 mm in the 6- and 24-month follow-ups. In a study by Peñarrocha et al.,[38] the marginal bone loss was 0.95 mm using digital radiography. All the implants displayed some extent of bone loss throughout the follow-up period in a study by Bratu et al.[39] At 12 months after loading, the microthreaded implants and the polished neck implants displayed 0.9 versus 1.5 mm marginal bone loss, respectively.

It is difficult to compare the results of the present study with those of other studies because, to our knowledge, this is the first study to assess marginal bone loss associated with implants placed in native bone and in sites subjected to socket preservation. The marginal bone height values for the control and the test groups in the present study are in accordance with the ones observed in previous studies[19,40,41] documenting the outcome of implants placed in native bone as well as regenerated bone. A bone level change of 0.8 to 1.3 mm was reported at the 5-year follow-up examination by Buser et al.[40] In that study, as well as in our investigation, the staged approach was chosen, in which the bone is first regenerated and the implant subsequently placed into a ridge exhibiting sufficient bone volume. The level of the marginal bone was 1.3 to 1.6 mm below the shoulder of the implant at 5 years after implant insertion in a study by Benić et al.[19] Values of 1.73 mm for the control group and 1.83 mm for the test group were reported in another study at the 5-year follow-up examination.[41]

The increased height and width of bone available for implant placement, after tooth extraction, allowed implants to be placed in proper position (Figure 5).




**Fiqure 5** Position of implant placement. A: lingual position of implant in healed ridge, B: normal position of socket preservation site

## CONCLUSIONS

Based on the results of the present study, it can be concluded that implants placed into sites subjected to ridge preservation exhibited a clinical performance similar to implants placed into non-grafted sites with respect to implant survival and marginal bone loss. However, it seems from these findings that extraction alone may lead to unpredictable healing patterns in which the remaining ridge does not often allow for an esthetic and functional solution without the aid of an additional bone augmentation procedure simultaneously with implant placement. Furthermore, the height and width preservation of the ridge allowed the emergence profile of the implant supported rehabilitation. Thus, the ridge-preservation approach could attain a satisfying clinical outcome for the patients.

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