

CLINICAL, RADIOGRAPHIC AND HISTOLOGICAL OUTCOMES OF SINUS FLOOR AUGMENTATION FOR DELAYED IMPLANT PLACEMENT USING AUTOGENOUS FRESH TOOTH GRAFT

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ABSTRACT

Objectives: To investigate the effectiveness of the freshly extracted dental particulate in maxillary sinus grafting.

Patients and Methods: This prospective study was carried on 8 patients who underwent sinus augmentation. After atraumatic extraction, the teeth were ground and processed into a bacteria free dentin particulate, then grafted immediately into the maxillary sinus; after 6 months from the sinus lift procedure patients received 13 implants and core biopsies were collected. The primary outcome was the change in the graft height and was assessed radiographically, the secondary outcomes were new bone formation and implant survival rate.

Results: According to the radiographic analysis, the graft showed loss of 2.4 ± 0.6 mm after 6 months. The percentage of graft height loss was 19.9 ± 4.9 %. While at 12 months, total graft height loss was 2.65 ± 0.7 mm. The percentage of graft loss was 22.4 ± 4.4 %. In the histologic picture, new bone formation together with the autogenous tooth graft materials was observed. Survival rate of dental implants after 6 months from loading was 100 %.

Conclusions: Autogenous demineralized dentin matrix particulate grafted immediately after extractions is safe and successful biomaterial with excellent bone forming capacity in sinus augmentation, it can be considered as a good alternative to bone graft in sinus lift procedure.

KEYWORDS: Autogenous tooth graft, demineralized dentin particulate, maxillary sinus augmentation.

INTRODUCTION

Posterior edentulous maxilla represents a challenging situation in implant dentistry. The alveolar ridge resorption following tooth loss is associated with sinus pneumatization leading

to atrophied maxilla with insufficient available alveolar bone for implant placement. However, different surgical procedures have been introduced to augment posterior maxilla and increase available bone, maxillary sinus lift is considered the most reliable procedure⁽¹⁻²⁾.

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Sinus lift was initially introduced by **Tatum** in 1976, while the first publication describing this procedure was by **Boyne and James** in 1980. Sinus lift procedure is designed to increase the available bone volume via guided bone regeneration using the sinus membrane as a natural barrier⁽³⁻⁴⁾. Lateral approach (using Caldwell-Luc osteotomy), and the axial approach (using Summers osteotomy) have been used for maxillary sinus augmentation. Although, the crestal approach represent a simple and less invasive technique when compared to lateral approach, its use is restricted to cases with minimal bone loss. To the contrary, lateral approach provides better control, greater membrane elevation and consequently more gain in postoperative bone volume⁽⁵⁻⁶⁾.

Various bone grafts have been effectively used to reconstruct bony defects. There are four types of bone graft materials: autograft, allograft, xenograft and alloplast, the utilization of these materials relies upon clinical applications, volume of deficiency and evidence based investigations⁽⁷⁾. Autograft has been considered the gold standard, due to its regenerative osteogenicity, osteoinductivity and osteoconductivity. However, many clinicians do not favor autograft due to donor site complications, prolonged surgical time and limited grafts amount⁽⁸⁾.

Different bone substitutes (allografts, xenografts, alloplasts) have been used in sinus lift. They represent an attractive alternative for autogenous bone. However, the lack of osteoinductive properties, longer maturation period and high cost compared to autogenous graft represent main disadvantages for these materials⁽⁹⁻¹⁰⁾. Therefore many researchers, in a trial to compensate the disadvantages of different grafting materials, focused on human tooth as one of the intraoral donor sites with great chemical similarities to bone⁽¹¹⁾.

Teeth and bones share numerous similarities; both embryologically originated in the neural crest, also both have similar chemical compositions;

the dentin of the teeth and the bone have 65% inorganic parts including the calcium phosphate lineage and 35% organic components such as collagen, it is therefore not surprising that dentin that involves more than 85% of tooth structure can serve as native bone grafting material⁽¹²⁾. Recently, several investigations revealed that extracted teeth from patients that undergo a process of cleaning, crushing, demineralization and sterilization is a perfect grafting material in filling bone defects⁽¹³⁾.

