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Clinical and Radiographic Comparison between Piezoelectric Implant Osteotomy Preparation versus Conventional Drilling Technique

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Abstract

Piezo-surgery was introduced for implant site preparation due to its atraumatic capabilities in preparation of the recipient bed thus offering improved osseointegration and better bone healing. **OBJECTIVE**: to evaluate the effect of using piezoelectric bone surgery for implant osteotomy preparation on implant stability and osteointegration compared with conventional drilling techniques. **METHODS:** 16 implants equally installed in the maxillary anterior or premolar regions of adult patients, divided into two groups: Group I where the implant osteotomy site was performed using conventional drills. Group II where the implant osteotomy site was performed using specific piezoelectric inserts. All implants were clinically evaluated for implant stability using OSTELL device immediately after implant placement and 6 months postoperatively, as well as radiographically by digital parallel periapical tecgnique immediately post-opertively, then after three and six months to assess changes in relative bone density using digora software. **RESULTS:** Both groups showed a significant increase in implant stability values (ostell readings) throughout the study period. Piezoelectric osteotomy group showed statistically higher Ostell values after six months in comparison to the conventional drilling group. Radiographic evaluation showed that relative bone density values increased for both groups at the apex, mesial and distal implant aspects throughout the study period, with the highest density values at the six months period. Comparison in density values between both groups showed statistically higher bone density values in the piezoelectric osateotomy group after six months. Correlation between clinical implant stability values (Ostell readings) and radiographic bone density values showed a significant positive correlation at the six months follow-up period. **CONCLUSIONS:** Osseointegration is improved surrounding implants inserted in bone when Piezoelectric drilling is used for drilling of osteotomy sites in the anterior maxillary region can be a successful option for increasing implant stability values throughout the healing period in comparison to conventional drilling techniques.

Keywords: Conventional Drilling, Clinical, Radiographic, Piezoelectric Implant.

INTRODUCTION

Osteotomies done for implant placement has been classically performed using drills of various shapes to conform the site to the implant's geometry (1). Since bone tissues are vulnerable to heat, an increase in heat induction during a surgical procedure can damage the bone (2). 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 (3).

Drilling procedures may cause not only mechanical trauma to the bone, but also heat-induced bone necrosis, representing a significant risk for failed osseointegration and implant failure. As an alternative, ultrasonic drilling for implant placement allows precise and effective bone cutting without damaging bone or adjacent soft tissues (4). Conventional rotary instruments generate excessive heat during the osteotomies, and this heat may affect bone cell viability and lead to thermal necrosis. Piezosurgery, in contrast, is characterized by the cavitation effect with abundant cooling solution, generating harmless thermal effect and resulting in better biological outcome (5).

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 [6, 7]. 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 [8]. In addition, 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 [9].

Studies comparing piezoelectric osteotomy with conventional techniques performed with carbide and diamond series drills concluded that piezosurgery provides more favorable bone repair [10]. 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 [11]. There has been an increasing interest recently in the application of ultrasound to implant site preparation. Several experimental and clinical studies have recently been published addressing such topic [12,13]. However, up to our knowledge, no previous studies were conducted in Egypt comparing implant stability and osseointegration of implant site osteotomy performed by piezoelectric inserts and conventional drilling technique.

PATIENTS AND METHODS

The present study was conducted after the approval of the Research Ethics Committee, Faculty of Dentistry, Suez Canal University. The patients were informed about the procedures and an informed consent was signed by each participant before the beginning of the study.

STUDY DESIGN

This clinical trial was conducted on 8 patients, selected from the out-patient clinic of the Oral MaxilloFacial Surgery department, Faculty of Dentistry, Suez Canal University who were seeking dental implant therapy.

THE PRESENT STUDY INCLUDED 16 IMPLANTS EQUALLY DIVIDED INTO TWO GROUPS:

Group I: Included 8 implants inserted in the maxilla of patients where the implant site osteotomy was performed using conventional drills (control group).

Group II: Included 8 implants inserted in the maxilla of patients where the implant site osteotomy was performed using specific piezoelectric inserts (study group).

INCLUSION CRITERIA

Patients of age 18 – 50 years of both genders, having missing maxillary anterior teeth or maxillary premolars. Criteria of the edentulous ridge included adequate bone quality and quantity in proposed implant site. Adequate oral hygiene.

