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Evaluation of Maxillary Sinus lifting Using Piezoelectric Device versus Trephine Design

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Abstract
Enlargement of the maxillary sinus often precludes implant placement in the posterior quadrant without augmentation to increase bone height to stabilize the implant fixtures and provide load handling following restoration. Maxillary sinus augmentation has been a technical challenge due to the potential for tearing of the Schneiderian membrane during lateral window formation.
Purpose: this study is to evaluate the outcomes of the maxillary sinus floor augmentation both clinically and radiographically using the piezoelectric device versus trephine design before implant installation.
Material& Methods: This study was carried out on twelve partial edentulous atrophic posterior maxillary regions in twelve patients, in whom the maxillary alveolar ridge has not enough bone volume for reliable placement of endosseous implants. The twelve patients were divided in two equal group. Group I used piezoelectric device and group II used trephine bur design for lateral window approach for sinus lifting then adding bone graft material (bovine bone with autogenous bone) for increase bone volume that needed for implant installation later.
Result: No statistically significant difference existed between two techniques for lateral window approach.
Conclusion: the utilization of piezoelectric surgery, rather than trephine bur design, for lateral window preparation and membrane separation leads to reduction in the occurrence of the intraoperative complications of bleeding and membrane perforation but it is time consuming comparing with trephine bur design.
Keywords: *Piezoelectric device, trephine design, bone graft, sinus floor elevation, Schneiderian membrane.*

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I. Introduction

Restoration of the atrophied edentulous maxilla possesses a great challenge to the oral and maxillofacial surgeon. Conventional removable denture prosthesis is not adequate for many patients, so improved dental implantology has led many to request alternative approaches depending on dental implants .[1]

Improvement of prosthodontics may not be sufficient to compensate for the maxillary resorption, additional procedures, such as insertion of endosseous implants to support the prosthetic construction, are needed. However, reliable insertion of implants is often complicated in the upper jaw because of insufficient height and width of the alveolar process. In such cases the insufficient bone volume of the maxilla must be overcome by reconstructive Preprosthetic surgery before implants can be installed at the preferred sites. [2-4]

Missing dentition in maxillary alveolar ridge usually causes severe resorption and rapid sinus pneumatization due to loss of bone volume.[5] The resorption rate varies from individual to another but leaves inadequate bone height for placement of endosseous implants in the end. [6] Despite the lack of satisfactory bone height, some clinicians have tried to place short implants 7-8 in length to support prosthetic restoration, but high failure rates (35% or greater) have been reported. [7]

Sinus augmentation surgery is the widely accepted preprosthetic gold standard for creating sufficient bone volume for the placement of endosseous implants in an atrophic posterior maxilla.[8-9]

Recently, the most common surgical techniques are lateral window or crestal approaches to overcome the vertical deficiencies of the atrophic posterior maxilla.[10]

The evolution of the surgical technique in the lateral approach through trap-door window access to the maxillary bone for sinus membrane lifting is aimed at reducing the complications that may jeopardize the outcome of procedural success or implant survival. Piezoelectric surgery has demonstrated its advantageous capability to reduce the perforation rate dramatically. [11]

Using the ultrasonic vibration of the piezoelectric device in conjunction with hand instrumentation can attain bone compaction, thereby reducing the possibility of membrane perforation. The implant may be placed simultaneously or delayed.[12]

There is another membrane approach technique for the sinus lateral wall osteotomy that minimizes the risk of Schneiderian membrane perforation using a trephine design.[13]

The trephine be used with light pressure and with a 1–2-mm in-and-out stroke as its advanced to the desired depth. We also recommend running the trephine in reverse as it is less likely to slip during initial osseous penetration, and if close to the sinus membrane, it decreases the chances of tearing the membrane.[14]

This procedure is intended to increase bone height in the posterior maxilla through formation of new bone in the caudal section of the maxillary sinus, improve stability and survival of the implant.[15]

The graft material of choice for sinus augmentation should support osteointegration, osteoconduction, osteoinduction and osteogenesis processes. Only autogenous bone transplants support all 4 processes while bone substitute materials support a subset of these processes such as bovine bone.[16]

The aim of this study was to evaluate the outcomes of the maxillary sinus floor elevation both clinically and radiographically using the piezoelectric device versus trephine design before implant installation.

