



# 자가치아뼈이식재를 이용한 상악동증강술: 일차 보고

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## Abstract

### Maxillary Sinus Augmentation Using Autogenous Teeth: Preliminary Report

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**Purpose:** The purpose of this study was to evaluate the effectiveness of autogenous tooth graft materials after maxillary sinus bone grafts.

**Methods:** The study involved 23 implants in 22 patients who visited the Department of Oral and Maxillofacial Surgery and the Department of Periodontics, Chosun University Dental Hospital, in 2008 and received autogenous tooth graft materials for maxillary sinus bone grafts.

**Results:** For eight patients with maxillary bone graft materials prior to implant placement, the healing period averaged five months. For eleven patients with simultaneous maxillary bone graft and implant placement, eight patients received a second surgery, with an average healing time of six months. Three patients had a longer observation period with only a fixture implanted. Three patients who received only a bone graft required more time to implant placement because of the lack of residual bone and also for personal reasons. Only 5 patients had biopsies performed and complications such as infection and dehiscence healed well. The application of autogenous graft materials to the maxillary bone graft sites did not exert any significant effects on the success rates. When a mixture of graft materials was used, the post-surgical bone resorption rate was reduced. Histological analysis showed that new bone formation and remodeling were initiated during the three-to-six month healing period. Bone formation capacity increased continuously up to six months after the maxillary bone graft.

**Conclusion:** According to this analysis, excellent stability and bone-forming capacity were seen in cases where autogenous materials were used alone or mixed with other materials. Autogenous tooth graft materials may be substituted instead of autogenous bones.

**Key words:** Autogenous teeth, Clinical study, Graft materials, Maxillary sinus augmentation

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## Introduction

Autogenous bones have osteoconductive, osteoinductive, and osteogenic properties with the advantages of fast healing and strong resistance to infection. Nonetheless, autogenous bone also has shortcomings in that the resorption rate is fast, and a second operational area is generated[1]. Therefore, bone graft materials similar to autogenous bones provide advantages that can overcome restrictions in terms of the amount of tissue harvested. Such bone graft materials can reduce second surgery areas in the implants placed in the maxillary molar areas.

Given this evidence, recent studies have focused on autogenous tooth graft materials (AutoBT<sup>®</sup>). The osteoconduction and osteoinduction of AutoBT<sup>®</sup> are excellent, and the histological healing process is similar to that of autogenous bone grafts[2,3]. Therefore, in comparison with autogenous bone grafts, these materials can reduce the donor area. The healing period is 3~6 months, which is shorter than that of other bone graft materials. Therefore, it can be applied usefully in the maxillary molar areas requiring maxillary sinus augmentation[2]. In this study, the effectiveness of autogenous tooth graft materials was shown via histological analyses of maxillary sinus bone grafts.

## Materials and Methods

### 1. Subjects

The study involved 23 implants in 22 patients who visited

the Department of Oral and Maxillofacial Surgery and the Department of Periodontics, Chosun University Dental Hospital, in 2008 and received autogenous tooth graft materials for maxillary sinus bone grafts. In eight patients, only autogenous tooth materials were used; in 14 patients, a bone graft with mixture materials was performed using a mixture of autogenous tooth graft materials, autogenous bones, allogenic bones, and synthetic bones.

After tooth extraction, the teeth were processed and used as maxillary bone graft materials. In 11 patients, bone graft and implant placement were performed simultaneously (Fig. 1, 2). Among eleven patients, six patients were grafted with tooth material and five patients were grafted with mixture material.

### 2. Follow-up and histological analysis

Prior to the implant placement but after maxillary bone graft procedures, CT scans were taken at three and six months post-surgery (Fig. 3, 4). Vertical bone heights were measured 3~6 months after placement. A consent form was obtained from each of five patients, and histological tests were performed on the bone graft areas (Fig. 5, 6). The specimens were fixed in 10% formalin for 24 hours and decalcified with Calci-Clear Rapid<sup>™</sup> (National Diagnostics, Atlanta, GA, USA). The specimens were treated with a Hypercentre XP tissue processor (Shadon, Cheshire, UK) and embedded in paraffin. The specimens were sectioned, stained with hematoxylin & eosin, and histologically examined under a microscope. In addition, the ratios of new bone formation, woven bone, lamellar bone, and residual



Fig. 1. Lateral window approach.

