

# PIEZOELECTRIC VERSUS CONVENTIONAL SURGICAL DRILLING FOR IMPLANT PLACEMENT IN ANTERIOR MAXILLA

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## ABSTRACT

**INTRODUCTION:** Osteotomies done for implant placement has been classically performed using drills of various shapes to conform the site to the implant's geometry. Drilling procedures may cause not only mechanical trauma to the bone but also heat-induced bone necrosis, representing a significant risk for failed osseointegration. As an alternative, ultrasonic drilling for implant placement allows precise and effective bone cutting without damaging adjacent soft tissues.

**OBJECTIVES:** This study evaluated the effect of Piezoelectric drilling in decreasing the peri-implant marginal bone loss as well as increasing the implant stability values throughout a 6 months healing period.

**MATERIALS AND METHODS:** A clinical and radiographic study with a split-mouth design was carried out on 10 patients. Each patient received two implants in both sides of anterior maxilla, one implant was placed with piezoelectric drilling (study group) and the other was placed with conventional drilling (control group). Assessments included measurements of implant stability using Osstell and measurements of the linear changes in the peri-implant marginal bone using cone beam computed tomography images. Measurements were done immediately post-operative, at 3 months and 6 months.

**RESULTS:** The clinical and radiographical results of the Piezoelectric study sides were better than the conventional control sides. Marginal bone loss was significantly lower in the study group. Implant Stability Quotient (ISQ) values were significantly higher in the study group at the immediate time of placement and at 6 months.

**CONCLUSIONS:** Within the limitations of this clinical trial, it can be concluded that the piezoelectric drilling for implant placement in the anterior maxilla is a successful option for reducing marginal bone loss and increasing implant stability throughout the healing period.

**KEYWORDS:** Ultrasonic/piezoelectric drilling, piezotome, implants, maxilla.

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## INTRODUCTION

The factors associated with a prognosis of dental implants and implant failure have been immensely studied (1). Marginal bone loss less than 1.5 mm in the first year and subsequent annual bone level changes of 0.2 mm at the implant and bone interface are generally accepted as within the limits of a normal physiologic process (2,3). Although this loss of Marginal bone height around the implant during the early healing phase has been considered an acceptable physiologic change, continued loss of marginal bone height following osseointegration may result in increased mobility and subsequent failure (4).

Factors thought to influence the amount of changes in marginal bone height after implant placement include delayed vs. immediate implant placement, staging, the timing of implant loading, the requirement of bone graft at the implant site, the presence of infection, medical conditions that compromise wound healing, smoking, status of oral hygiene, the location of implant placement, and the size of the implants (5,6). Other mechanical factors such as periosteum elevation during surgery, overheating of the instrument resulting in osteonecrosis, occlusal trauma, cantilever effect, and physiologic bone remodeling from inflammatory process and plaque accumulation have been also suggested (7).

Bone tissue necrosis caused by heat induction during drilling may be one of the most important causes of early implant failure (8). Since bone tissues are vulnerable to

heat, an increase in heat induction during a surgical procedure can damage the bone (9).

The frictional heat induced during bone cutting procedures is related to the size and shape of the drill, the drill material, the use of irrigation, and bone density (9-11).

Implant site preparation has been classically performed using burs of different shapes to conform the site to the implant's geometry. Drilling procedures may cause not only mechanical trauma to the bone but also heat-induced bone necrosis, thus representing a significant risk for failure (12).

Conventional rotary instruments generate excessive heat during the osteotomies, and this heat may affect bone cell viability and lead to thermal necrosis (13).

Piezosurgery, in contrast, is characterized by the cavitation effect with abundant cooling solution, generating harmless thermal effect and resulting in better biological outcome (14).

Piezoelectric ultrasound was developed by maxillofacial surgeons. It uses radio waves that allow the ultrasound tips to oscillate and vibrate so that they can divide solid interfaces, such as bone tissue. The piezoelectric device is characterized by having ultrasonic vibrations with an average frequency of 25-29 kHz, an oscillation (amplitude) of 60-210 µm, and power up to 50W (15,16).

