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ORIGINAL ARTICLE

Comparative analysis of guided bone regeneration using autogenous tooth bone graft material with and without resorbable membrane

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Abstract *Background/purpose:* The use of membrane in preventing soft tissue ingrowth during guided bone regeneration (GBR) procedure for better clinical results is controversial. The present study compares and analyzes the clinical results of GBR using the autogenous tooth bone graft (AutoBT; Korea Tooth Bank Co., Seoul, Korea) material with and without the resorbable membrane (Bio-Arm, ACE Surgical. Supply Company, Inc., USA).

Materials and methods: Patients who received dental implants with simultaneous GBR from the same clinician at the Dental Department of Seoul National University Bundang Hospital from March 2009 to May 2012 were selected in this study. A total of 20 patients with a total number of 30 dental implants were included in this study. The patients who received GBR with resorbable membrane were in Group 1 and those without membrane were in Group 2. AutoBT was grafted in all patients. In each group, pre- and postoperative bone loss, regeneration in percentage (%), and complications were evaluated.

Results: There was no statistically significant difference in pre- and postoperative reduction of bone defect height, bone level change, and bone regeneration in percentage (%) between the two groups ($P > 0.05$).

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Conclusion: Both groups showed clinically acceptable bone regeneration without any eventful complications. Within the limitation of this study, we can carefully conclude that the use of resorbable membrane is not a critical factor in GBR when using AutoBT.

Introduction

Guided bone regeneration (GBR) is widely employed to overcome insufficient bone quantity and anatomical problems. During the procedure, the need of a membrane has been a question to many clinicians. The use of a membrane in GBR is thought to be advantageous, achieving mechanical stabilization and preventing micromovement of the bone graft material.[1]

Although resorbable membranes are widely used as they do not need to be removed after placement, it is known that removal is nearly impossible when the membrane is only partially resorbed and that there can be giant cell reactions during the process of resorption.[2,3] Moreover, the early exposure of the membrane necessitates frequent postoperative observation followed by potential additional fees. In contrast, there are reports showing no significant difference in bone regeneration when groups of with and without membranes were compared with intact periosteum.[3,4]

Choosing the appropriate bone graft material in GBR is challenging. Choosing the graft material needs to be dictated by the size of the bone defects and the purpose of procedures. In search of near ideal bone graft material, Kim et al developed an autogenous tooth bone graft material (AutoBT; Korea Tooth Bank Co., Seoul, Korea) from patient's own extracted teeth. AutoBT consists of inorganic components, such as low-crystalline hydroxylapatite, tricalcium phosphate, amorphous calcium phosphate, and octacalcium phosphate.[5] With inorganic and organic components, such as noncollagenous proteins, AutoBT showed potential osteoconductivity and osteoinductivity.[6] Moreover, the safety and biocompatibility of AutoBT was reflected in a clinical study with quick postoperative bone healing.[7]

There have been numerous reports that compare the needs of membranes in GBR. However, this is the first study that compared and evaluated the clinical results of GBR using AutoBT with and without resorbable collagen membrane when implants were exposed at the time of second surgery.

Materials and methods

Patient selection

Patients who received dental implants with simultaneous GBR from the same examiner at the Dental Department of Seoul National University Bundang Hospital from March 2009 to May 2012 were included in the study. Following the approval from institutional review board of Seoul National University Bundang Hospital (IRB No.: B-1210-176-111), the study progressed. As a result, a total of 30 implants were placed in 20 patients who met the inclusion criteria (Table 1). Seven patients had controlled systemic conditions such as diabetes mellitus, hypertension, liver problem, and cardiac problem.

Inclusion criteria

(1) Vertical dehiscence bony defects of greater than 1 mm and less than 8 mm after implant placement, which were grafted with particulate AutoBT only for GBR, were included.
(2) Smoking and parafunctional habits were not assessed.
(3) Patients with controlled systemic diseases were included in the study.