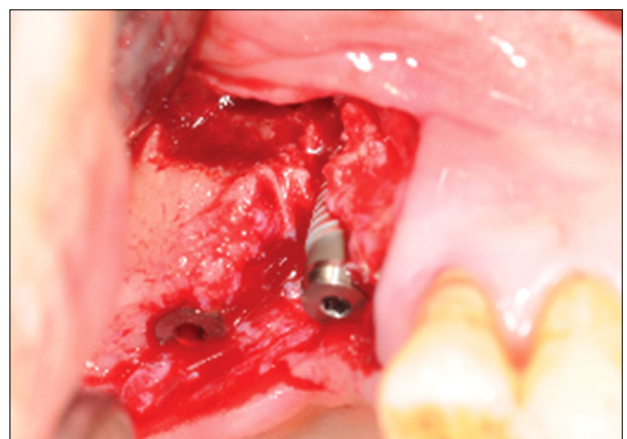


Fig. 2. Immediate implantation.

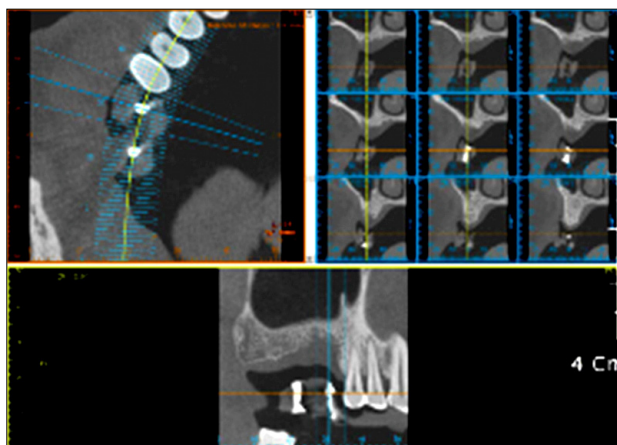


Fig. 3. Preoperative CT.

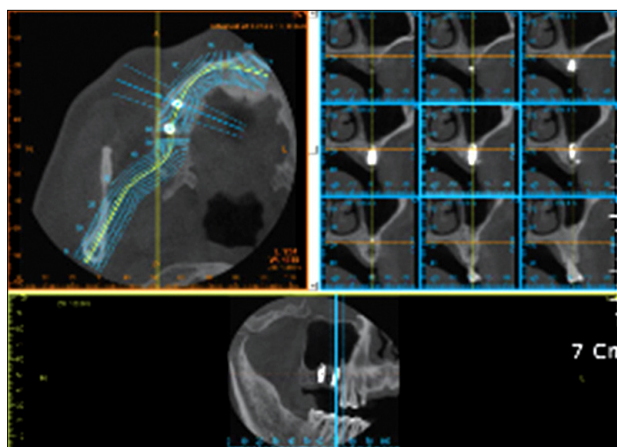


Fig. 4. Postoperative (six-month) CT.

graft materials were measured by the Visus Image Analysis System (Image & Microscope Technology, Daejeon, Korea). Statistical analysis was performed with the SPSS v12.0 software package.

## Results

The outcomes of the 22 patients who received autogenous tooth graft materials for their maxillary sinus bone grafts were examined via follow-up observation. Among 23 implants placed in 22 patients, no failure was observed. In seven patients, complications such as infection, dehiscence, and maxillary perforation developed. Three patients who developed dehiscences healed spontaneously via wound management. Two patients who developed perforations healed after treatment (during the surgery) with-

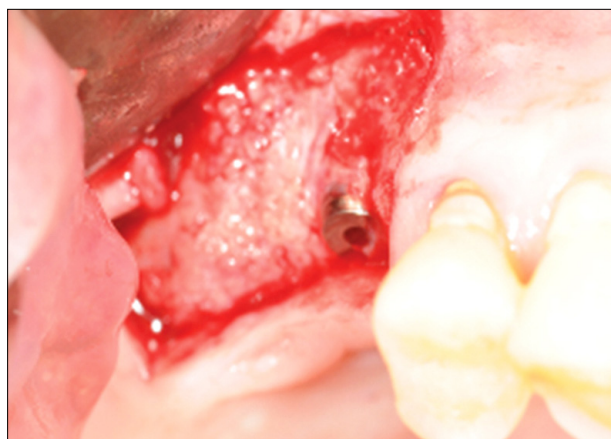


Fig. 5. Intraoral view after six months.