EXCLUSION CRITERIA

Patients were those with vertical or horizontal bone loss, systemic or bone disease directly affecting bone healing, inadequate inter arch space, smoking patients, and bruxism or bad oral habits . History of any surgery or grafting or procedure at the designated edentulous ridge and patiens suffering from osteoporosis or other bone disease.

MATERIALS

K1 line conical connection dental implants. Piezoelectric device operates a frequency of 25-29 kHz and power of up to 16 Watts with a sophisticated oscillation control module. Piezoelectric Inserts. Ultrasonic diamond coated tips of ascending diameters. Implant: Prep Kit Pro (IM1S , IM2A , IP2-3, IM3A , IP3-4 ,IM4A).

PREOPERATIVE PREPARATION:

Dental history, assessment of soft tissue and oral hygiene of the patients was assessed and referred to Oral Medicine and periodontlgy to undergo scaling and polishing for all the patients preoperatively. Interocclusal arch space was determined preoperatively. Bone width was determined clinically.

RADIOGRAPHIC EVALUATION:

Radiographic assessment pre-operatively by CBCT was conducted to ensure adequate bone quality and quantity in the potential implant site. Preoperative cone beam computed tomographic radiographs was acquired using the Scanora -3D imaging CBCT scanner using a CMOS flat panel detector with isotropic voxel size 133 µm.

SURGICAL PROCEDURES:

1- OPERATIVE PHASE:

All patients were operated under local anesthesia using Articaine hydrochloride 4% (Artinibsa) with 1:100.000 epinephrine. All the patients were anesthetized by infiltration technique for the buccal mucoperiostium and for the palatal mucoperiostium. Before doing the incisions, the patients were instructed to rinse with a 0.125% chlorhexidine mouth wash (Hexitol, ADCO,Egypt). 10% povidone iodine (Betadine, The nile Co., Egypt) was applied gently to the surgical site. 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. 1A)**.

Implant site preparation was performed by either, conventional drilling for patients included in group I or using piezoelectric surgery for patients included in group II. All patients received oxy implants K1 line from Italy. After implant site preparation. Implant was seated manually by screwdriver to reach 2/3 of the implant length and completed by using a torque wrench to be submerged 2mm below alveolar crest **(Fig. 1B, 1c).**

Clinical evaluation of implant stability was measured initially at the time of implant placement with the Osstell device by using smart beg attached to the implant and after 6 months **(Fig. 2B, 2C).** Then cover screws were applied to the implants and the mucoperiostealflaps were repositioned and sutured with 3-0 silk sutures **(Fig. 1D, 2A)**. All the surgical procedures were performed by the same surgeon using standardized technique under aseptic conditions.

Radiographic evaluation was done by Digital parallel periapical technique immediately post implant insertion, after 3 months and 6 Months later. Images were assessed using Digora soft were for evaluation of bone density by comparing relative density values surrounding the implant throughout the study period **(Fig. 2D).**

Surgical procedures by using conventional drilling for Group I (Control group):

The proposed implant site was marked with an initial bur (1.8 mm in diameter) at 800 rpm & torque 30Ncm. An initial rotatory taper drill was used first; successively larger rotatory tapered drills in diameter were used to expand the implant area to the desired diameter at speed between 500-800 rpm with irrigation with saline. Implant preparation osteotomy was done by conventional drilling by using the surgical drills of the supplier kit of oxy k1 Dental Implant system **(Fig. 3A).**

Surgical drills of increasing diameters were used till a final adequate drill was reached according to bone width and length. Then, oxyimplant of suitable diameter and length was placed **(Fig. 3B)**.