The purpose of this study is to evaluate the effectiveness of the autogenous tooth graft materials as an autogenous graft with low technique sensitivity in maxillary sinus augmentation.

PATIENTS AND METHODS

This study was carried in accordance with international standards of quality for clinical trials, the Declaration of Helsinki; 8 patients were selected from the outpatient clinic of the Department of Oral and Maxillofacial Surgery, Faculty of Oral and Dental Medicine, Cairo University from July 2016 to October 2016. All the patients underwent maxillary sinus augmentation procedure utilizing autogenous tooth bone graft materials while 13 delayed implant placement was performed after six months from the augmentation procedure in the second surgery.

A. Participants:

Patients were selected according to the following criteria: Patients with missing posterior maxillary teeth with less than 4 mm available bone for implant placement indicating the need for maxillary sinus floor augmentation before implantation; have at least one vital non restorable tooth indicated for extraction; free from any systemic or local disease that may affect normal healing of bone; free from any sinus disease that might affect the health and integrity of the sinus lining; non-smokers. All the patients received information about the surgical procedures and gave written informed consent.

B. Intervention:

All patients were assessed clinically to assure their accordance with eligibility criteria. A preoperative panorama is taken for inspection of the sinus and for measuring the remaining residual ridge till the sinus floor, the selected patients have thickness of bone less than 4 mm, making them candidates for 2 stage surgical procedures; the first is open sinus lift and the second is for implant placement after 6 months.

Surgery and tooth Bone Materials

Surgical procedures were performed under local anesthesia. Patients were instructed to rinse their mouth with Chlorohexidine Gluconate 0.1% mouth wash for one minute. Atraumatic extraction was done to the non restorable tooth, immediately after extraction, restorations like fillings and crowns, calculus, carious lesions and remaining periodontal ligament were removed. The roots were splitted in case of multi-roots; teeth were cleaned and dried via air syringe, then were grinded by bone mill into small dentin particles (**Fig.1**).

The dentin particles is immersed in 70 % ethanol and 5% peracetic acid for 10 minutes to dissolve all organic debris and bacteria, demineralized with 2% nitric acid solution to transform to demineralized dentin matrix (DDM) particulate and so expose the dentine organic matrix, the particulate is then

washed by sterile phosphate-buffered saline. The bacteria-free dentin particulate is ready for grafting the maxillary sinus⁽¹⁴⁻¹⁵⁾.

After tooth extraction and preparation, Caldwell-Luc procedure was done under local anesthesia; crestal incision on the edentulous ridge with a mesiovertical release was made followed by elevation a full-thickness mucoperiosteal flap to expose lateral maxillary sinus wall. A bony window was made in the lateral sinus wall using carbide round bur under copious amount of saline irrigation. After gently detaching from the lateral wall and floor, the Schneiderian membrane was elevated upward till the desired height using broad curettes for tooth bone graft placement. DDM was placed into the prepared site below the newly positioned Schneiderian membrane (**Fig. 2**). Bioresorbable collagen membrane (BioGides®, Geistlich Biomaterials, Wolhusen) was used to cover the osteotomy window. Finally, the flap is closed.

Postoperative instructions and medications were: Extraoral ice packs for first postoperative six hours; non-steroidal anti-inflammatory analgesic (Diclofenac potassium 50mg) three times daily for three days; corticosteroid anti inflammatory course (Epidrone 4 ml) intra muscular injections for 2 days; antibiotic (clindamycin 300 mg) three times daily for five days; mouth wash was used 24 hours