Fig. 6. Second implant surgery.

out special sequelae. For the two patients who developed post-surgical infections, aggressive wound management was applied, and medications were utilized. In one patient whose barrier membrane was exposed, the barrier membrane was removed, and the site healed well without special sequelae. The cases were analyzed based on (1) whether bone graft and implant placement were performed; (2) whether mixed bone graft materials were used; and (3) post-surgical residual bone heights. The healing processes were assessed via histological analysis.

### 1. Types of surgery

Twenty-two patients who received maxillary sinus bone grafts using autogenous tooth graft materials were categorized based on whether they received simultaneous implant placement or augmentation (Table 1). Among the eight

patients with maxillary bone graft materials prior to implant placement, the healing period averaged five months. Among the 11 patients with simultaneous maxillary bone graft and implant placement, eight patients received a second surgery, with an average healing time of six months (for the second surgery). During surgery, a maxillary perforation developed in one patient; nonetheless, after treatment, the perforation healed normally without any special sequelae. In two patients, dehiscences developed during soft tissue healing, although they healed spontaneously without any special treatment.

## 2. Bone materials

The cases were analyzed according to the types of bone graft materials used. In eight patients, only autogenous tooth graft materials were used. Fourteen patients were treated with a mixture of autogenous tooth graft materials, autogenous bone, allogenic bone Tutoplast (Tutogen medical GmbH, Neunkirchen, Germany), xenogenic bone Bio-Oss (Geistlich Biomaterials, Baden Baden, Germany), and synthetic bone OSTEON (GENOSS, Seoul, Korea) (Table 2). Among the eight patients who received only autogenous tooth graft materials for their maxillary sinus bone grafts, maxillary perforations developed in two

patients. Nevertheless, no special complications developed. In one patient, a post-surgical infection was observed; it was treated with appropriate wound management and the administration of antibiotics.

In the group receiving the mixture of autogenous tooth graft materials with Tutoplast, complications involving dehiscence and post-surgical infections were observed in one patient each, although the dehiscence healed spontaneously. In the patient who developed a post-surgical infection, the exposed membrane was removed, appropriate wound management and medications were administered, and the infection healed promptly. No other complications were observed.

Regarding post-surgical complications, maxillary perforations can be associated with the amount of maxillary elevation, whereas surgical techniques may be associated with dehiscence. These complications healed well, and the application of autogenous graft materials to the maxillary bone graft sites did not exert any significant effects on the success rates. In contrast, infections (which can be the biggest cause of failure in maxillary sinus bone grafts) were observed in two patients, although they re-

**Table 1.** Types of surgery

Surgery	Patients (n)
Sinus augmentation	9
Sinus augmentation+Ridge augmentation	2
Sinus augmentation+Implant surgery	10
Sinus augmentation+Ridge augmentation +Implant surgery	1

**Table 2.** Bone materials used in sinus augmentation and associated complications

Bone materials	Patients (n)	Complications (n)
1	8	Perforation (2), Infection (1)
1+4	5	Dehiscence (1), Infection (1)
1+5	3	
1+2+4	3	Dehiscence (1)
1+4+5	2	Dehiscence (1)
1+3+4+5	1	

1, AutoBT; 2, OSTEON; 3, Autogenous bone; 4, Tutoplast; 5, Bio-Oss.