Ultrasonic devices have the ability to cut mineralized hard tissues as teeth or bone in a very safe and precise way, with minor tissue damage (17).

Soft tissues such as nerves and blood vessels are not altered by the cutting tip because of their ability to oscillate at the same speed and amplitude as the cutting tip (18). Moreover, surgical accuracy is facilitated by good visibility in the surgical field (19).

Studies comparing piezoelectric osteotomy with conventional techniques performed with carbide and diamond series drills concluded that piezosurgery provides more favorable bone repair (20). Moreover, other studies showed that there is a reduction in the number of inflammatory cells and an increase in osteogenesis around piezoelectric ultrasound-installed implants compared with conventional drill systems (21).

There has been an increasing interest in the possibility of applying ultrasounds to implant site preparation. Several experimental (22) and clinical studies (23) have recently been published.

In our study, piezoelectric drilling was compared to conventional surgical drilling for implants placement in anterior maxilla regarding marginal bone loss and implant stability during the healing period.

## MATERIALS AND METHODS

An appropriate ethical clearance was obtained from the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

The patients were informed about the procedures and an informed consent was signed by each participant.

### Study design

This clinical trial was conducted on 10 patients, of age 30-50 years and of both sexes, selected from the Out-patient Clinic.

The study was a split-mouth design where both the study and the control groups were in the same patient, where one side of the arch represented the study side and the other side represented the control side.

### Criteria of patient selection

#### Inclusion criteria

Patients of age 30 – 50 years of both sexes, having missing maxillary anterior teeth or maxillary premolars.

Criteria of the edentulous ridge included : a maxillary vertical dimension of at least 10 mm measured from the alveolar crest to the nasal spine and horizontal alveolar dimension not less than 5 mm at the top of the crest and 6 to 8 mm at the basal part of the ridge measured from the outer surface of the labial/buccal bone to the outer surface of the palatal bone.

#### Exclusion criteria:

Excluded patients were those with any systemic disease directly affecting bone healing, local disease that may interfere with bone healing, history of any grafting procedure at the designated edentulous ridge and patients suffering osteoporosis.

## MATERIALS

- Kisses Biogenesis dental implants (Biogenesis dental implants, Korea®).  
Tapered screw internal hexagon double threaded implant Sand-blasted, Large grit, Acid-etched (SLA) surface treated implant.
- Piezotome device (Acteon Satalec, France®)  
The device operates at a frequency of 25-29 kHz, with an advanced oscillation control module that introduce interruptions in the high-frequency oscillations. These

interruptions help to avoid heating of the bone and maintain optimum sectioning capacity. The amplitude of the microoscillations is in the range of 60-210 µm at an ultrasonic power up to 16 Watts.

- Intra-lift kit of Piezotome.

Ultrasonic diamond coated tips of ascending diameters ; TKW1 of a diameter 1.35 mm, TKW2 of a diameter 2.1 mm, TKW3 of a diameter 2.35 mm and TKW4 of a diameter 2.8 mm.

## METHODS

### Preoperative Preparation

- Clinical bucco-palatal measurements were done using calipers to ensure that there was sufficient bone width for placement of 3.5 mm diameter implant in the anterior maxilla .
- Impressions were taken and a diagnostic wax-up was performed on the study cast to fabricate a prosthetically driven vacuum-formed stent in order to locate the proposed osteotomy sites during surgery.

### Radiographic evaluation

- Pre-operative Orthopantogram(OPG) and Cone beam computed tomography(CBCT) were done for measuring bone height and width at the site of the implant.
- The width of each implant site was measured accurately on the reformatted cross-sectional images at 4 points in the vertical plane (at top of the crest, at 3 mm, 6 mm, and 9 mm towards the basal bone).

### Surgical procedures

#### Operative Phase:

All surgeries were performed under local anesthesia (buccal infiltration) using articaine hydrochloride 4 % (Septanest, Septodont, France®).