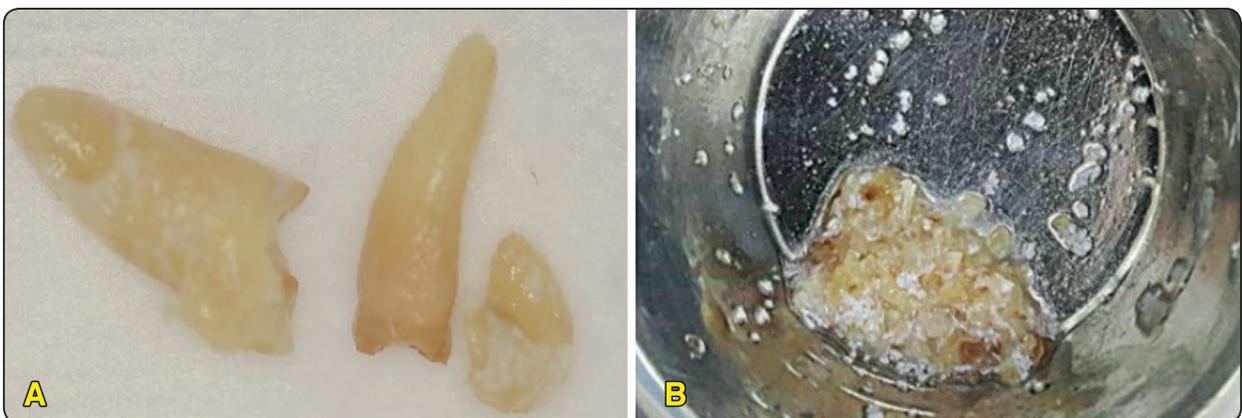


Fig. 1: (A): extracted roots after cleaning (B): dentin particulate after grinding

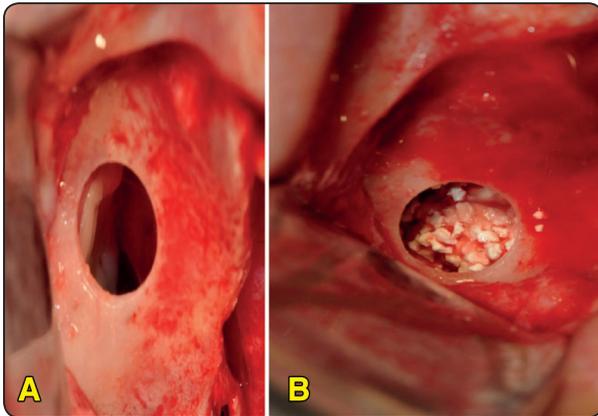


Fig. 2: (A): Elevation of the Schneiderian membrane (B): Dentin particulate filling sinus

after surgery 3 times a day for 1 week; regular oral hygiene measures were resumed after 24 hours; avoid creation of negative pressure. Patients were recalled 1 week postoperatively for suture removal and clinical evaluation. Next visits were scheduled at 1 week, 6, 12 and 18 months postoperatively.

In order to standardize the radiographic evaluation, all radiographs were performed with the same device (Scanora1; Soredex Orion Corporation Ltd., Helsinki, Finland) using the same settings and the same software program. Radiographic evaluation was focused on graft height at the augmented area. CBCT radiographs were performed for every patient 1 week (T_0) postoperatively; second CBCT radiographs were performed after 6 months (T_6) to assess available bone for implant placement.

Second-stage surgery was performed after 6 months, it included dental implant placement and biopsy harvesting; a 3 mm diameter trephine bur was utilized to collect a transcortical bone graft biopsy from the grafted sinuses, where the drilling depth was planned from the CBCT. Core biopsy was fixed by 10% buffered formalin. When submitted for histologic examination, decalcification of the specimen was attained by suspension in EDTA 10% solution for fourteen days with regular rechanging of the solution every day. Dehydration of the

specimen was then achieved using alcohol, followed by clearing in xylol. Afterward it was inserted in paraffin wax to be in a block form. The paraffin block was segmented using a microtome into thin paraffin sections, each of approximately 5 microns thick. The sections were stained with Hematoxylin and Eosin. Stained sections were examined in order to estimate the newly formed bone in the graft. 12 months after sinus lift procedure (6 months after implant placement) loading of dental implants were done and the third CBCT radiographs were performed (T_{12}) (Fig 3).