**Table 3.** Variation in bone height after sinus augmentation

Patient	Bone materials	Residual bone height (mm)	After Sinus augmentation (mm)	After 3M (mm)	After 6M (mm)
1	1	5	17	16	15
2	1	11	13	13	12
3 (Lt)	1	10	16	15	14
(Rt)	1	8	16	15	15
4	1+4	4	13	13	13
5	1+4	8	16	15	15
6	1+5	7	14	14	14
7	1+2+4	3	16	16	15
8	1+2+4	7	16	15	15
9	1	4	15	11	
10	1	2	10	9	
11	1	8	12	11	
12	1+4	14	19	17	
13	1+4+5	2	18	18	

solved without further sequelae via appropriate treatment. Thus, it was confirmed that autogenous tooth graft materials could resist post-surgical infections.

### 3. Bone height after sinus augmentation

Changes in the vertical bone heights were measured using baseline points on CT scans taken immediately, three months, and six months after 23 implant surgeries in 22 patients (Table 3). The follow-up period was varied according to the time of the maxillary bone graft procedure. Specifically, 13 patients were examined for three months after surgery, and eight others were examined for up to six months. Table 2 describes the bone graft materials that were used.

Except for one patient, the initial height of the vertical bone measured immediately after surgery (or a vertical height with only about 1 mm in resorption) was maintained up to 3 months after surgery. Specifically, the average resorption rate of vertical bone was approximately 0.9 mm in fourteen patients, even after three months. After six months, the average resorption rate was approximately 1.0 mm in nine of the patients. For the six patients who received maxillary sinus bone grafts using only autogenous tooth graft materials, the average vertical bone resorption rate was approximately 1.3 mm after three months, and approximately 1.5 mm after six months. However, for seven patients in which a mixture of autogenous tooth graft materials and other bone graft materials were used, the average vertical bone resorption rate was approximately 0.57 mm after three months and approximately 0.6 mm after six months (Table 4).

Statistical analysis was performed. Assuming that the bone resorption rates of the alveolar ridges were identical three months after surgery, the rates of bone resorption of autogenous teeth in patients who received the mixture

of autologous tooth graft materials and other bone graft materials were not significantly different. In contrast, six months after surgery, the *P* value was 0.048, which was statistically significant. When the mixture of graft materials was used, the post-surgical bone resorption rate was reduced. Therefore, in situations where maxillary bone volumes must be maintained and repneumatization of the maxillary sinus must be prevented, a mixture of autogenous tooth graft materials and other bone graft materials can lead to more satisfactory results.

### 4. Histomorphometric analysis

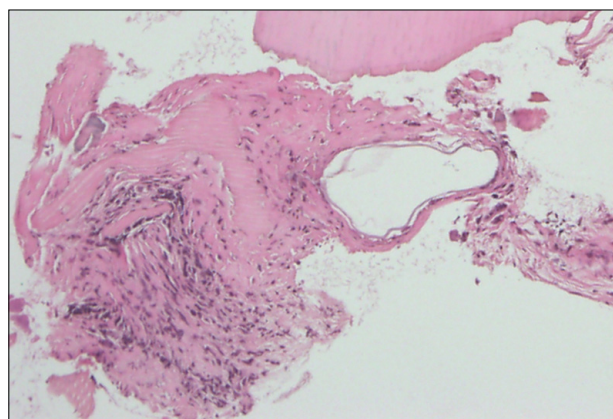
In the five patients who received only autogenous tooth graft materials for their maxillary sinus bone grafts, histological tests were performed three and six months after the graft procedures.

The results of the histological analysis showed that new bone formation and remodeling were initiated during the three-to-six month healing period (after surgery) in the vicinity of autogenous tooth graft materials. Bone formation capacity increased continuously up to six months after the maxillary bone graft. The content of the residual bones representing autogenous graft materials decreased gradually as the proportion of woven bone increased. Lamellar bone content increased at the same time (Fig. 7, 8). Most of the autogenous tooth materials eventually underwent resorption; bone remodeling reactions were observed, and new bony trabeculae were formed (Table 5).