Patient distribution

Patients who received GBR with resorbable collagen membrane were placed in Group 1 and without membrane were in Group 2. Group 1 consisted of 8 patients (7 males, 1 female), and 12 patients (8 males, 4 females) were included

Table 1 Implant distributions: appropriate implants were placed with proper length (ranging from 5 mm to 13 mm) and width (ranging from 4 mm to 6 mm) according to patients' needs.

	Group 1	Group 2
Superline[a]	5	8
Zimmer[b]	1	1
GSIII[c]	4	4
CMI[d]	3	1 (Excluded)
TSIII (SA)[c]	3	0
Total	16	14
Length (mm)		
5	2	0
7	2	0
8	2	6
8.5	0	1
10	7	3
11.5	3	0
12	0	1
13	0	3
Total	16	14
Width (mm)		
4	3	1
4.5	2	2
4.7	1	0
5	8	9
6	2	2
Total	16	14

[a] Superline (Dentium, Seoul, Korea).
[b] Zimmer (Zimmer Dental Inc., Carlsbad California, USA).
[c] GS III, TS III (OSSTEM, Busan, Korea).
[d] CMI (Neobiotech, Seoul, Korea).

Table 2 Patient and intervention characteristics: 30 implants were placed in a total of 20 patients in the present study with a mean age of 49 years in Group 1 and 57 years in Group 2.

	Group 1	Group 2
Female	1	4
Male	7	8
Total no. of patients	8	12
Implant in maxilla	3	6
Implant in mandible	13	8
Total no. of implants	16	14
Mean age in years at the time of implant insertion (range)	49.88 (26—68)	57.00 (34—77)
Month from implant placement to exposure (range)	3.6 (2—7)	2.65 (1—4)

in Group 2. In Group 1, a total of 16 implants were placed, three in the maxilla and 13 in the mandible. In Group 2, among the total of 14 implants placed, six were in the maxilla and eight were in the mandible. The average age of Group1 was 49.8 years (range: 26-68 years old) and Group 2 was 57.0 years (range: 34-77 years old) (Table 2).

Surgical procedures

Patients were presurgically prepared with 0.1% chlorhexidine oral rinse for 1 minute. For two patients with cardiac conditions, a preoperative prophylactic antibiotic (amoxicillin 2 g) was prescribed. Implants were placed employing the routinely practiced surgical methods after the elevation of full thickness mucoperiosteal flap in both groups (Figs. 1 and 2). Peri-implant vertical bony defects were measured at mesial, distal, buccal, and lingual sites using the periodontal probe. In Group 1, resorbable collagen membrane (Bio-Arm, ACE Surgical. Supply Company, Inc., USA) covered AutoBT grafted site followed by the closure with 4-0 Vicryls

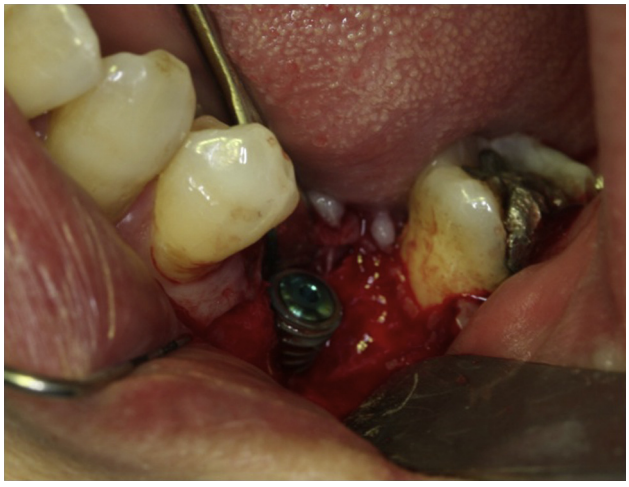

Figure 1 The implant is placed on a missing #36 area. Vertical bone defects are measured in buccal (5 mm), lingual (4 mm), and distal (5 mm).