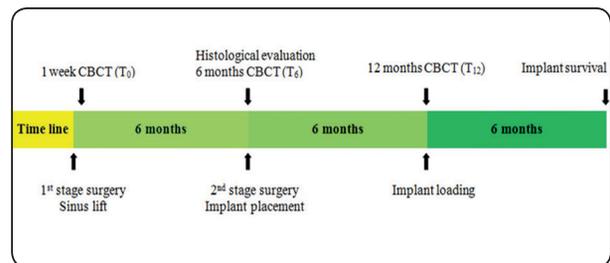


Fig. (3) Study time line

C. Outcomes

Primary end point

The primary end point of radiographic analysis was the change in the graft height. Radiographic measures were performed on the CBCT. All measures were performed at the highest point of new sinus floor with a millimeter scale by the software. Alveolar crest, original sinus floor and grafted sinus floor were traced and the following measures were recorded in T_0 , T_6 , and T_{12} : Residual bone height (R): The distance from the marginal bone crest to the original sinus floor; Total bone height (H): The distance from the marginal bone crest to the new sinus floor; graft height (G): The distance from the original sinus floor to the new sinus floor. (Fig 4)

To assess the change of graft height, amount and percentage of bone graft loss were calculated at 6 and 12 months postoperatively as follow: Bone loss after 6 months (L_6): The difference between graft

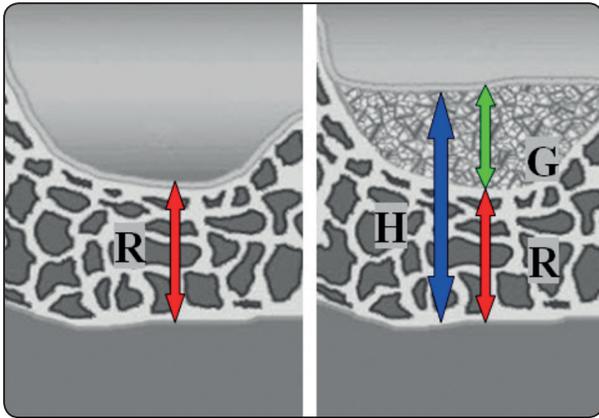


Fig. (4): Diagram showing radiographic measures. Residual bone height (**R**), Graft height (**G**), Total bone height (**H**)

height at one week and 6 month radiographs (G_0 - G_6); Percentage of bone loss after 6 months (PL_6): The percentage of the bone loss after 6 months (L_6) to the initial bone height of the graft (G_0). Bone loss after 12 months (L_{12}): The difference between graft height at one week and 12 month radiographs (G_0 - G_{12}). Percentage of bone loss after 12 months (PL_{12}): The percentage of the bone loss after 12 months (L_{12}) to the bone height of the graft (G_0). Bone loss from 6 months to 12 months (L_{6-12}): The difference between graft height at 6 months and 12 month radiographs (G_6 - G_{12}) **Fig (5)**.

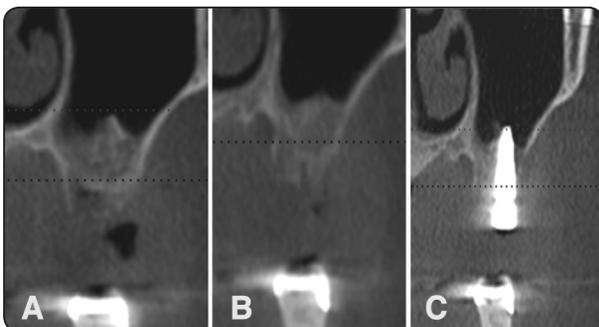


Fig. (5) (A): CBCT 1 week after augmentation (B): CBCT at the 6 months follow up after sinus lift (C): CBCT at the 12 months after sinus lift (6 months after implant placement)

Secondary end points

Additional analysis was performed to assess bone formation and implant survival rate. Histological analysis was performed for the core biopsy to assess bone formation and tissue reaction to the DDB. All implants were assessed 6 months after loading to evaluate survival rate.