II. Materials and Methods

This study was carried out on twelve partial edentulous atrophic posterior maxillary regions in nine patients (3 of patients have bilateral edentulous atrophic ridge), in whom the maxillary alveolar ridge has not enough bone volume for reliable placement of endosseous implants without sinus lifting surgery. All patients were received, examined, diagnosed and managed in the outpatient clinic of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Tanta University. All patients signed informed consents according to the guidelines of human research adopted by the REC at Faculty of Dentistry, Tanta University.

The patients had to meet the following criteria: 1-Both male and female patients.

2-Patients with missed posterior maxillary teeth with atrophic alveolar ridge (residual subantral alveolar bone height less than 5 mm). 3-Patients with good oral hygiene. 4-Interarch distance suitable for prosthetic rehabilitation. 5- Healthy gingival tissue. The patients had the following criteria should exclude; 1-Patients with relevant uncontrolled systemic diseases. 2-Parafunctional habits. 3-Pathological condition related to the sinus.

The twelve partial edentulous atrophic posterior maxillary areas included in this study were divided into two equal groups (six sides each) according to the device used for creating the bone window.

- ***Group I:*** in which the bony access of sinus lift was performed using piezoelectric device.
- ***Group II:*** in which the bony access of sinus lift was performed using trephine bur mounted in implant handpiece.

Preoperative preparation:

Medication:

Initially, all patients have been instructed to take (Ampicillin\sulbactam 1.5 gm. vial) and 4mg dexamethasone (Epidron) one hour before surgery.

The preparation of platelet rich plasma (PRP) and platelet rich fibrin (PRF) was important stage in our study as the preparation of PRP was being used to deliver growth factors in high concentration to surgical site requiring osseous grafting as it increase the rate of bone deposition and quality of bone regeneration, the PRF membrane was used as a barrier to prevent the impaction of graft material directly against the Schneiderian membrane to avoid perforation accidently.

Preparation of PRF:

1. 10 ml of patient whole blood was drawn from the patient and placed in glass test tube without anticoagulant and centrifuged at 3000 rpm for 10 minutes.
2. The biological steps of this centrifugation involve that the circulating blood thrombin turns fibrinogen into fibrin: this fibrin then was found at the center of the test tube. The PRF obtained was used in two ways:

- A filling material with a gelatinous consistency.
- Reaming part is shaped in order to form a resistant fibrin membrane which can be transferred onto Schneider's membrane (Fig. 1).

Figure 1: photograph of PRF membrane after preparation.

Preparation of PRP:
1. 10 ml of patient whole blood was drawn from the patient and placed into a centrifuge for approximately 10 minutes at 3400 to 5600 rpm.
2. The blood was separated into 3 layers: red blood cells, a buffy coat of platelets of white blood cells and serum.
3. The buffy coat and serum is then centrifuge again to increase concentration of platelets (Fig. 2).

Figure 2: photograph of PRP after preparation

- **Surgical Techniques:**

All patients underwent sinus augmentation according to **Tatum (1986)** technique, the operation of sinus lift was carried out under local anesthesia (Mepivacaine hydrochloride 2% with levonordefrin 1:200.000 vasoconstrictor). A crestal incision was made on the palatal aspect of the maxillary posterior edentulous ridge from the tuberosity to one tooth anterior to the anterior wall of the maxillary sinus. A vertical release incision was made on the distal end of the incision. A broad-base anterior vertical release incision was also made at the anterior end of the incision The facial full thickness mucoperiosteal flap was reflected to expose the complete lateral wall of the maxilla and a portion of the zygoma by periosteal elevator. The overall design of the lateral-access window was determined after the review of the CBCT scan, which help to determine the thickness of the lateral wall of the antrum, the position of the antral floor from the crest of the ridge, the posterior wall of the anterior wall in relationship to the teeth (if present), and the presence of septa on the floor and/or walls of the sinus.