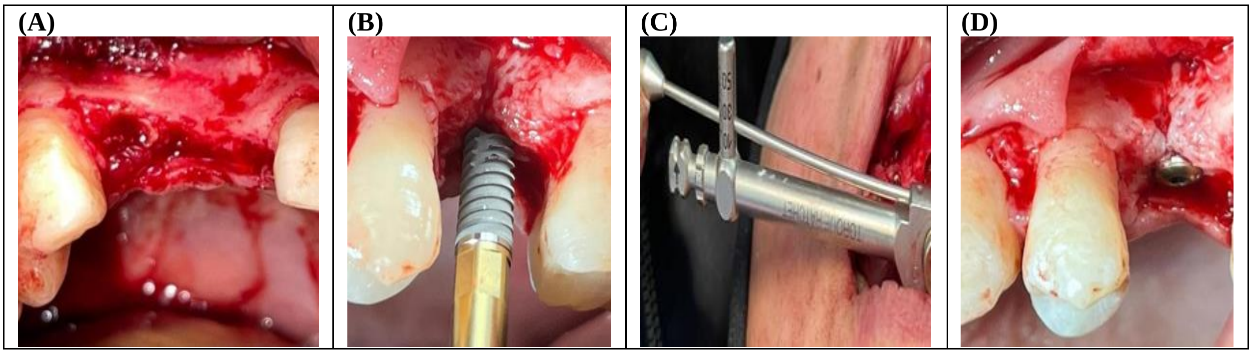

Figure 1: Photograph showing (A) Mucoperiosteal flap, (B) implant insertion, (C) placement of implant by using Torque wrench and (D) Implant with cover- screw in place.

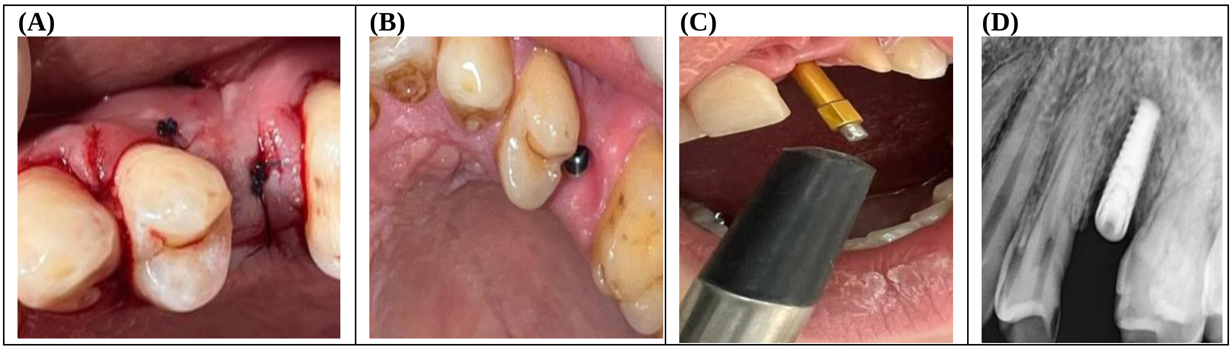

Figure 2: Photograph showing (A) suturing, (B) healing of soft tissue around implant after 6 months, (C) ostell and smart peg during measuring dental implant stability immediate post-operative and after 6 months and (D) radiograph of implant taken using digital parallel technique immediate post-operative.

(A) (B)

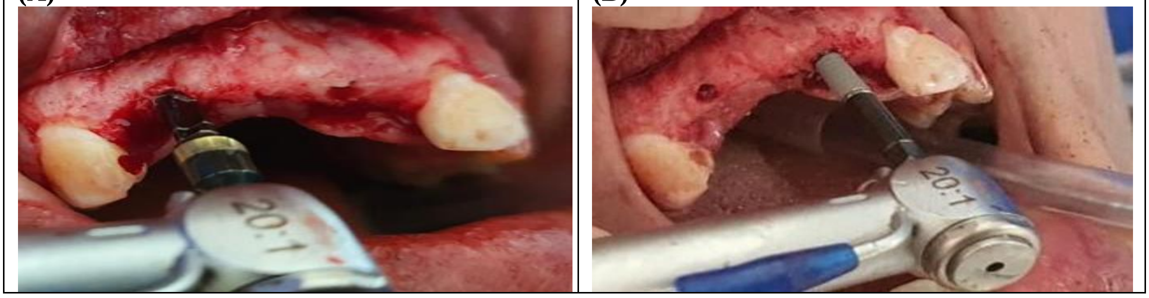

FIGURE 3: PHOTOGRAPH SHOWING (A) DRILLING BY CONVENTIONAL DRILLING AND (B) IMPLANT PLACEMENT MOTORIZED.

Surgical procedures by using piezoelectric insert for GroupII (study group):

Implant preparation osteotomy was done by specific piezoelectric inserts. IM1S as initial pilot osteotomy, IM2A of adiameter 2 mm, IP2-3 to optimize concentricity of implant site preparation between 2and 3 mm preparation of the cortical basal bone, IM3A of a diameter 3 mm, IP3-4 to optimize concentricity of implant site preparation between 3 and 4 mm preparation of the cortical basal bone, then IM4A of diameter 4 mm **(Fig. 4)**. Finally, oxy implant with suitable size and length was placed.