D. Statistical analysis

Statistical analysis was performed using SPSS (Statistical package for the social sciences-IBM® SPSS® Statistics Version 20 for Windows, IBM Corp., Armonk, NY, USA). The data were represented as mean \pm standard deviation (SD). Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. For parametric data; Paired t-test was used to compare variables between different time points. For non-parametric data; Wilcoxon signed-rank test was used. The results were considered statistically significant if the p value was less than 0.05.

RESULTS

Radiographic assessment

Radiographic evaluation was mainly concerned with the change in the graft height. The initial graft height (G_0) was 12.3 ± 2.1 mm. After 6 months, the graft height (G_6) dropped to 9.9 ± 1.9 mm, and there was statistically significant difference between the 2 time points (G_0 , G_6). At 12 months, minor change had occurred to the graft. The graft height (G_{12}) was 9.7 ± 1.7 mm, with no statistically significant difference when compared to graft height at 6 months (G_6). The graft showed height loss of 2.4 ± 0.6 mm after 6 months. The percentage of graft height loss was 19.9 ± 4.9 %. While at 12 months, total graft height loss was 2.65 ± 0.7 mm. The percentage of graft loss was 22.4 ± 4.4 %. The change in graft height between 6 and 12 months was minimal (0.2 ± 0.3) mm (**Table 1**) (**Fig.6**).

TABLE (1) Mean and standard deviation (in mm) of the radiographic values before and after grafting at different time intervals

	R	H ₀	G ₀	G ₆	L ₆	PL ₆	G ₁₂	L ₁₂₋₆	L ₁₂	PL ₁₂
Mean ±SD	3 ± 0.7	15.3 ± 2.1	12.3 ± 2.1	9.9 ± 2	2.4 ± 0.6	19.9 ± 4.9	9.7 ± 1.7	0.2 ± 0.3	2.7 ± 0.7	22.4 ± 4.4

*R Residual bone, *H₀ Total bone height at 1 week, *G₀ Graft height at 1 week, *G₆ Graft height at 6 months, *L₆ graft loss after 6 months, *PL₆ Percentage of graft loss after 6 months, *G₁₂ Graft height at 12 months, *L₁₂₋₆ graft loss from 6 months to 12 months, *L₁₂ Total graft loss after 12 months, *PL₁₂ Percentage of graft loss after 12 months

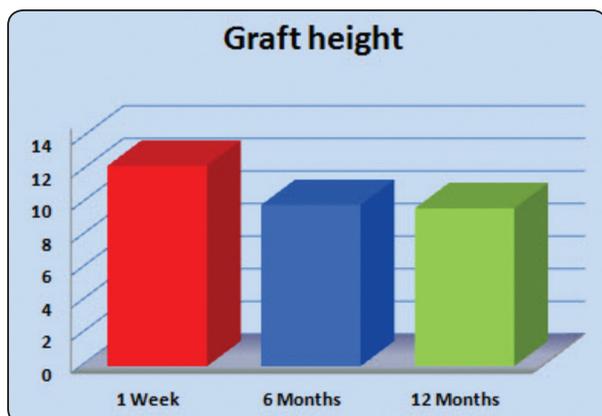


Fig. (6): Bar chart showing graft height at different time points



Fig. (7) A histology section of core biopsy with the arrow denoting newly formed bone matrix beside autogenous tooth graft

Clinical assessment:

Normal healing process was observed after the 2 phases of the surgical procedure; Sinus perforation occurred in 1 case, bioresorbable collagen membrane; (BioGides®, Geistlich Biomaterials, Wolhusen) was placed as a barrier between the sinus membrane and the graft material in this case. Wound dehiscence at the crest of the ridge developed in 1 case, it was managed by daily irrigation with saline with no subsequent complications, none of our patients experienced implant failure throughout the follow up period, resulting in a survival rate of 100 % after 6 months of implants loading.

