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OSSEODENSIFICATION VERSUS PIEZOSURGERY IN CRESTAL SINUS LIFTING WITH SIMULTANEOUS IMPLANT PLACEMENT

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ABSTRACT

Objective: Evaluation of implant stability, vertical and horizontal bone gain and bone density using osseodensification technique versus Piezosurgery in transcrestal maxillary sinus lifting. **Subjects & Methods**: Twenty-two patients were included in the study and randomly divided into 2 equal groups: Group 1: 11 patients treated by densah drills (Versah, Jackson, MI, USA) transcrestal sinus lift with bone grafting (xenograft) and simultaneous dental implant placement. Group 2: 11 patients treated by piezoelectric transcrestal sinus lift (Piezotome; Satelec) with bone grafting (xenograft) and simultaneous dental implant placement. CBCT radiograph was done before and after 6 months of dental implant placement. **Results**: Both groups showed statistically significant differences from baseline to 6 months. osseodensification showed a better technique for gaining better implant stability and bone density. Both groups showed no difference in both vertical and horizontal bone gain. **Conclusion**: Osseodensification and piezoelectric surgery are both effective methods for crestal sinus elevation, with higher implant stability and bone density in the osseodensification group after 6 months.

KEYWORDS: Osseodensification, Densah bur, Sinus lift, Piezosurgery.

INTRODUCTION

Removable (complete or partial) dentures can be used to treat edentulous individuals; however, removable prosthesis impairs taste perception and chewing ability[1]. In this sense, dental implants have become a dependable therapeutic option for eligible patients, [2] but their success rate is mostly determined by the quality and volume of alveolar bone[3]. The majority of implant failures occur in the posterior maxillary area, where bone quality is low[4,5]. Other variables that may contribute to implant failure and challenges in the posterior maxilla include limited vision, reduced inter-arch space, and sinus pneumatization owing to alveolar ridge atrophy. In such circumstances, sinus augmentation is essential to produce enough vertical bone volume for implant insertion with good stability[6].

Several approaches for treating a vertically deficient, edentulous, posterior maxillary ridge with low bone quality have been presented. Traditionally, two methods of sinus elevation were used: direct sinus elevation via a lateral window approach and

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indirect sinus elevation by a crestal approach[7]. The lateral window approach has been found to yield reliable clinical results[8]. However, the technique's morbidity and invasiveness, possibility of severing the alveolar antral artery, sinus membrane perforation, delay in healing, and risk of postsurgical infection are important adverse effects [9]. Crestal sinus elevation procedures, on the other hand, are less intrusive, take less time, and result in less patient morbidity. However, the risk of membrane perforation can be as high as 24% due to lacking of direct vision and access [10].

Various techniques for indirectly elevating the sinus membrane have been proposed, including the Osteotome Sinus Floor Elevation (OSFE) introduced by Summers in 1994, in which an osteotome was used to fracture the sinus floor and lift the sinus membrane,[11] however, this procedure has many drawbacks [12]. In an attempt to overcome these drawbacks, in 2001, Vercellotti et al. proposed the use of piezoelectric ultrasound as a novel alternative method for performing osteotomies during maxillary sinus lifting procedures[13]. The ability of the piezoelectric device to selectively cut only mineralized structures without injuring soft tissues is a significant feature[13,14]. Schneiderian membrane perforation did not occur during the piezoelectric preparation of the lateral window of the direct technique[15]. Piezosurgery was used to expose the maxillary sinus mucosa via the alveolar crest pathway in maxillary sinus floor elevation with hydraulic pressure for the graft and simultaneous implant placement. The benefits of this procedure include less trauma, no malleting, and a lower risk of sinus membrane perforation during surgery; nonetheless, membrane perforation by strong hydraulic pressure is possible [16].

Osseous densification, a biomechanical osteotomy preparation technique that preserves bone through a non-excavating drilling process, was proposed. This technique uses specially designed drills with tapered geometry and specially designed flutes to progressively expand the osteotomy while compacting bone into its walls and apex. This method enhances implant stability by compaction autografting [17].

SUBJECTS AND METHODS

Patient induction and grouping

Twenty-two patients were enrolled in this randomized clinical trial, these patients were selected from those attending the outpatient clinic at department of oral medicine, periodontology, oral diagnosis and radiology, and they were randomly divided into 2 equal groups: **Group 1**: eleven patients (5 males and 6 females with mean age 51.8±5.09) treated by densah burs (Versah, Jackson, MI, USA) crestal sinus lifting with bone grafting (xenograft: xenogenic tutobone; tutogen) and implant placement. **Group 2**: eleven patients (7 males and 4 females with mean age 48.0±7.26) treated by piezoelectric (Piezotome; Satelec) crestal sinus lifting with bone grafting (xenograft: xenogenic tutobone; tutogen) and implant placement.