The bone window cut:

In case of using piezoelectric device (Fig.3) (group I), the whole bone window cut dimensions within range 1cm height and 1.5 width. The inferior line of the rectangular access window on the lateral maxilla was placed approximately 2 to 5 mm above the level of the antral floor. The most superior aspect of the lateral-access window should be approximately 8 to 10 mm above the inferior line. The anterior vertical line of the access window is scored approximately 5 mm distal to the anterior vertical wall of the antrum. The distal vertical line on the lateral maxilla is approximately 15 mm from the anterior limit of the window and is usually in the region of the first molar, which was within our direct vision. The piezoelectric device cutting through bone without cutting in soft tissue with waves of micro vibrations with cooling system (saline solution) until the bluish shadow of Schneiderian membrane appeared then the bony window cut is separated from the surrounding bone but still attached to the membrane.

Figure 3: photograph showing piezoelectric device used in group I.

In case of using the trephine bur mounted in hand piece (Fig. 4) (group II), the head of trephine bur had serrations. When we reached the exact bone volume, we removed the bur, and it came out with the bone inside. Sometimes it kept attached to the surrounded bone and needed slight punch.

Figure 4: photograph showing the trephine bur that mounted in implant handpiece and sinus lift elevators.

Separation of Schneiderian membrane:

A flat-ended of mirror handle and mallet were used to gently in fracture the lateral-access window from the surrounding bone, while still attached to the thin sinus membrane. The bone window elevated as a whole unit with the membrane to act as a barrier with the PRF that will applied. A short-bladed soft tissue curette designed with two right-angle bends was introduced along the margin of the window. The curette was slid along the bone margin, 360 degrees around the access window. This ensures the release of the membrane from the surrounding walls of the sinus without tearing from the sharp bony access margins.

Once the mucosa on the antral floor was elevated, the lateral, distal, and medial wall of the sinus were addressed. The sinus membrane was inspected for perforations or openings into the antrum proper by asking patient to keep breathing and noticed if there were any air bubbles or heard any hissing sound. The periosteal elevators and curettes further reflected the membrane off the anterior vertical wall, floor, and medial vertical wall to a height of at least 16 mm from the crest of the ridge

Maxillary sinus packing:

At these stage the membrane was reflected so the site was ready for the sinus graft, the top layer consisted of the PRF adjusted beside the bone widow that cut but still attached to the membrane and the PRF that faced to membrane act as a barrier then the second layer (sinus graft materials) consisted of autogenous bone taken from the tuberosity of the same side and bovine bone graft mixed with 0.5 ml PRP and 0.2 ml antibiotic (clindamycin) to decrease risk of infection. The mixture forms the intermediate layer of the sinus graft, and it was placed below the top layer and the autogenous bone on the original sinus floor on the bottom. These materials were mixed and milled by using bone mill placed in an open 3-mL syringe that has its end removed and placed in the sinus graft site with a forward and inferior packing motion. A resorbable membrane was placed over the lateral-access window. This delays the invasion of fibrous tissue into the graft and enhances the repair of the lateral bony wall. The mucoperiosteal flap were reapproximated and closed without tension by vicryl 4.0.

Postoperative clinical Evaluation:

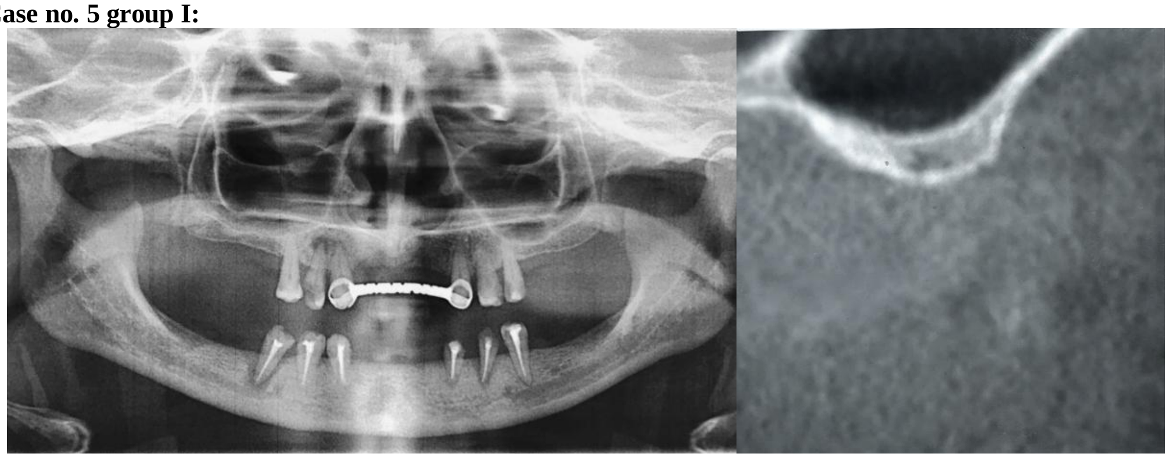
1. Patients were followed up 10 days and one month postoperatively to evaluate wound healing, swelling, pain, bleeding, incidence of infection either orally or antral and presence or absence of oroantral fistula.