Before doing the incisions, the patients were instructed to rinse with a 0.125% chlorhexidine mouth wash (Hexitol, ADCO, Egypt) , also a 10% povidone iodine (Betadine, The Nile Co., Egypt) was applied gently to the surgical site .

Both implants of the study and control sides were placed in the same surgery.

A three incision lines pyramidal mucoperiosteal flap was raised from the buccal side with the buccal release-incisions minimum 2mm mesial and distal of the working area. (Fig. 1.A)

For the study group implant drilling Procedure was done using specialized Intra-lift tips for the Piezotome-device from Acteon Satalec.

Four Intra-lift diamond tips were used for drilling the osteotomy of increasing diameters till a final diameter of 2.8 mm for placement of 3.5 mm diameter and 10-12 mm length implant. (Fig. 1.B, C,)

Implant was inserted manually using a torque wrench. (Fig. 1.D)

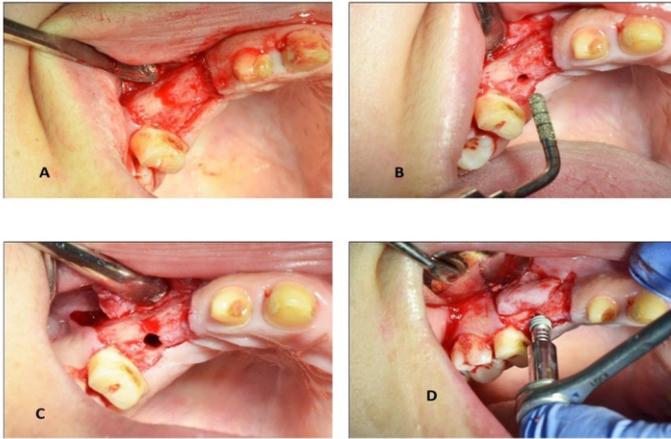
For the control group the same flap design was done, (Fig. 2.A) then implant drilling procedures was done using the surgical drills of the supplier kit of Biogenesis Dental Implant system.

Surgical drills of increasing diameters were used till a final drill diameter of 3 mm for placement of a 3.5 mm diameter and 10-12 mm length implant. (Fig. 2.B, C)

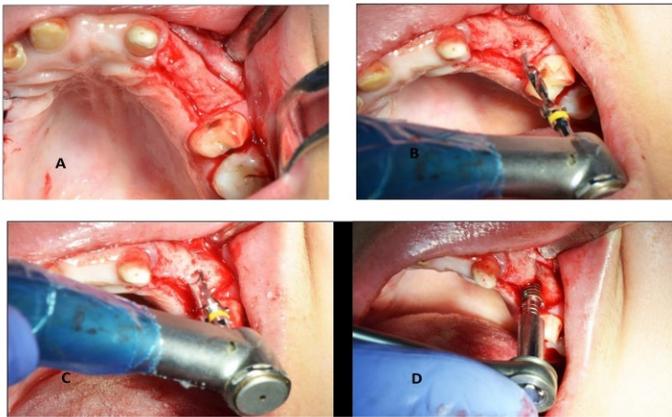
Implants were inserted manually using a torque wrench. (Fig. 2 D)

Before applying the cover screws to the implants, immediate implant stability was assessed through ISQ values using Osstell device(Osstell IDx, Sweden®)

Then cover screws were applied to the implants and the mucoperiosteal flaps were repositioned and sutured with 3-0 silk sutures. (Fig. 3.A,B)



**Figure 1:**A- Mucoperiosteal flap of the study side. B- Intra-lift tips used for osteotomy. C- Final osteotomy shape and position. D- Implant placement using torque wrench.



**Figure 2:**A- Mucoperiosteal flap of the control side. B & C- Implant osteotomy done using Surgical drills of the supplier kit. D- Implant insertion using torque wrench.



**Figure 3:**A- Implant of study side with cover-screw in place. B- Post-operative suturing using 3-0 silk sutures. C- Healing abutments at 4 months post-operative. D- Final prosthesis (Porcelain fused to metal bridge).