(A) (B) (C) (D)

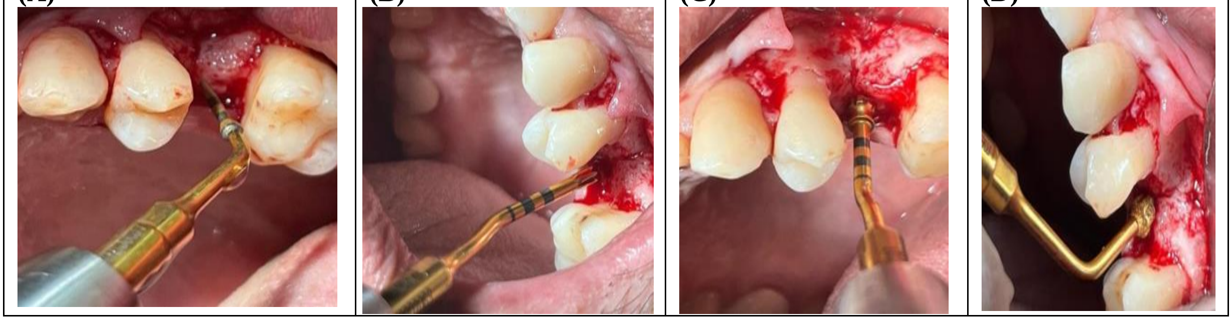

Figure 4: Photograph showing drilling by piezoelectric insert (A) (IM1S), (B) (IM3A), (C) (IM4A) and (D) (IP3 - 4).

Post-operative care

Antibiotics and anti-inflammatory drugs were prescribed for five days. Amoxicillin trihydrate and potassium clavulanate 1gm every 12 hours (Augmenten 1gm, GlaxoSmithKline, UK®). The anti-inflammatory drugs were 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 postoperatively.

POST-SURGICAL EVALUATION

Assessment of implant stability was done 6 months post-operative using osstell IDx device of compare with mmediate post-opertive values. Each patient was radiographically assessed using standardized digital periapical radiograph immediately post-opertive, after 3 months then after 6 months for assessment of relative bone density changes with time.

Statistical analysis

Statistical analysis was done by SPSS v26 (IBM Inc., Armonk, NY). A normality test (Shapiro-Wilk) was done to check the normal distribution of the samples. Descriptive statistics were calculated in the form of Mean ± Standard deviation (SD). Independent T- test was used to compare between the study and control groups for radiographic bone density and clinical implant stability using ostel. One-way ANOVAs was used to compare data at different the time intervals within eachgroup under study. The Pearson correlation coefficient was used for estimating the relationship between radiograph findings and clinical findings. A two tailed P value < 0.05 was considered significant.

RESULTS

Demographic Data

The current study showed 44.4% of the patients were males with average age36±8.5. On the other hand, 55.6% ware females with average age 25.74±7.4.Statical analysis showed no significant difference between patients regarding both, gender and mean age where P < 0.05 **(Table 1)**.

Results of clinical assessment:

All cases in both groups showed normal mucosa at implant site at different follow-ups. No case showed any post-operative infection (peri-implantitis). There was no redness, signs of inflammation, fistula in any case in control group I or study group II. Upon comparing ostel readings immediately after implant insertion and after six months in the study group, there was a statistically significant increase in implant stability readings with 33.6 % higher readings at six months period. Regarding the control group, results show a statistically significant increase in implant stability readings reaching 24% higher readings at six months. Upon comparing between study and control groups at base line and after 6 months, there was no statistical significant difference in Ostel readings between both groups at base line (immediate post-opertive) where study group showed mean value 57.4±5.4 and control group (53.8±5.6). However, after 6 months, there was statistically significant difference between both groups (P<0.05). The study group showed significantly higher mean values (76.6±5.1) in comparison to the control (66.6±6.0) **(Table 2)**.

Table (1): Gender and mean age distribution of the studied cases

	N	%	Mean Age (±SD)
Male	**3**	**44.4**	**36 ±8.5**
Female	**5**	**55.6**	**25 ± 7.4**
Total	**8**	**100%**	**28.11**
Chi square	**0.1111**		**T test= 1.17**
P value	**0.738 ns**		**2.80 ns**

Ns: No Significant Difference; SD: standard deviation

Table (2): Ostelreadings for both groups immediately and after six months and comparison between study and control groups at each follow up.