Postoperative Radiographical evaluation:

CBCT was performed for all patients in both groups immediately (base line) and 3 months postoperatively. Comparison between the results of 3 months postoperative to the immediate results was performed for detection of the following:

- Changes in the endosinus bone height.
- Crestal bone loss.
- Health of the grafted sinus and presence of fluid.

Case no. 5 group I:



Preoperative panoramic and CBCT photo radiograph showing bilateral atrophic maxillary ridge with pneumatization of maxillary sinus. No detected related bone pathology in patient no. 5 group I.

Intraoperative photograph showing cutting with piezoelectric device and made the outline of the bone widow with no bleeding.

Intraoperative photograph showing bone window elevation with hand instrument.

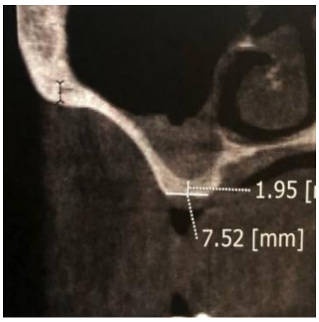
Intraoperative photograph showing complete elevation of schneiderian membrane and placing of PRF and enough space for graft material.

Intraoperative photograph showing compelete packing of the mixture of graft material with autogenous bone from tuberosity.

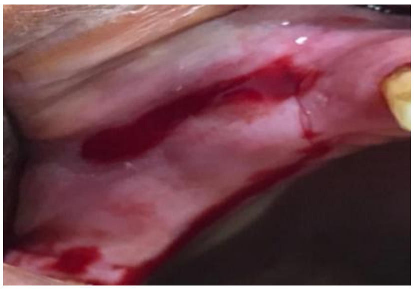
Intraoperative photograph showing resorbable membrane on the opening of lateral window for holding the graft material in place.

Intraoperative photograph showing closure of the flap.

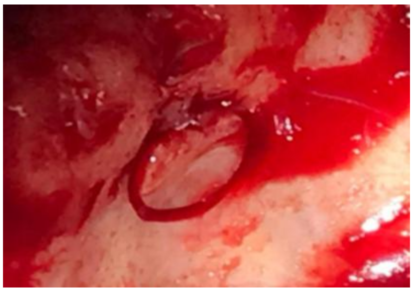
Case no. 1 group II:



preoperative panoramic and CBCT photo radiograph showing atrophic maxillary ridge on right side with pneumatization of maxillary sinus. No detected related bone pathology in patient no.1 group II.



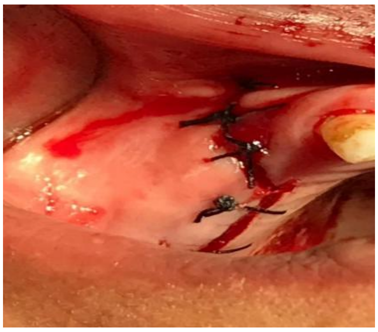
intraoperative photograph the incision of the flap.



Intraoperative photograph showing the intial cutting of trephine design.

intraoperative photograph showing packing of the mixture of graft material particles.

intraoperative photograph showing resorbable membrane Placed over graft material.



postoperative photograph showing closure of wound

postoperative photograph showing the wound healing after 10 days .

III. Results

Intra-Operative Findings: (**Table 2**)

In the piezoelectric group, the time necessary for osteotomy and sinus-membrane elevation ranged from 60 to 90 minutes, while in the trephine bur it ranged from 30 to 45 minutes. The operative time required for trephine bur and manual elevators was significantly shorter than operative time spent in piezoelectric device (p-value =0.002). In the piezoelectric group, there was no sinus membrane perforation in any of the cases, while three cases (50%) in the trephine group had sinus membrane perforations where miniaturizing and the Schneiderian membrane was folded and PRF was placed over it. However, this difference was not statistically significant due to the small sample size.