#### Post-operative care

Antibiotics were administrated post-operatively for 5 days, amoxicillin trihydrate and potassium clavulanate 1gm every 12 hours (Augmentin 1gm, GlaxoSmithKline, UK®), in addition to anti-inflammatory drugs, ibuprofen 600mg every 8 hours (Brufen 600mg, Abbott, US®).

Patients were instructed to apply cool packs over the cheek and upper lip 20 minutes every hours for 5-6 hours post-operatively.

Patients were advised to use chlorhexidine oral rinse (Hexitol) three times daily for the first week post-operatively.

#### Post-surgical evaluation

- Assessment of implant stability immediately, 3 months and 6 months post-operative using osstell IDx.
- CBCT assessment for the calculation of marginal bone loss (MBL) immediately, 3 months and 6 months post-operative.
- On the cross-sectional view, a line was drawn just parallel to the implant, starting at the crest of the buccal plate of bone and ending at the apical level of the bone (nasal floor, floor of nasal and maxillary sinuses); height will be recorded in half-millimeter-steps to allow for unavoidable aberrations of the CBCT-device.

#### Statistical analysis

- Appropriate statistical analysis was used, ANOVA-test and Post Hoc test (LSD) were used to compare between the studied periods in the same group. While Student T-test and Mann Whitney-test were used to compare between the two groups throughout the healing period.

#### Prosthetic Protocol

- Second stage (loading) was done at 4 months postoperatively in both groups.
- Gingival formers (healing abutments) were inserted for 1-2 weeks to provide good gingival contour around the implant collar. (Fig. 3.C)
- Impressions were taken using impression copings, then abutments were inserted.
- Cement retained final restorations were delivered in place. (Fig. 3.D)
- Thorough check of occlusal interferences was done in both static occlusion and dynamic side shift (left-right) to exclude study-biases by crestal overload.

#### RESULTS

Six female and four male patients of a mean age 34 years (between 25 and 50 years) had undergone implants placement in anterior maxilla using Piezotome at one side of the arch and conventional surgical drills at the other side and received a total of 20 implants. (Table 1)

The number of inserted implants was evenly distributed in both groups (study group: 10 implants, control group: 10 implants)

#### Clinical Results

The comparison between the two groups according to ISQ values using Osstell device throughout the follow up period showed significant difference between implant stability readings of both groups at the immediate post-operative time ( $P \leq 0.007$ ) and at 6 months ( $P \leq 0.043$ ) in favor of the Piezoelectric study side, although the comparison between the 2 groups at 3 months follow up wasn't statistically significant ( $P \geq 0.056$ ). (Table 2)

**Table 1 :** Demographic data, group assignment and implant locations and dimensions

Case No.	Sex	Age	Cases randomized allocation.	Implants No.	Implant sites	Implant diameters	Implant length
1.	Female	36	Study side	1	14	3.5	10 mm
			Control side	2	24	3.5	10 mm
2.	Male	39	Study side	3	22	3.5	12 mm
			Control side	4	11	3.5	12 mm
3.	Male	32	Study side	5	21	3.5	10 mm
			Control side	6	11	3.5	12 mm
4.	Female	29	Study side	7	21	3.5	10 mm
			Control side	8	13	3.5	12 mm
5.	Female	42	Study side	9	24	3.5	10 mm
			Control side	10	14	3.5	10 mm
6.	Female	33	Study side	11	22	3.5	10 mm
			Control side	12	12	3.5	10 mm
7.	Female	25	Study side	13	23	3.5	12 mm
			Control side	14	11	3.5	14 mm
8.	Male	40	Study side	15	21	3.5	12 mm
			Control side	16	11	3.5	14 mm
9.	Male	31	Study side	17	22	3.5	12 mm
			Control side	18	13	3.5	12 mm
10.	Female	39	Study side	19	23	3.5	10 mm
			Control side	20	13	3.5	10 mm

**Table 2 :** Comparison between the two studied groups according to implant stability quotient (ISQ) at the immediate time of placement, at 3 months and 6 months.