Inclusion criteria

Patients demonstrated residual bone height of less than 6mm in both young and adult patients of both sexes. The edentulous ridges had been covered with mucoperiosteum that was devoid of inflammation, the remaining natural teeth had adequate periodontal tissue support, and there were enough inter-arch and intra-arch spaces for the prosthetic part.

Exclusion criteria

Patients with systemic illnesses that may affect the success of treatment, such as pregnancy and heavy smokers, Patients suffering from systemic diseases that may impair bone quality, Patients who are unwilling to cooperate, Patients suffering active periodontal disease, poor oral hygiene, restricted mouth opening and unfavorable inter-arch space and patients with maxillary sinus disorder or recent sinus surgery.

Ethical considerations

The aim of the study was explained to all participants directly, and written consent was obtained. The ethical research committee of AL-Azhar University, Cairo, Egypt, accepted this work under its reference number (410/293).

Intervention

Pre-surgical Therapy: Each patient was provided comprehensive instructions on adequate oral hygiene procedures prior to surgery. Under local anaesthesia, a complete mouth supragingival and subgingival scaling and root planning took place with ultrasonic and manual instrumentation. Cone-beam computed tomography (CBCT) was used to determine the bone's height, width, and density.

Surgical Procedure: Following local anaesthesia at the implant site, a full thickness flap was raised to expose the alveolar crest. The osteotomy preparation began with a pilot drill and should terminate 1mm short of the sinus floor. **In group 1; (Densah sinus lifting)**: The drill motor was set to reverse-densifying mode (anticlockwise drill speed 800-1500 rpm with copious irrigation), and the densah bur (2.2 mm) was used until 1 mm short of the sinus floor, then the next wider Densah Burs (2.5, 3.0 mm) in the exact mode and progressed into the previously created osteotomy with controlling pressure and a pumping motion. When the drill reached the thick sinus floor, pressure was regulated with a gentle pumping motion to progress past the sinus floor in 1 mm increments, then the next broader densah drill (3.5, 4.0 mm) was utilised to advance in the osteotomy (figures 1-2). **In group 2: (Piezoelectric sinus lifting)** The cortical bone was removed first with a 2-mm twist drill, followed by the intralift tips (Intralift; TKW1, TKW2, TKW3, TKW4, and TKW5; Satelec). TKW1 to TKW4 tips with diameters of 1.35 mm, 2.1 mm, 2.35 mm, and 2.8 mm were used to gradually enlarge the access canal to the Schneider membrane, mild pressure was exerted on the tips to deepen the channel, and a sterile spray (80 mL/min) was used to cool the tips to avoid heat damage. The TKW5 tip was then introduced into the access canal, and ultrasonic activation was performed for 5 seconds with internal irrigation at 40 mL/min, followed by 50 mL/min and subsequently 60 mL/min. The hydraulic pressure pushed the sinus membrane higher, the floating of the sinus membrane was examined, and the TKW4 (2.8 mm) was used again to enlarge the access channel to the sinus membrane before inserting the bone graft. Implant drills were eventually used sequentially until the desired implant size was obtained (3.0 mm, 3.5 mm, and 4 mm) (figures 3-4).

For both groups: Clinical check was done to assure that the membrane still intact, through blocking the patient's nostrils and the patient was asked to blow through his or her nose.

Bone graft and implant placement

The same amount of xenograft (Tutobone TM, Tutogen Medical GmbH, Germany) was added as the grafting material (0.5 cc for each implant) and driven to the sinus across the osteotomy site up to the desired level of sinus elevation was achieved, and then the implant fixture (Nucleoss T6, Turkey) was inserted. This study's implants were of the same dimensions (10 mm length* 4.1mm diameter). The flap was sutured and removed after 10 days of implant placement.

Clinical assessment of implant primary stability

Primary stability was assessed using the Ostell device[18] (Osstell Inc. W&H Dentalwerk, Bürmoos, Salzburg, Austria) by attaching a smart peg to the implant and measuring the Implant Stability Quotient (ISQ) value. Osstell enables for the assessment of implant stability by resonance frequency analysis (RFA). ISQ levels more than 70 have been regarded as most favourable for implant stability, however ISQ values less than 60 suggest low primary stability. The ISQ value correlates to the implant's lateral stability, which is determined by the stiffness of the connection between the bone and the implant surface.