Post-Operative Findings:

The percentage of patients in trephine bur group who had postoperative bleeding was higher than in the piezoelectric group (66.7% vs. 16.7%); however, this difference was not statistically significant (p-value = 0.242). Postoperative bleeding had continued from two to four days with minimal unilateral and less frequent epistaxis (almost once daily) that was related to the three cases that have minute membrane perforation and the PRF help for rapid healing (**Table 3**). The higher rate of postoperative bleeding among trephine bur patients.

No postoperative sinus pain or infection were reported in both groups. However, there was slight edema and discomfort in all cases of both groups. All patients had developed uneventful healing and no signs or symptoms of maxillary sinus disease were reported after the augmentation surgical procedures (**Table 3**).

Radiographic Findings:

Bone height:

Radiographic cone beam CT assessment for changes in the endo sinus bone height, revealed that there was a considerable increase in the bone height after 10 days of sinus lifting and grafting in both groups, compared to baseline pre-operative measurement. Likewise, 3-months later in both groups, there was a substantial increase in bone height compared to either baseline. However, there were no statistically significant differences in bone height between both groups at each time point of measurement (**table 4).**

Radiographic assessment for crestal bone loss revealed that there was no significant crestal bone loss from 10-days to 3-months postoperative measurements (Table 5).

Radiographic assessment for vertical bone loss showed that there was no significant difference in the vertical bone after sinus lifting and grafting between both groups (**Table 6).**

Radiographical assessment showed that the sinus had no fluids was no fluid in both groups and the grafted material was placed well.

Table 1. Distribution of patients in both study groups according to their demographics.

		Group		p-value
		Piezoelectric device (n=6)	**Trephine design** (n=6)	
Age	Mean ± SD	43.5 ± 11.5	40.0 ± 9.4	0.180
	Range	21.0 - 52.0	21.0 - 46.0	NS
Sex	**Male**, n (%)	2 (33.3%)	3 (50.0%)	1.00
	Female, n (%)	4 (66.7%)	3 (50.0%)	NS

Table 2. Intra-operative Findings in both groups.

		Group		p-value
		Piezoelectric device (n=6)	**Trephine design** (n=6)	
Operative Time (min)	**Mean ± SD**	75 ± 15	37.5 ± 7.5	**0.002***
	Range	60 - 90	30 - 45	Sig
Membrane perforation	**No**, n (%)	6 (100.0%)	3 (50.0%)	0.182
	Yes, n (%)	0	3 (50.0%)	NS

Table 3. Post-operative complications in both study groups

		Group		p-value
		Piezoelectric device (n=6)	**Trephine design** (n=6)	
Bleeding	**No**, n (%)	5 (83.3%)	2 (33.3%)	0.242
	Yes, n (%)	1 (16.7%)	4 (66.7%)	NS
Sinus Pain	**No**, n (%)	6 (100.0%)	6 (100.0%)	NA
	Yes, n (%)	0	0	
Mucopurulent discharge (infection)	**No**, n (%)	6 (100.0%)	6 (100.0%)	NA
	Yes, n (%)	0	0	
Wound Healing	**Normal**	6 (100.0%)	6 (100.0%)	NA

Table 4. Pre- and Post-operative radiographic measurements of bone height in both groups.

Groups	Mean ± SD			p-value [1]
	Pre-Operative (Baseline)	**10-Days Postoperative**	**3-Months Postoperative**	
Piezoelectric device (n=6)	4.4 ± 0.8	14.9 ± 0.7	14.3 ± 0.8	**0.027**[*a] **0.028**[*b] **0.027**[*c]
Trephine design (n=6)	3.8 ± 0.9	14.8 ± 0.9	14.2 ± 0.9	**0.028**[*a] **0.027**[*b] **0.027**[*c]
p-value	**0.297** **NS**	**0.873** **NS**	**0.936** **NS**	

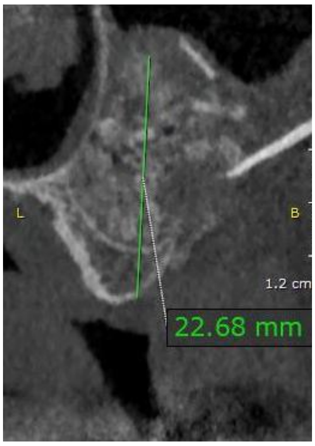
Table 5. Postoperative radiographic measurements of crestal bone loss.