Implant Stability quotient (ISQ)	Study (n = 10)	Control (n = 10)	Test of Sig.	p
<b>Immediate post-operative</b>				
Min. – Max.	66.0 – 81.0	60.0 – 75.0		
Mean ± SD.	74.80 ± 5.25	68.20 ± 4.42	t=3.044*	0.007*
Median	75.0	69.0		
<b>At 3 months</b>				
Min. – Max.	71.0 – 84.0	72.0 – 79.0		
Mean ± SD.	78.40 ± 3.95	75.30 ± 2.71	t= 2.047	0.056
Median	78.50	75.50		
<b>At 6 months</b>				
Min. – Max.	75.0 – 85.0	73.0 – 81.0		
Mean ± SD.	79.90 ± 3.38	76.80 ± 2.97	t= 2.177*	0.043*
Median	80.50	77.0		
<b>% Change from Imm. To 3m</b>	<b>7.11 ± 5.71</b>	<b>13.02±8.22</b>	U=27.0	0.082

t, p: t and p values for Student t-test for comparing between the two groups  
 U, p: U and p values for Mann Whitney test for comparing between the two groups  
 \*: Statistically significant at  $p \leq 0.05$   
 Study group: Piezo-electric  
 Control group: Conventional

**Radiographic Results**

The comparison between the two groups according to marginal bone loss using series of CBCTs showed significant decrease in marginal bone loss values of the study group compared to the values of control group ( $p \leq 0.05$ ) throughout the follow up period at 3 months and at six months intervals. (Fig. 4, Table 3)

**Table 3:** Comparison between the two studied groups according to marginal bone loss at 3 months and 6 months post-operatively.

Marginal Bone Loss around implants (mms)	Study (n = 10)	Control (n = 10)	Test of Sig.	P
<b>At 3 months</b>				
Min. – Max.	0.31 – 0.67	0.40 – 0.94		
Mean ± SD.	0.42±0.11	0.74±0.18	t = 4.847*	<0.001*
Median	0.42	0.81		
<b>At 6 months</b>				
Min. – Max.	0.49 – 0.87	0.57 – 1.20		
Mean ± SD.	0.62±0.12	0.97±0.22	t = 4.385*	<0.001*
Median	0.56	1.07		
<b>% Change</b>	<b>49.17±17.04</b>	<b>31.40±6.64</b>	U = 21.0*	0.028*

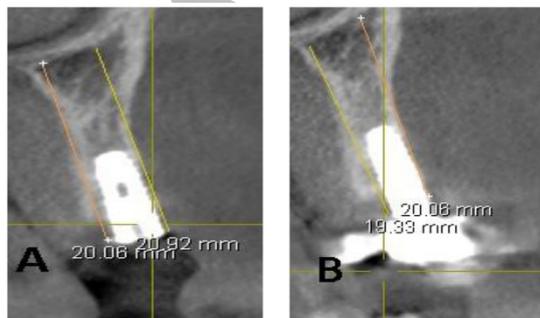
t, p: t and p values for Student t-test for comparing between the two groups

U, p: U and p values for Mann Whitney test for comparing between the two groups

\*: Statistically significant at  $p \leq 0.05$

Study group: Piezo-electric

Control group: Conventional



**Figure 4:** A- CBCT showing marginal bone level of study case at 3 months. B- Marginal bone level at 6 months. C- 6 months post-operative OPG showing both study and control sides implants

The mean value of marginal bone loss at three months interval was 0.42 mm in the study group and 0.74 mm in the control group, while the mean value of marginal bone loss at 6 months interval was 0.62 mm in the study group and 0.97 mm in the control group.

**DISCUSSION**

The method utilized in the preparation of implant osteotomy is one of the several surgical factors that may affect early marginal bone loss (24). Conventional implant osteotomy is prepared with drill sets, which are specifically structured to the needs of the relevant implant design. Drilling with sharp drills in the appropriate order under copious irrigation is of primary importance to preserve marginal bone, as trauma resulting from increased pressure and heat may lead to compromised healing and consequently to marginal bone loss (25). Piezoelectric surgery has been introduced as a valuable alternative to avoid disadvantages associated with the traditional rotating instruments (26).