Postoperative Care

Patients were instructed to apply cold pack to their cheeks during for the first 12 hours following surgery, avoid nose blowing and sneezing, and to stop drinking with straws for 10 days. The following medications were prescribed: Amoxicillin-clavulanate (Hibiotic 1 gm, Amoun, Egypt) 1 gm twice daily for 7 days, Metronidazole 250mg (Fagyl, GlaxoSmithKline, UK) 3 times daily for 7 days, Nasal decongestant: Xylometazoline (Otrivin, GlaxoSmithKline, UK) 3 times daily for 7 days (15 ml), and Ketoprufen 150 mg (Bi-profenid 150, SANOFI Aventus, France) twice daily for 5 days.

Follow-up and Prosthetic phase

After six months' Prosthetic phase started by surgical exposure of the implant, the ostell device was used to measure the secondary stability by recording the ISQ value. The healing abutment was placed for 2 weeks to make the emergence profile, then impression was done and cast was fabricated to prepare the screw-retained restorations.

Radiographic evaluation

A standard periapical film was performed to ensure that if the patient met the inclusion criteria, CBCT was performed to assess bone density, breadth, and height of the edentulous area. The target jaw segment (5 cm x 8 cm) field of view is captured using the planmeca Pro-face model (3D imaging system, Finland, Helsinki). CBCT matching was accomplished by rigid image registration via superimposition of two volumes over each other using the software's matching tool (high precision matching), followed by minute adjustments for accurate matching.

Bone height: bone height changes were assessed by measuring preoperative residual bone height and the distance from the implant platform to the base of grafted bone in the center of the implant after 6 months.

Bone width: Bone width was measured buccolingually in the CBCT cross section at the crest of residual bone. After 6 months, was measured at the implant platform and bone crest.

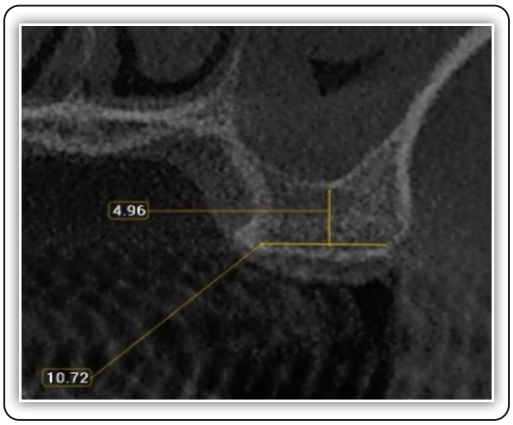

FIG (1) Preoperative CBCT cross section

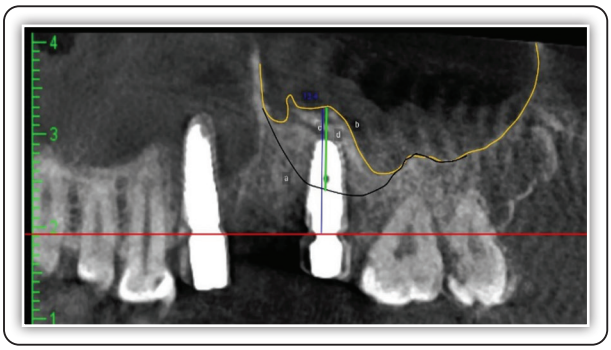

FIG (2) Sinus radiograph showing difference between pre and postoperative bone height and sinus augmentation (letter (a) preoperative sinus floor, letter (b) postoperative sinus floor, letter (c) bone height, letter (d) vertical bone gain.

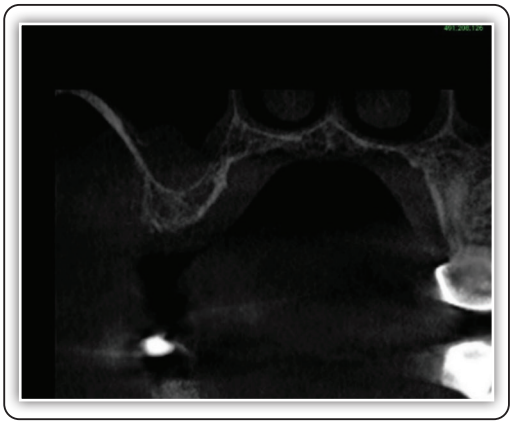

FIG (3) Preoperative CBCT cross section

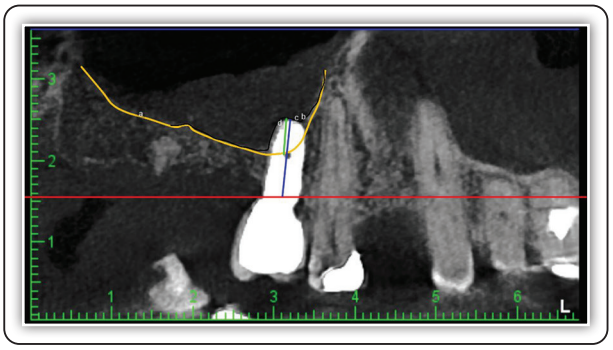

FIG (4) Sinus radiograph showing difference between pre and postoperative bone height and sinus augmentation (letter (a) preoperative sinus floor, letter (b) postoperative sinus floor, letter (c) bone height, letter (d) vertical bone gain.