GROUPS	Mean ± SD			p-value [1]
	10-days Crestal bone	**3-months Crestal bone**	**Difference (Crestal bone loss)**	
Piezoelectric device (n=6)	12.8 ± 1.5	12.8 ± 1.5	0.1 ± 0.1	**0.180** NS
Trephine design (n=6)	13.3 ± 1.8	13.3 ± 1.7	0.0 ± 0.1	**0.157** NS
p-value [2]	**0.617** NS	**0.618** NS	**0.847** NS	

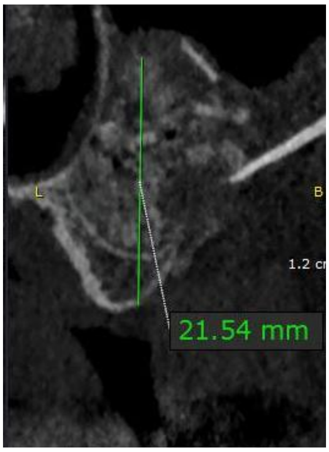
Table 6. Post-operative radiographic measurements of vertical bone loss.

GROUPS	Vertical bone loss Mean ± SD	p-value [1]
Piezoelectric device (n=6)	0.6 ± 0.1	0.193 NS
Trephine design (n=6)	0.6 ± 0.4	

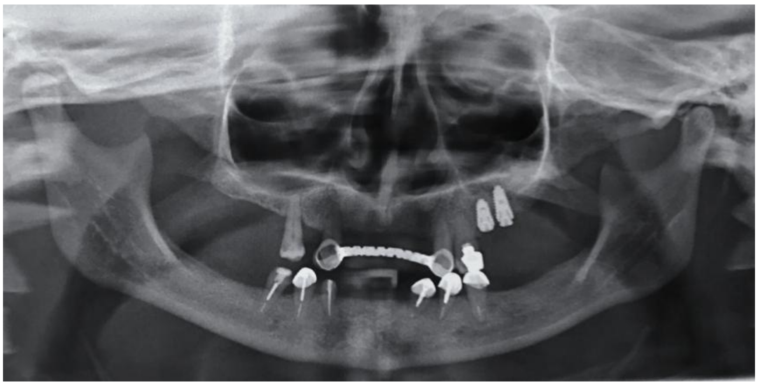
Case no. 5 group I:



Postoperative CBCT 10 days showing the increase in bone height with adequate packing of bone and the bone window that cut still vascularized after 10 days.

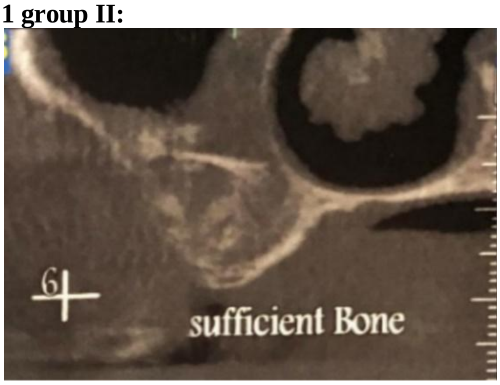


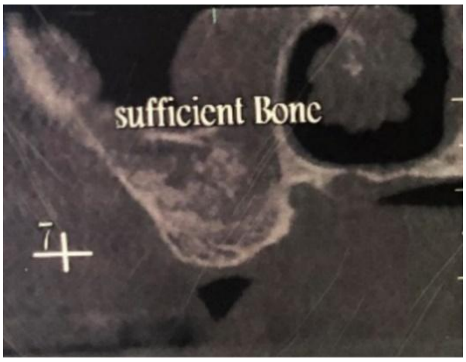
Postoperative CBCT 3 months with slight decrease in bone height but was still sufficient for implant placement and the bone widow still vascularized.



Postoperative panoramic photoradiograph showing the placement of implant in right side after 6 months of sinus augmentation.

Case no. 1 group II:





Postoperative CBCT 10 days showing the increase in bone height with adequate packing of bone, but there was the bony cut window still vascularized.