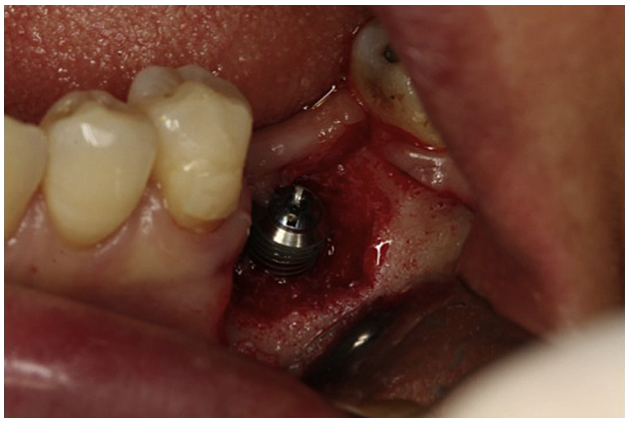

Figure 2 The implant is placed on a missing #36 area. Vertical bone defects are measured in buccal (3 mm), lingual (3 mm), mesial (6 mm), and distal (5 mm).

(Ethicon Inc., Sommerville, NJ, USA) (Fig. 3). In Group 2, only AutoBT was grafted at the defected sites (Fig. 4). Postoperative prescriptions included antibiotics and digestives for 5 days and chlorhexidine oral rinse for 7 days. The secondary exposure time was decided solely by the clinician during the implant placement surgery. The decision was depended upon the initial implant stability and the size of bony defects at the time of the first surgery (Table 2). During the second surgery, the flap design was identical to the first surgery and the bone measurements were taken at the identical sites using the same method (Figs. 5 and 6). The implant stability was measured by using Osstell Mentor (Integration Diagnostics AB, Goteborg, Sweden). The primary stability was measured immediately after the first surgery. The secondary stability was measured following the certain period of healing at the time of second surgery.

Bone defect evaluation method

Bone defect height was evaluated using the average value of the minimal vertical depth (NL) and the maximal vertical depth (ML) (Fig. 7).

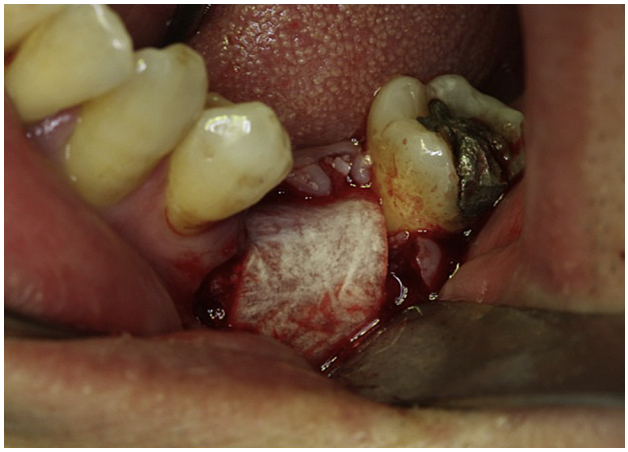

Figure 3 Bone defect is filled with AutoBT and covered with collagen membrane (Bio-Gide).

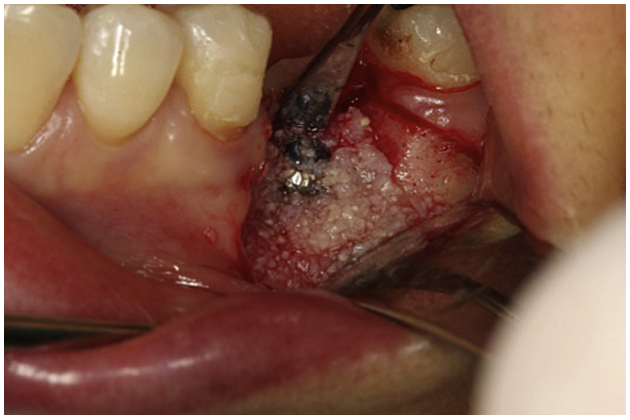

Figure 4 Bone defects are filled with AutoBT only.

$$\%\,\text{defect height reduction} = ((\text{preoperative bone level(baseline)} - \text{bone defect at surgical exposure in the 2nd surgery})/\text{preoperative bone level(baseline)}) \times 100$$

Statistical analysis

In all parameters, average and standard deviations were calculated. An independent t test (Shapiro-Wilk test: $P > 0.05$) was used in comparing the preoperative baseline and bone level change between the two groups. Mann-Whitney U test (Shapiro-Wilk test: $P < 0.05$) was employed in comparing the bone gain (%) in accordance with the preoperative bone level (baseline) between the groups. Furthermore, the preoperative bone level in relation to the bone defect at surgical exposure at the second surgery was evaluated within each group by using the Wilcoxon signed-rank test. All statistical analysis employed the use of SPSS program (Ver. 12 for Windows, SPSS Inc., Chicago, IL, USA), and the statistical significance was determined to be $P < 0.05$.