Using piezosurgical tips allowed us to compare them to conventional bone drilling methods regarding marginal bone loss and implant stability throughout a follow-up period of 6 months interval.

Achieving and maintaining implant stability are essential for successful clinical outcomes with dental implants. The stability of the implant depends on factors such as contact between implant surfaces, placement technique, and surrounding bone quality (27).

In our study, implants were placed in both sides of anterior maxillary arch, at which one side the osteotomy was done using the ultrasonic piezotome device and the other side the osteotomy was done using conventional surgical drills of the implant supplier kit.

The results of our study regarding implant stability were statistically significant, where the ISQ values at the immediate time of placement and at 6 months were significantly higher in the piezosurgical group than the conventional group..

These results came in correspondence with the results of previous clinical studies regarding piezosurgical implant bed preparation efficacy which have predominantly focused on stability changes and implant survival. In these studies, comparison of drill and piezosurgical osteotomies revealed greater ISQ values, limited decrease in ISQ values, and an earlier shifting from a decreasing to an increasing stability pattern and high comparable survival rates in favor of piezosurgery (28,29).

According to Stelze et al (28). in anterior maxillary region the risk of complications related to increased heat and pressure with piezosurgical osteotomy is reduced due to low bone density .Furthermore, low-density bone allows the preparation of implant osteotomy solely with consecutive piezosurgical implant tips without using crestal drills or bone taps allowing for better bone healing and subsequent reduced values of marginal bone loss specially during the early months of healing.

In our study, CBCT assessments for the calculation of marginal bone loss (MBL) were used. The implant was used as a reference by adjusting the cross-sectional and panoramic long axis in the center of the implant and bisecting it (showing the buccopalatal and mesiodistal dimensions).

On the cross-sectional view, a line was drawn just parallel to the implant, starting at the crest of the buccal plate of bone and ending at the apical level of the bone (nasal floor, floor of nasal and maxillary sinuses); height was recorded in millimeter steps to allow for unavoidable aberrations of the CBCT-device.

The same process was repeated from the palatal direction and the average of the palatal and buccal bone heights was calculated for each implant.

In our study, the results obtained regarding marginal bone loss showed that both groups had significant percentage of change in crestal bone level from the immediate time of placement till 6 months interval.

These results came in correspondence with the results obtained by Mounir et al (30) in their study to measure the marginal bone loss around the implant, the implant was used as a reference by adjusting the cross-sectional and panoramic long axis in the centre of the implant and bisecting it (showing the buccolingual and mesiodistal dimensions). Height was recorded in millimetres. The same process was repeated from the palatal direction. He concluded that there was a significant decrease in bone height at 6 months postoperative when compared to the immediate postoperative height in both groups,

Our study results were not in correspondence with the results of the study of Canullo et al (25), where fifteen patients received two adjacent implants in the mandibular molar region where the study group had the osteotomies finalized by 2 ultrasonic tips while the control group had conventional surgical osteotomies.

This study results stated that there was no statistical difference between both study groups which is not in correspondence with the results of our study, but we have to put in mind different clinical factors at which implants in our study were placed in anterior maxilla while implants in this study were placed in the posterior mandible. Also in this study the operator used the surgical drill for both groups till a diameter of 2.8 mm while in our study the study group was completely piezosurgically operated.

Marginal bone loss related to osteotomy solely prepared with piezosurgery, as well as implant stability values throughout the healing period should be evaluated by further clinical trials incorporating different piezosurgical tip and implant designs, posterior maxillary and mandibular sites, other biochemical markers and longer follow up periods.

## CONCLUSION

Within the limitations of this study, it can be concluded that Piezoelectric drilling of implant osteotomies in the anterior maxillary region can be a successful option for reducing marginal bone loss around the implant as well as increasing implant stability values throughout the healing period.

## CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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