Radiologic Evaluation of Putty Versus Powder Form of Demineralized Bone Matrix in Sinus Floor Elevation

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The aim of this study was to evaluate differences in ossification of the 2 forms of demineralized bone matrix (DBM)—putty and powder—radiographically, using digital densitometry on panoramic radiographs in maxillary sinus floor augmentation procedures. Twelve subjects needing bilateral maxillary sinus floor augmentation for the placement of osseointegrated implants were included in this study. The left and right maxillary sinuses were augmented in the same session in each patient using the 2 preferred forms of DBM—putty and powder—during the same session. One sinus was augmented with DBM putty form and the other sinus was augmented with DBM powder form randomly. Every patient had a total of 4 panoramic radiographs taken, preoperatively and in the first, third, and sixth month postoperatively. The densitometry measurements were taken from each step of the aluminium step-wedge, from both sinuses from different points a total of 3 times, and the average of these measurements was calculated. The amount of mineralization in each graft material in every radiograph was clarified by the appearance of a difference in the equivalent aluminium thickness, and the obtained results were statistically evaluated. The results showed that there were no significant differences between two graft materials statistically. These two graft materials could be good alternatives in sinus lifting procedures because of less morbidity, lower price, and good ossification. The results indicate that 2 different types of DBM achieved good ossification in the sinus lifting procedure, and there is not a considerable distinction in these 2 forms.

Key Words: sinus floor augmentation, demineralized bone matrix, densitometric analysis, putty, powder

INTRODUCTION

Pneumatization of the maxillary sinus and alveolar bone resorption after extraction of maxillary posterior teeth results in horizontal and vertical bone resorption. The atrophic posterior maxilla is a challenging site to place dental implants.[1,2] Various maxillary sinus floor augmentation techniques and graft materials have been proposed for managing severe bone loss in the posterior maxilla.[3–8]

The use of demineralized bone matrix (DBM) as a bone graft was first described in 1889 by Senn.[9] Much later, Urist[10] discovered that this material is capable of inducing ectopic bone formation when implanted subcutaneously in rats. The first application of DBM in maxillofacial surgery was described by Libin et al[11] in 1975. In

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DOI: 10.1563/AAID-JOI-D-10-00017

recent years several studies have shown that the use of DBM in the maxillofacial area had satisfactory results.[12,13] DBM contains active proteins such as bone morphogenetic protein (BMP), transforming growth factor-beta, osteogenin, insulin-like growth factor, and fibroblast growth factor, which are indirectly involved in bone healing cascade.[13] Efforts to produce forms of DBM with improved intraoperative handling characteristics has led to the development of putty, powder, flex, gel, and paste forms.[14]

The aim of this study was to evaluate differences in density of the 2 forms of DBM—putty and powder—radiographically, using digital densitometry on panoramic radiographs in maxillary sinus floor augmentation procedures.

Materials and Methods

Twelve subjects who were referred to the department of Oral and Maxillofacial Surgery at Ankara University, Faculty of Dentistry for bilateral maxillary sinus floor augmentation to enable dental implant treatment were included in this study. These patients were to be treated using the 2 most preferred forms of DBM—putty and powder—during the same session. The study was approved by Ankara University Dentistry Faculty Research Ethics Committee. Preoperative plain radiograms were taken to evaluate residual bone height and sinus pathology. According to the classification of Cawood and Howell,[15] Class V and VI cases were included in the study. None of the patients had significant sinus pathology and systemic diseases. All patients underwent bilateral sinus surgery.