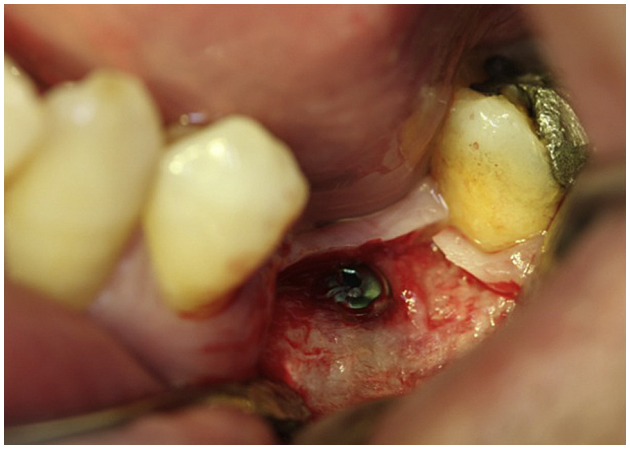

Figure 5 Implanted site is exposed after 9 weeks and clinical bone defects are filled with new bone in group 1.

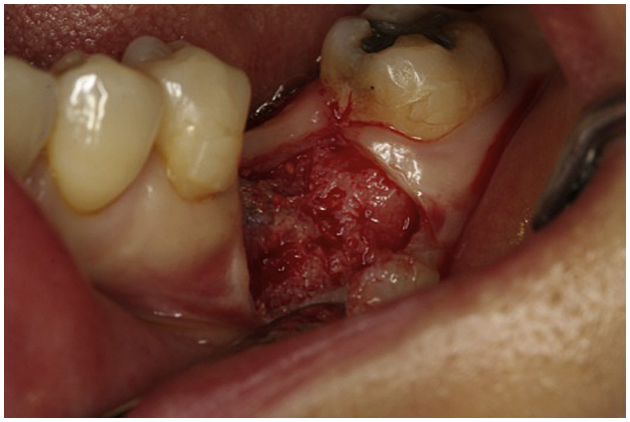

Figure 6 Implanted site is exposed after 9 weeks and clinical bone defects are filled with new bone in group 2.

Results

Preoperative bone level (baseline) was 2.38 ± 0.28 mm (Group 1) and 2.58 ± 0.34 mm (Group 2) without any statistical significance ($P > 0.05$). The amount of bone defect at surgical exposure in second surgery was 0.19 ± 0.11 mm (Group 1) and 0.23 ± 0.11 mm (Group 2) showing no statistical significance ($P > 0.05$). The values of bone level change in two groups were 2.19 ± 0.32 mm (Group 1) and 2.35 ± 0.40 mm (Group 2) ($P > 0.05$). Bone gain (%) appeared to be 89.06 ± 27.33% (Group 1), and 86.92 ± 22.78% (Group 2), with no statistical significance ($P > 0.05$). When the preoperative bone level was evaluated in accordance with the bone defect at the secondary surgical exposure within each group, the value of bone height gain appeared to be statistically significant ($P < 0.05$) (Table 3). In Group 1, 13 implants out of 18