Postoperative CBCT 3 months showing slight decrease in bone height but was still sufficient for implant placement, the bony cut window still vascularized.

IV. Discussion

The alveolar processes of the jaws continually change after tooth loss with extensive resorption. This resorption could lead to a remarkable decrease in the available bone for future dental implant placement. Alveolar resorption and increased pneumatization of the sinus after the extraction of teeth limits the quantity and quality of the bone necessary for successful implant placement, especially in the edentulous posterior maxilla. [17] Surgeons have overcome this obstacle by performing bone grafting procedures such as lateral window maxillary sinus augmentation. [18]

This study aimed to evaluate the clinical and radiographical outcomes of the maxillary sinus lifting by lateral window approach using two different techniques of bone cut. In this study piezoelectric device operation did not result in any injury or perforation of Schneiderian membrane. Because piezoelectric surgery does not cut soft tissues in direct contact provided that no extra force is used that may cause mechanical trauma to the tissues. This advantage of using this device was previously reported and confirmed by Toscano et al. 19 Other surgeries had performed by piezosurgery with combinations, e.g., osteotomy with rotating instruments reducing the risk of membrane perforation during maxillary sinus augmentation. and preparation of the membrane with piezosurgery, may be an alternative approach combining time efficiency with safey. [20]

In group II, using trephine design there were Schneiderian membrane perforations occurred in three patients (50 % of cases), and other studies showed that cases were performed by trephine bur mounted in handpiece in osteotomy which represents a risk for membrane perforation followed by the manual elevation of the membrane with hand instruments (MILA sinus lift kits).[21]

In this study the postoperative complication among patients in both study groups was nasal bleeding. Trephine design was associated with more frequent immediate post-operative nasal bleeding than piezoelectric device and with no statistical significance and this was explained by the presence of membrane perforations in 50% of cases in trephine group. This was controlled by applying nasal packing for only one hour and stressing on the post-operative instructions to avoid blowing the nose, taking in liquids through straw or sneezing. In our study we noticed that piezoelectric device (group I) was time consuming, and it was statistically significant compared with trephine bur design (group II). Using piezoelectric device taking time during the lateral bone window opening due to vibrations that decrease the possibility of perforations. The piezoelectric technique increases the total surgical time of the procedures, but the time spent to protect the soft tissues is minimized. This is consistent with Vercellotti et al. [22]

The piezo surgical device promotes a clean surgical area as it keeps it free from bleeding during bone cutting, because of air-water cavitation of the ultrasonic device. This allows a better view of the surgical site. [23] While in group II using trephine design there was bleeding after membrane perforation. [24]

The bleeding that related to the 3 cases of membrane perforation was overcome and healed by the action and the effect of the PRF that applied as the barrier and the folding of the membrane so there was slight epistaxis unilateral related to the operated side with the instruction of using nasal pack. Becker et al and Caudry et al, [25-26] showed that forty-one intraoperative perforations (20.4%) were documented and treated according to the following scheme: defects smaller than 5 mm were covered with a collagen membrane or with PRF. Larger defects were additionally sutured.

In our study, CBCT showed increase in the bone volume with average 12 to 15 ml in first month, followed by a slight decrease with range 0.5 to 2 ml in all cases after 3 months with no difference according to the technique used in lateral approach for sinus lifting. Also, CBCT showed the partially attached bone window that manipulated and cut eigher with piezoelectric device or trephine design are still vascularized that lead to it is still received its blood supply from surrounding bone or from schneiderian membrane and act as a barrier with PRF as a first layer other studies reported bony window acts as an osteoinductive homologous barrier membrane over various bone graft materials and accelerates new bone formation in lateral sinus augmentation.

However, there were no statistically significant differences in the bone augmentation level between the two different surgical techniques.

V. Conclusion

The aim of the present study was to evaluate the incidence of sinus membrane perforation comparing piezoelectric device with. Trephine design. Regarding to the presented results, piezosurgery can be recommended reducing the risk of membrane perforation during MSA. However, the trephine design had more incidence of membrane perforation. The results suggest that piezosurgery was associated with a lower perforation rate. The recent incorporation of piezoelectric technology when performing a lateral window elevation is one way to potentially reduce or eliminate many of the complications associated with this procedure, although it is time consuming.

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