Surgical technique

All of the operations were performed under local anaesthetic using articaine hydrochloride (Ultracaine D-S Forte Ampul, Aventis). With a mid-crestal incision and vertical releasing incisions, a mucoperiosteal flap was elevated to expose the sinus wall. An osteotomy was carried out in the lateral wall and the Schneiderian membrane was detached from the sinus wall very carefully to create a space for placement of the graft materials. The left and right maxillary sinuses were augmented in the same session in each patient. One sinus was augmented with DBM putty form (DynaGraft bone putty, Keystone Dental, Burlington, Mass), and the other sinus was augmented with DBM powder form (Bone Powder, Pacific Coast Tissue Bank, Los Angeles, Calif) randomly after a minimum 30 minutes of rehydration process in 0.9% saline solution. After the graft had been placed, the flap was repositioned and sutured with 3-0 silk suture. Antibiotic (amoxicillin, 3 times per day) and analgesic (naproxen sodium, 2 times per day) therapy was administrated 1 hour before surgery and for 5 days following surgery. Chlorhexidine gluconate mouthwash was used twice daily for 2 weeks. The patients were advised to have a soft diet and to avoid sneezing until suture removal. Implant placement was performed 6 months-after sinus lifting procedure.

Aluminium step-wedge

An aluminium step-wedge was used as a reference material in the conventional radiographic densitometry study. The step-wedge was made using 99.7% pure aluminium plate, 1 mm thick, and was cut into 2-, 4-, 6-, 8-, 10-, and 12-mm lengths. By placing the pieces one on top of the other as in stairs, a 6-step aluminium step wedge was made (Figure 1). In order to ensure calibration and standardization, the aluminium step-wedge was placed at a fixed point (bottom right corner) inside the film cassette before taking the radiographs. Care was taken not to have the step-wedge superimposed on the hyoid bone or any other bone tissue while the films were taken (Figure 2).

In this study the radiographic examinations were made using panoramic radiographs. The radiographic exanimations were carried out by Ankara University,

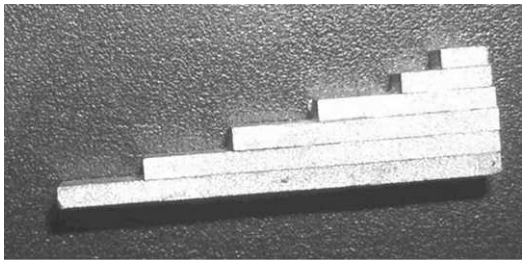

Figure 1. Aluminium step-wedge.

Department of Oral Diagnosis and Radiology by the same radiologist.

In our study, Medipot X-O/RP (Planmeca, Helsinki, Finland) sense green 15 × 30 panoramic films were used. With a panoramic device made by Planmeca (model PM 2001 CC Proline) radiographs were taken for each patient using 80 kVp, 12 mA, and total infiltration 2.5 mm Al. The development of the films was carried out using a Velepex Extra-XE model automatic developing device under the same conditions.

Every patient had a total of 4 panoramic radiographs taken, preoperatively and in the first, third and sixth month postoperatively.

Densitometric evaluation

The densitometric evaluation was performed by the same blinded staff of the Nuclear Sciences Institute of Ankara University, Medical Physics Department. A 1-mm diameter digital densitometer (model 07-443, Fluke Biomedical, Everett, Wash) was used in optic density measurements. The results were read from the digital screen at that time and recorded (Figure 3).

The densitometry measurements were taken from each step of the aluminium step-wedge, from both the sinus where the sinus augmentations took place and from different points for a total of 3 times, and the average of these measurements was calculated.

In every radiograph, the average results taken from the sinus region were defined by the aluminium equivalent thickness. In this way, the amount of mineralization in each graft material in every radiograph could be estimated by the appearance of a difference in the equivalent aluminium thickness, and the obtained results were statistically evaluated.

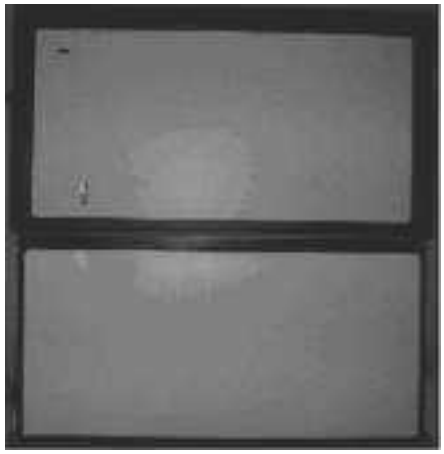

Figure 2. Position of the aluminium step-wedge on the film cassette.