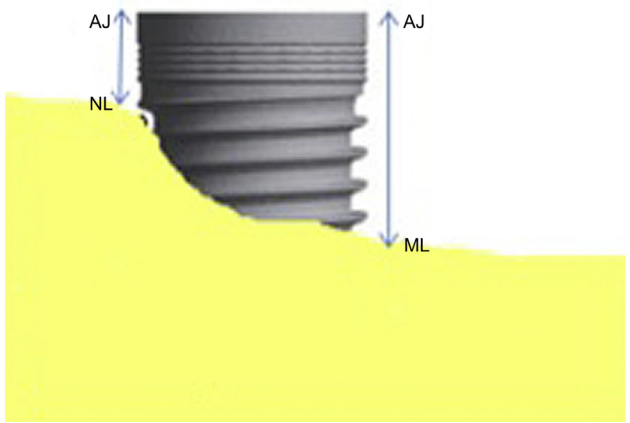

Figure 7 Illustration of the measurement reference points at baseline. The same intrasurgical measurements are obtained at implant exposure. AJ = abutment junction; ML = maximum vertical depth of the marginal bone to be vertically regenerated (ML-AJ); NL = minimal vertical depth of the marginal bone to be vertically regenerated (NL-AJ).

Table 3 The comparison between Group 1 and Group 2 in mean bone level (mm) change around implants and % in bone gain.

	Group 1 ($n = 16$) Mean (SD)	Group 2 ($n = 13$) Mean (SD)	Sig*
Bone defect baseline[a]	2.38 (0.28)*	2.58 (0.34)*	—
Bone defect at surgical exposure[b]	0.19 (0.11)*	0.23 (0.11)*	—
Bone level change[c]	2.19 (0.32)	2.35 (0.40)	—
Bone gain (%)[d]	89.06 (27.33)	86.92 (22.78)	—
Sig**	*	*	

* Independent T-test (a,c), Mann-Whitney U test (b,d), $P > 0.05$.
** Wilcoxon signed-rank test, $P < 0.05$.

implants (81%) showed completely filled regenerated bone at bony defected sites. Whereas, bony defects around 9 implants out of 14 implants (64%) were completely filled with regenerated bone in Group 2. The average primary stability ISQ values were 63.64 ± 11.81 in Group 1 and 65.53 ± 8.14 in Group 2. The average secondary stability ISQ values were 78.38 ± 6.85 in Group 1 and 76.15 ± 7.08 in Group 2. There was no statistically significant difference between the two groups in these values ($P > 0.05$).

Each group had a single case of a postoperative complication. In Group 1, a 40-year-old male patient had postoperative wound opening in the region of posterior mandible. With conservative management including daily dressing and strict oral hygiene care, the wound healed with no infection. The preoperative bone level (baseline) in this patient was 2 mm and the bone defect at re-entry appeared to be 1 mm, leading to 50% of bone gain. In Group 2, a 47-year-old male patient, presented with an implant in the maxillary premolar region complained of intermittent pain from the area, however, without any clinical signs of infection. Owing to the failure of osseointegration observed at the second surgery following 3 months of healing of this patient, the implant fixture was extracted and replaced with a fixture of bigger diameter, with additional bone graft procedures. However, the statistical calculations took place excluding the values from this patient.

Discussion

This study evaluated the amount of bone regeneration following GBR using AutoBT with and without membrane. Membranes used in GBR have known to prevent interference factors to bone regeneration process such as ingrowth of surrounding soft tissue cells and stress, leading to selective bone cell growth.[1] Additionally, reports showed that the use of membrane was one of the positive factors in enhancement of long-term implant prognosis and esthetics.[8]

However, other studies reported that the use of a membrane could increase the frequency of wound opening. The resultant early exposure of the membrane may lead to reduction in the amount of peri-implant tissue regenerated jeopardizing bone regeneration around implants up to 80%.[9–11] Gotfrendsen et al reported that following immediate implant placements at total of 32 sites, e-PTFE membranes were used at 16 sites resulting in exposure at 61% of the sites, whereas in the 16 sites without the membrane, only 19% sites had wound opening. They also reported bone regeneration was significantly jeopardized when the exposed membrane was not removed.[12] In the reports of implant placement with simultaneous GBR, Nowzari et al experienced 47% of membrane exposure during the 9-month healing period, and Becker et al observed 41% of e-PTFE membrane exposure and infection.[10,13] In such early exposure of resorbable membrane, the membrane can be prematurely resorbed leading to the loss of bone graft material and the possible isolation between the graft material and the recipient bed.[14,15] In the present study, there was a single case from Group 1 that had wound opening leading to membrane exposure. After conservative care on the wound site, no further infection was observed around the exposure.