**Table 4.** Mean±SD and paired t-test results of resorption of bone height classified by bone materials used over different observation periods

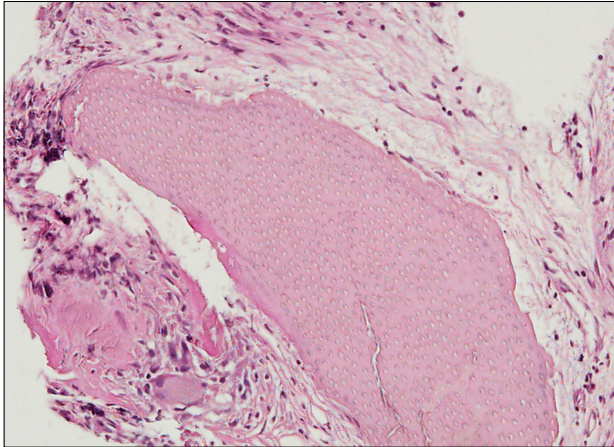
	Resorption of vertical bone height		
	Only AutoBT	AutoBT+Bone Materials	<i>P</i> value
After 3M (mm)	1.29±0.474	0.57±0.297	0.226
After 6M (mm)	1.50±0.289	0.6±0.245	0.048*

\**P*<0.05



**Fig. 7.** After six months later of autogenous tooth bone grafting, new forming osteoid with osteoblast arrangement is observed around graft materials (×10).





**Fig. 8.** After six months later of autogenous tooth bone grafting, graft material is absorbed and bone remodeling is observed around tooth graft material (×20).

## Discussion

Numerous studies have been conducted on autogenous tooth graft materials. The present retrospective study revealed findings similar to those from previous studies.

It has been reported that autogenous graft materials containing four types of calcium phosphate (HA, TCP, ACP, and OCP) as inorganic components were associated with reactions similar to bone remodeling during autogenous bone graft procedures, given the similarity of their composition to that of alveolar bone[4,5]. Based on histological analysis of the inorganic components of the autogenous tooth graft materials, surface structures, and healing processes, Kim et al. reported in 2009 that autologous tooth graft materials undergo healing processes not only by osteoconduction but also via osteoinductive mechanisms. Such materials are associated with bone formation capacity comparable to that found in autogenous bone. They also have post-surgical stability comparable to that of autogenous bone, and can thus be used predictably in clinical studies[3,6,7].

According to Kim et al.[2] histomorphological analyses showed that autogenous bone graft materials underwent resorption and remodeling processes similar to those observed in free autogenous bone graft materials three months after the bone graft procedure. The autogenous bone graft materials showed 46% to 87% new bone formation three to six months after surgery. The bone was connected to adjacent bones by gradual resorption, which

**Table 5.** Histomorphometric analysis of the grafted AutoBT

Patient	Healing time (M)	WB : LB : RB ratio	Bone forming activity (%)
1	6	76 : 23 : 1	48
2	6	85 : 14 : 1	87
3	3	15 : 0 : 85	8
	6	86 : 11 : 3	78
4	3	51 : 1 : 48	52
5	3	56 : 0 : 44	17

WB, woven bone; LB, lamellar bone; RB, residual bone.

formed more stable structures. After six months, new trabecular bones were formed, and most of the autogenous tooth graft materials had undergone resorption. This difference is significant when considering that the formation of new bones from several bone substitutes requires an average of four to nine months[8-12].

The early bone formation capacity of autogenous bone grafts is superior to that of other bone graft materials. It is advantageous, therefore, to perform maxillary bone graft and implant placement concurrently[13]. In a study investigating autogenous bone and xenogenic bone Bio-Oss, maxillary sinus bone grafts and implant placement were performed simultaneously, with bone implant contact (BIC) examined one, two, eight, and twelve months after surgery[14]. One month after surgery, the BIC was  $25.1 \pm 9.96$  and  $21.0 \pm 9.01$  for autogenous bone and xenogenic bone, respectively. Two months after surgery, values were  $40.1 \pm 5.25$  and  $30.4 \pm 20.91$ , respectively. During the early period after bone grafts, osseointegration of autogenous bones was significantly different than in xenogenic bone. Eight months after surgery, autogenous bone showed a BIC of  $51.7 \pm 9.96$ , whereas Bio-Oss showed a BIC of  $52.6 \pm 16.22$ . Twelve months after surgery, autogenous bones had a BIC of  $55.1 \pm 13.10$ , whereas Bio-Oss had a BIC of  $56.5 \pm 14.77$ . The BIC did not show statistically significant differences. In the present study, the early bone formation ability of autogenous bone was found to be better than that of other bone graft materials. Additionally, the healing period of autogenous tooth graft materials was about 3~6 months, similar to that of autogenous bone. These results indicate good bone formation capacity, comparable to that found in autogenous bones[15-17].