Bone density: In the preoperative CBCT, typical rectangular forms were drawn buccal and palatal to the predicted future implant location to measure bone density (H.U). six months later, rectangular shapes had been drawn along the palatal and buccal walls from the implant shoulder to the apex. It was done using the software's bone density measuring tool.

Statistical analysis

Data was entered into the computer and analyzed with the IBM SPSS software programme version 26.0 (Armonk, NY: IBM Corp). Range (minimum and maximum), mean, standard deviation, and median were used to characterise quantitative data. The obtained results were deemed significant at 0.05. The tests utilised were the Chi square test, the Student t-test, and the Paired t-test.

RESULTS

A total sample of 22 patients grouped into 2 equal groups according to treatment modality as following: **Group 1**: 11 patients (5 males and 6 females with mean age 51.8±5.09) treated by densah burs crestal sinus lift. **Group 2**: 11 patients (7 males and 4 females with mean age 48.0±7.26) treated by piezoelectric crestal sinus lift.

Demographic data:

There was no statistically significant difference between the treated groups regarding gender and age. (Table 1)

Clinical evaluation

I. Implant stability

Comparison between the two studied groups according to implant stability showed that; at Baseline (primary stability), as well as, after 6 months (secondary stability), there was a statistically significant difference between groups (p≤0.001*). Densah group showed higher mean implant stability than the Piezo group at base line as well as after 6 months. Regarding changes with each group; both groups showed a significant increase after 6 months. (Table 2).

TABLE (1) Comparison between the two studied groups according to demographic data

		Densah		Piezo		test	p
		No.	%	No.	%		
Demographic	**Sex**						
	Male	5	45	7	64	χ^2=0.733	0.392
	Female	6	55	4	36		
	Age (years)	51.81	±5.09	48.00	±7.26	**t-test** = 1.427	0.169

χ^2: *Chi square test,* *t: Student t-test* p: p value

TABLE (2) Comparison between the two studied groups according to stability.

		Densah		Piezo		t-test	p
		Mean	SD	Mean	SD		
Stability	**At baseline**	72.58	3.02	69.30	1.63	3.067	0.006*
	After 6 months	85.67	5.88	73.90	3.54v	5.532	≤0.001*
p0		≤0.001*			≤0.001*		

t-test: independent t-test. p: p value between groups. p0: p value between times.

Radiographic evaluation

I. Bone density

Each group showed a significant increase in bone density after 6 months. Comparison between the studied groups according to Density showed; at Baseline, there was a non-significant difference between groups (p=0.762). After 6 months, Densah group showed highest mean implant density than the Piezo group. (Table 3)

II. Bone height

At Baseline as well as after 6 months, there was a non-significant difference between groups (p=0.554 and 0.957 respectively). According to changes within each group; both groups showed a significant difference after 6 months. (Table 3)

III. Bone width

According to Bone width, at baseline and after 6 months, there was a non-significant difference between groups (p=0.794 and 0.925respectively). No group showed a significant difference after 6 months. (Table 3)

TABLE (3) Comparison between the two studied groups according to Bone density, Bone height and Bone width.

		Densah		Piezo		t-test	p
		Mean	SD	Mean	SD		
Density	**At baseline**	291.68	141.23	275.09	104.38	0.308	0.762
	After 6 months	624.73	126.29	510.96	124.62	2.116	0.047*
p0		≤0.001*			≤0.001*		
Bone height	**At baseline**	4.61	0.37	4.71	0.34	0.602	0.554
	After 6 months	10.48	0.535	10.49	0.49	0.055	0.957
p0		≤0.001*			≤0.001*		
Bone width	**At baseline**	7.26	1.43	7.40	1.08	0.264	0.794
	After 6 months	7.29	1.54	7.24	0.88	0.095	0.925
p0		0.616			0.213		

t-test: independent t-test p: p value between groups p0: p value between times

DISCUSSION

Dental implants have a favorable success rate, especially when implanted in the highly mineralized bone of the anterior mandible; the posterior maxilla, which has the lowest bone quality, is the least favorable region[19,20]. It has been declared that, the posterior maxilla has Type IV bone quality (D4), and the bone–implant contact is the poorest in D4 bone quality when compared to other bone densities[21,22]. Such anatomical abnormalities may affect the osseointegration and success rate of implants in these regions. Many techniques have been proposed to increase local bone volume, permitting implant insertion in the posterior maxilla in patients with inadequate bone height. These procedures include lateral sinus elevation, guided bone regeneration (GBR), and onlay block graft [23].