A few authors claimed that use of membrane rather interferes with microvasular circulation leading to a delay in healing of mucoperiosteal flap.[16] In the animal study conducted by Aaboe et al, a few sites of GBR using bovine xenograft material and membrane showed resorption in regenerated bone immediately below the membranes. It supported consequential possibilities of the byproducts leading to chemotaxis of osteoclasts thereby resulting in further bone resorption.[17] Further, they reported that for the buccal dehiscence defects, the cohorts of GBR without the membrane showed greater bone gain than the cohorts with the membrane.[18]

Some studies, however, showed results that there is no difference in use of membrane. Yet other factors, such as proper healing period, healthy periosteum, and good oral hygiene played important roles in bone regeneration after GBR. Rasmusson et al reported that there was no difference in implant stability and bone regeneration between the groups of with and without membrane following implant placement.[19] Also, they added that the use of membrane did not enhance revascularization within the graft material.[19] Lindhe et al presented that periosteal flap elevated carefully may function as membrane and nourish the grafted site with growth factors.[3] However, Weng et al claimed that the periosteum has a low potential for bone regeneration and that it does not contribute to new bone formation.[20] With the vulnerability of the periosteum during the surgery and due to its resilience, some authors report that the periosteum may not fully function to maintain the space for bone regeneration.[21]

In the present study, there were 13 cases (81%) of 100% bone regeneration in Group 1, whereas Group 2 had only 9 cases (64%) of complete bone regeneration. These presented results may attribute to the factors leading to instability of the grafted areas such as muscle attachment, postsurgical pressure to the flap, and palatal vault height. Although the periosteum is known to have many potential regenerative functions, it is not so rigid that space maintenance and resistance to stress can be challenging. Moreover, there is a high chance of intraoperative periosteum damage. It is at times inevitable to damage the periosteum when raising the flap and giving relieving incisions to achieve primary closure. Efforts need to be

practiced to minimize periosteal damage through giving clean incision and raising the flap carefully, and when the membrane is used it is necessary to minimize the exposure by careful pre-surgical planning and placing incision at the optimal location.[8]

Failure of osseointegration was observed in a patient of Group 2 where no membrane was used. The 47-year-old male patient was a diabetic under control and a heavy smoker (30 cigarettes per daily). An implant fixture CMI (length: 10 mm, diameter: 4.5 mm) was placed in the maxillary premolar area of the patient. The premolar tooth was extracted owing to continuous pain and mobility (Grade III) even after treatment of the periapical lesion with apicoectomy and periapical curettage followed by grafting with demineralized freeze-dried bone. An implant fixture was placed with simultaneous GBR 1 month after the extraction. The average vertical bone defect height was 4 mm and the primary ISQ value was 62. There was no clinical sign of postoperative complications such as abscess, however, the patient complained of intermittent pain. At the time of second surgery following 3 months of healing, the failure of osseointegration was observed and the implant fixture was removed. A new fixture of greater diameter was placed with GBR. In this patient, persistent periapical lesion, guarded periodontal condition, and sub-optimal bone quality, along with the patient's smoking status, were thought to be the factors leading to the failure of osseointegration.

The present study draws some limitations. The study included limited observation period after GBR with limited number of sample size. Moreover, the implant fixture types were not standardized to all patients. Patient selection was needed to be more controlled for acute evaluation despite included patients with systemic diseases were controlled and received approval from their physicians for dental surgeries. Age calibration between two groups was needed as well. However, there are only few studies that employed the use of AutoBT. Therefore, the present study maybe considered being significant in evaluating the clinical results at the time of secondary surgery after healing periods of GBR using AutoBT with and without membrane.

Within the limitations of this study, there was no statistically significant difference between the two groups of with and without membrane in pre- and postoperative reduction of bone defect height, bone level change, and bone gain (%). Based on the results of the present study, we can carefully conclude that AutoBT can be an effective bone grafting material in GBR regardless in use of membranes.

Acknowledgments

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