Statistical analysis

Data were analyzed using SPSS (Statistical Package for Social Science, version 11.5, Chicago, Ill) packages. Complete statistics were shown in the form of median (minimum-maximum). To determine whether there was a statistical difference between the repeated measurements in the powder and putty sides, they were analyzed with the Bonferroni corrected Friedman test. During the follow-up time,

Figure 3. Digital densitometer device.

TABLE 1

Preoperative and postoperative statistical analysis of the densitometric data from the sinus region where demineralized bone matrix powder was used*

Powder	Preoperative	Postoperative 1-month	Postoperative 3-month	Postoperative 6-month	*P* Value
Average	2.52	4.61	3.92	5.03	.000
SD	1.096	1.37	1.28	0.34	
P	0.972	0.944	0.822	0.739	

*SD indicates standard deviation; P, significance.

the importance of the difference between the 2 materials was analyzed with the Bonferroni corrected Wilcoxon signed rank test. Also, according to the reference follow-up time, the amount of change between the 2 materials was calculated with the step-wedge, and $P \leq .05$ was accepted as statistically significant.

RESULTS

Twelve patients (7 female and 5 male) were included in this study. The range of ages was between 22 and 58, with a mean age of 40 years. Twenty-four augmentations were performed on 12 patients. One patient had a perforation of the Schneiderian membrane during the sinus elevation, and the membrane was repaired using a collagen membrane. Postoperative healing was uneventful in all cases. Even though there had been no clinical findings or symptoms of infection, in one patient the graft material was found to be infected during placement of the implants. The infected graft material and tissues were removed from the sinus. As there was no image of the other side for comparison, this patient was not included in the study.

Once the data obtained from the preoperative and postoperative (first, third, and sixth months) radiographs were statistically evaluated, a significant difference was found in the optic density between the preoperative and postoperative periods in the sinus augmentations using the DBM powder (Table 1). In the same way, in the sinus floor augmentations using the DBM putty, a significant difference was found in optic density between the preoperative and postoperative values (Table 2). The mineralization difference between putty and powder form of DBM is also shown in Figure 4.

In this study, once changes between the starting and follow-up periods of the graft materials were evaluated, comparisons were made in the optic density between the preoperative and postoperative periods. From a densitometry perspective, there were no significant differences between the powder and putty in any time (Table 3).

DISCUSSION

The aim of the sinus floor augmentation procedure is to create bone quantity and quality so as to ensure the placement of dental implants of sufficient length and satisfying initial stability.[16] Although autogenous bone grafts are thought to be

TABLE 2

Preoperative and postoperative statistical analysis of the densitometric data from the sinus region where demineralized bone matrix putty was used*

Putty	Preoperative	Postoperative 1-month	Postoperative 3-month	Postoperative 6-month	*P* Value
Average	2.368	4.706	3.818	4.795	.000
SD	1.203	1.381	1.417	1.080	
P	0.870	0.436	0.865	0.966	

*SD indicates standard deviation; P, significance.

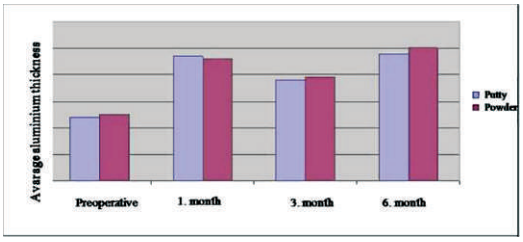

Figure 4. Mineralization levels of putty and powder form of demineralized bone matrix.

the gold standard for bone grafting, it has some disadvantages such as the formation of a second surgical region, causing morbidity in the donor region and only being able to take a limited amount.[17,18] The introduction of new graft materials such as allografts, xenografts, and alloplastic materials has provided alternatives to autogenous bone.[19] Osteoinductive graft materials form new bone endosteally from the floor of the sinus as expected, but may also form bone de novo within the graft depending on its osteoinductive capacity.[20] Osteoinductivity is a pharmacokinetic principle and is thought to be directly proportional to the concentration of BMP present in the grafted material.[20] Early observations of the effect on BMP used in the human sinus have demonstrated bone formation from the elevated sinus lining where pluripotent cells and vascular capacity are certainly present.[20]