Histological Analysis :

In the histologic picture, autogenous tooth graft materials together with newly formed bone were observed (Fig 7).

DISCUSSION

A long time ago, numerous researches demonstrated that autogenous teeth when transplanted into extraction sockets got ankylosed in the bone of the jaw. What is more, it is well documented that avulsed teeth that are reimplanted back into their sockets, experience firm reattachment directly to the bone ⁽¹⁶⁾. Ankylosed root either in avulsed or

transplanted teeth undergo replacement resorption where the ankylosed root is continuously resorbed and replaced with bone, ending by resorbing the whole root, while the alveolar process is preserved during this period⁽¹⁷⁾. Accordingly, some clinicians have tried to replace autogenous bone graft by teeth as a graft material for bone formation⁽¹³⁾. In our study we tried to assess the effectiveness of the autogenous tooth graft materials as an autogenous graft in maxillary sinus augmentation

In this study, we used DDM as grafting material for maxillary sinus augmentation. The DDM utilized in this study went through grinding and demineralization process before grafting. The aim of the grinding process was to facilitate the dentin resorption and replacement by osseous tissue⁽¹⁸⁻¹⁹⁾. Demineralization process was performed to enhance new bone formation. Numerous studies proved that the demineralization process and uncovering the collagen matrix exposes matrix derived growth and differentiation factors for effective osteogenesis and increases BMP-2 bioavailability⁽²⁰⁻²¹⁾. After sinus grafting procedure, bioresorbable membrane was used to cover the lateral window. The placement of a barrier membrane showed better results with the sinus lift compared to no membrane coverage, it decreases dramatically the amount of soft tissue invasion to the grafted sinus⁽²²⁾.

An important point to consider in maxillary sinus lift using DDM is the simplicity of the graft harvesting procedure, no complications occurred during graft harvesting or after surgical procedure, unlike the autogenous bone harvesting that is associated with donor site morbidity and prolonged surgical time⁽²³⁻²⁶⁾, indicating DDM as a safer and easier substitute for autogenous bone grafting.

The overall implant survival rate of our study was 100%, and it was competent with recent articles and systematic reviews monitoring the implant survival rate with sinus lift⁽²¹⁻²⁷⁾. This result is also harmonious with **Starch-Jensen et al.** study

that showed high survival rate with no difference between autogenous graft and bone substitutes in maxillary sinus augmentation⁽²⁸⁾.

Graft stability in maxillary sinus augmentation procedures is affected by numerous factors, type of grafting material followed by the presence of implants are the most important factors⁽²⁹⁾. In this study, DDM showed high stability as a grafting material. DDM graft lost 19.9 % (2.4 mm) of its original height 6 months after grafting procedure. This result is comparable to that shown by different bone substitutes, unlike autogenous bone graft which undergo higher resorption. After implant placement, the graft showed minimal resorption (0.2 mm). This may be attributed - beside the graft stability- to implants placement⁽²⁹⁻³¹⁾.

Depending only on a radiograph to evaluate bone graft success has been doubted. Difficulties in quality, standardization and interpretation remain problematic. Over the years, the success of grafting procedures is evaluated using histological techniques beside the radiographic assessment.⁽³²⁾ Our histological analysis of the DDB graft showed new bone formation beside osteoclasts and osteoblasts around the graft, indicating the gradual replacement of the graft by new bone. Various studies demonstrated DDM ability to be incorporated in bone via secretion of BMP-2 without producing inflammation, where they are gradually resorbed and replaced by new bone⁽³³⁾.

This study presents DDM as an effective and safe autogenous grafting material for maxillary sinus augmentation. DDM showed high graft stability and promising results in bone formation. It can be utilized as an alternative to various bone graft materials, but we recommend further clinical trials to compare it with different graft types and longer follow up period to judge the implant success rate more precisely. Moreover, the optimal time for implantation after grafting represents another query requiring further investigations.

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