Summers developed the osteotome technique in 1994 as a less invasive alternative approach for sinus floor elevation with concurrent grafting to improve the primary stability of posterior maxillary dental implants[11]. Piezoelectric ultrasound was used as an alternative method to carry out osteotomies in maxillary sinus lift surgeries because it minimizes trauma and rate of membrane perforation during the operation, with shorter surgery time [13]. Huwais and Meyer introduced densah burs for maxillary sinus lifting in 2018, providing a safe technique with fewer problems than an osteotome or lateral approach, less perforation, and less invasiveness[24].

Twenty-two patients were enrolled in this study, and were divided into 2 equal groups; osseodensification treated group (eleven patients: 5 males and 6 females with mean age 51.81±5.09) and piezosurgery treated group (eleven patients: 7 males and 4 females with mean age 48.00±7.26). There was no statistically significant difference between gender distributions and mean age values in the two groups.

It was evident from the obtained results that, at base line; there was a statistically significant difference between mean implant primary stability measurements in the two groups. Densah showed a statistically significant higher mean implant stability than Piezo group. This finding was similar to studies [25,26] which revealed the highest implant stability in the densah group. while in contradiction with other studies[27-29] reported no significant difference concerning primary stability. However, secondary stability measured after six months; showed a statistically significant difference between mean implant stability measurements between the two groups. Again, Densah showed the statistically significant highest mean implant stability, which was in agreement with previous results [27,30].

Bone density after six months in both groups showed significant difference compared to baseline. Comparison of the treated groups regarding bone density showed a clear and significant increase after 6 months, where Densah group showed higher bone density. The significant change in stability between both groups was primarily due to bone density around the implant and the drilling protocol of the osseodensification procedure. The motorised expansion of the osteotomy site, along with the unique properties of densah burs, enhanced bone density surrounding the implant in the osseodensification group, which was more than that found in the piezo groups. The spring back effect and elastic rebound of bone upon the implant surface after implant placement additionally improved the mechanical connection between the implant and surrounding bone, along with the intact, well-organized trabecular pattern of bone around the implant, which raised the implant primary stability, and helped in further healing of bone over the 6 months follow up, resulting in excellent secondary stability [17, 31].

Although it has been noted that piezosurgery increases the duration of bone cutting but not the overall operating time due to the lack of soft tissue protection, piezosurgery is more time-consuming than osseodensification approach[32]. The use of

piezosurgery provides benefits such as cut precision, greater intra-operative control, a clear surgical site, and selective cut of mineralized tissues with preservation of soft tissues. In addition, piezosurgery permits the surgeon to work in direct contact with the Schneiderian membrane, making it safe for membrane elevation while having little effect on implant stability and bone density [33,34].

Bone height measurements in the two groups at base line as well as after 6 months showed no statistically significant difference between the two treated groups. As regards changes within each group, a statistically significant increase in bone height after six months in both groups was noted. While bone width showed no statistically significant difference at base line or at six months in both groups along the follow-up period time.

Although autogenous bone has been found to be the material of choice for bone reconstruction surgeries [35] it does have some drawbacks [36]. To avoid the utilisation of autogenous bone and donor site morbidity, bone substitutes are commonly used; hence, xenograft (Tutogen, a commercially available particulate graft of deproteinized, bovine hydroxyapatite) was utilised in the current study. As previously reported, xenograft was employed in the present study in order to boost success and predictability [37-39].

The implant survival rate was 95.4%, which was comparable to that seen in prior investigation involving sinus floor elevation [20,23,25,39]. Some investigations have found that insufficient height of the remaining alveolar ridge is not a sufficient reason for implant failure, but trauma, infection, or contamination during surgery may have contributed to this unfavorable outcome. The ossesodensification group had the fewest complications, such as trauma, haemorrhage, sinus membrane perforation, and maxillary sinusitis. The piezosurgery group experienced one implant failure at the end due to lack of osseointegration. Densah technique had shorter surgery time than piezo group with less complications.

CONCLUSION

Osseodensification and piezoelectric surgery are both effective methods for crestal sinus elevation, with higher implant stability and bone density in the osseodensification group after 6 months.

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