Some reports question the variability of BMP concentration and activity in commercially available allografts, and therefore qualify them as less predictable.[3] Product fabrication and formulation are critical in ensuring the quality and osteoinductive properties of the product. The osteoinductive properties of DBM are variable from one cadaver source to another.[3] As a general rule, the younger the cadaver, the more BMPs are available in the bone. In addition, the demineralized cortical bone mineral contains a higher concentration of BMPs than trabecular bone and is recommended.[3]

Glowacki and Mulliken[21] and Acarturk and Hollinger[22] showed better results with demineralized bone powder because the surface area of the graft exposed to the recipient side was increased. Karaduba et al[23] observed that samples taken from the regions where demineralized bone powder was grafted showed a large part of new bone formation (70%–75%), and they also reported that the newly formed bone was mature and dense. However, in another study, Nishibori et al[24] showed unsuccessful results of DBM when compared with autogenous bone graft. Jensen et al[20] studied 145 sinus grafts in 100 patients by panoramic radiograph because it was the most frequent film used. A total of 9 different materials (alloplast, allograft, chin bone, hip bone, combination of autograft and alloplast, combination of chin bone and alloplast, combination of allograft and xenograft, combination of hip bone and alloplast, combination of allograft and alloplast), including various grafting combinations, were included in this study. They compared the difference in graft height over 3 years for various graft materials and mixtures of materials and showed the least change in graft height for

Table 3

Statistical evaluation of preoperative demineralized bone matrix powder and putty allograft mineral density compared to different periods*

	Average	SD	P
Powder, 1 month Putty, 1 month	−0.24917	0.93957	0.378
Powder, 3 months Putty, 3 months	−0.05333	0.74903	0.810
Powder, 6 months Putty, 6 months	0.7917	0.74708	0.721

*SD indicates standard deviation; P, significance.

the combination of an autograft (intraoral bone) and an alloplast (mostly porous hydroxyapatite), with a mean of 0.79 mm (bone loss). The greatest loss in graft height was observed for the freeze-dried demineralized bone, with a mean change of 2.09 mm. However, all the graft materials appeared stable, losing only 1–2 mm of graft height over the 3-year timeframe as long as implants remained present and in function.

The results of this study showed that the bone density in sides grafted with the putty form of DBM increased in the postoperative first month and then decreased in the third month slightly and again increased in the sixth month. These results were similar when compared with the sides grafted with the powder form of DBM. The high bone density appearance in the first month depends perhaps on edema and nonresorption of the graft material. In the sixth month, the mineralization procedure occurred and the grafted side appeared to be of a high density in the radiographic evaluation. Chesmel et al[14] showed that human DBM in gel, putty, and sheet forms performed as well as an autograft in a critical defect in the athymic rat models. There were no significant differences between these 3 forms. Also, the particle size of graft material used was approximately 150–425 μm. In old rats the induced bone appeared to be of less quantity, it formed at a slower rate, and it exhibited less bone marrow cellularity than did the bone in young rats. Apart from the presence of growth factors, the size of the DBM particles is also important. Optimal bone formation was found with DBM particle sizes of 250 μm to 500 μm.[25–27] Xu et al[28] also demonstrated that small particles of DBM showed better results than large particles of DBM in sinus augmentation with histologic and implant integration analysis.

These findings show that in a sinus region grafted with demineralized frozen-dried material, bone was completely unformed and that it was unable to produce high enough levels or quality of bone for any future implant. However, sinus regions grafted with autogenous bone grafts were able to produce high enough levels and quality of bone for any future implants. Also, it was reported that the cancellous DBM show changeable results. In this study, we tried to determine whether successful results would be obtained in the use of two different forms of DBM allografts or not, and also whether there was any advantage between one form and the other. The results were similar when compared with other studies in the literature.

In conclusion, DBM is a good alternative in the sinus lifting procedure, and there is no significant difference between putty and powder forms of this material when compared with radiographic and clinical examinations.

Abbreviations

BMP: bone morphogenic protein
DBM: demineralized bone matrix

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