In similar studies where implants were placed immediately after tooth extraction, pocket depth (PD), clinical attachment level (AL), bone density, and marginal bone loss

associated with autogenous bone patients (group 1) and synthetic bone patients (group 2) were compared after nine and twelve months[18,19]. Autogenous bone showed better results than synthetic bone across all categories, and in particular, more significant differences were found at 12 months after surgery than at nine months ( $P<.01$ ). With autogenous bone grafts, the early stability of implants was superior to that of xenogenic bones, whereas torque was more than 30N-cm[20].

However, when autogenous bones were used alone, the bone resorption rates were relatively higher. In particular, when used alone for a maxillary bone graft, re-pneumatization can occur[3]. Therefore, it is recommended that clinicians mix more than two types of materials to take advantage of bone graft materials and to augment the volume of the graft materials[13,21].

In a study on bone resorption rates of autogenous bones used for implant placement, Schaaf et al.[22] showed that annual resorption rates averaged 1.3 mm one year after surgery in the alveolar ridge area. In a 2010 study by Johansson et al. that examined bone loss in alveolar ridges and apical areas, autogenous bones were used for maxillary sinus bone grafts and examined for 60 months after surgery. One year after implant placement, the rates of bone resorption in the proximal and distal areas of the apical portions of the implants were 0.81 mm and 0.86 mm, respectively.

One year and 60 months after receiving the occlusal load, similar to our initial assumptions, the marginal bone loss levels in the proximal and distal areas were not significantly different. The levels of bone loss in the proximal end areas were not significantly different. Nonetheless, the average amounts of bone loss in the distal area after one year and 60 months were 0.33 mm and 0.73 mm, respectively. The difference was statistically significant. When autogenous bones were used for maxillary sinus bone grafts, the amount of bone loss in the proximal end areas was relatively larger than that of the alveolar ridge, and in particular, the amount of bone loss was prominent in the implant distal area.

In a study reported by Hallman et al.[23], who performed maxillary sinus bone grafts using a mixture of autogenous bones and xenogenic bone Bio-Oss, the average bone loss three years after occlusal load was shown to be  $1.3\pm1.1$

mm. The amount of bone loss after the connection of the abutment at one year and three years was  $0.4\pm0.9$  mm,  $0.8\pm1.5$  mm, and  $1.1\pm1.1$  mm, respectively, which was not statistically different from the amount of bone loss ( $0.2\pm0.5$  mm,  $0.9\pm1.0$  mm, and  $0.7\pm1.0$  mm) observed in the implants in the residual bones. The average Resonance Frequency Analysis (RFA) using Osstell™ was  $66.2\pm4.1$ , which was not significantly different from the average RFA involving implants in residual bones ( $67.4\pm4.5$ ). Hallman reported that the use of the mixture of autogenous bones and xenogenic bones exerted minimal effects on the stability of the maxillary mucosa, whereas good bone formation was shown.

To summarize the above studies, the composition of autogenous tooth graft materials is similar to that of autogenous bones, and its clinical healing process is similar to that of autogenous bones. When it is used for maxillary sinus bone grafts, autogenous tooth graft materials show bone remodeling reaction and resorption rates comparable to those of autogenous bones. In the present study, a significant difference was observed between bone resorption levels when a mixture of autogenous tooth graft materials and other bone graft materials was used, as compared to the use of autogenous bone graft materials alone. More studies are warranted in the future to further investigate the potential of autogenous tooth graft materials.

## Conclusions

When autogenous tooth graft materials were used for maxillary sinus bone grafts, clinically safe healing reactions were observed. Histologically excellent bone formation capacity was seen. In addition, excellent stability was seen in cases where autogenous materials were used alone or mixed with other materials. In summary, graft materials may be substituted for autogenous bone.

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