	Study		**Control**		*Indep. T-test*	*P value*
	Mean	SD	Mean	SD		
Immediate	57.4	5.4	53.8	5.6	1.3	0.209
6. months	76.6	5.1	66.6	6.0	3.58	0.003**
Mean difference	19.3		12.9			
Percentage of change %	33.6%		24.0 %			
Paired T-test	*13.06*		*10.22*			
P value	*<0.001***		*<0.001***			

***: Significant difference at P<0.05*

As regards of radiographic bone density at the mesial aspect for both groups, there was a statistically significant increase in bone density with time. From immediate to 3 months, 3-6 months and from immediate to 6 months, with the highest percentage increase in both groups recorded at the period from immediate to 6 months where the increase in bone density was 15.9 % in the study group and 10.4 % in the control group. Upon comparing radiographic bone density values between both groups at the different follow ups, there was no significant different between groups at immediate radiograph. Moreover, at both 3 and 6 month follow ups, results show statistically significant higher bone density values in the study group in comparison to the control group. The highest bone density measurements was recorded after 6 months in both the study and control groups with mean values (188.0±5.0) and (168.9±8.0) respectively, and (P. <0.001) **(Table 3)**.

Regarding radiographic bone density at the distal aspect for both groups, there was a statistically significant increase in bone density with time. From immediate to 3 months, 3months to 6 months and from immediate to 6 months, with the highest percentage increase in both groups recorded at the period from immediate to 6 months where the increase in bone density was 13.3 % in the study group and 8.2 % in the control group. Upon comparing radiographic bone density values between both groups at the different follow ups, results show a statistically significant higher bone density values at immediate and after 6months in the study group. At 3 months, there was no statistically significant difference between both groups regarding bone density at the distal aspect. The highest bone density measurements was recorded in both groups after 6 months with values (185.6±5.2) in the study group and (174.3±7.4) in the control group and highest P-value = 0.003 **(Table 4)**.

Table (3): Radiographic bone density at the mesial aspectfor both groups at diffierent follow-ups and comparison between groups.

	Study		Control		*Indep. T-test*	*P value*
	Mean	**SD**	**Mean**	**SD**		
Immediate	153.6[c]	6.1	153.0[c]	7.3	***0.186***	***0.85***
3. months	171.3[a]	7.4	160.9[b]	7.4	***2.797***	***0.014*****
6. months	188.0[b]	5.0	168.9[a]	8.0	***5.734***	***<0.001****
F test	***60.28***		***8.82***			
P value	***<0.001*****		***0.002*****			
	Mean difference	**% change**	**Mean difference**	**% Change**		
IM-3 months	17.6	7.9	11.5	5.1		
3-6months	16.8	8.0	9.8	5.0		
Im-6 months	34.4	15.9	22.4	10.4		

***: different superscript letters means significant difference at P<0.05*

Table (4): Radiographic bone density at the distal aspect for both groups at different follow-ups and comparison between groups.

	Study		Control		*Indep. T-test*	*P value*
	Mean	**SD**	**Mean**	**SD**		
Immediate	153.3[a]	6.4	161.0[c]	4.6	***2.77***	***0.015*****
3. months	168.3[b]	4.6	163.6[b]	7.1	***1.55***	***0.144***
6. months	185.6[c]	5.2	174.3[a]	7.4	***3.54***	***0.003*****
F test	***70.35***		***9.29***			
P value	***<0.001*****		***0.001*****			
	Mean difference	**% change**	**Mean difference**	**% change**		
IM-3 months	15.0	2.6	9.8	1.6		
3-6months	17.4	10.6	10.3	6.5		
Im-6 months	32.4	13.3	21.1	8.2		

***: different superscript letters means significant difference at P<0.05*

As regards of radiographic bone density at the apex (apical region) for both groups, there was a statistically significant increase in bone density with time. From immediate to 3 months, 3 months to 6 months and from immediate to 6 months, with the highest percentage increase in both groups seen at the period from immediate to 6 months where the increase in bone density was 13.9 % in the study group and 7.6 % in the control group. Upon comparing radiographic bone density values between both groups at the different follow ups, results show no statistically difference between both groups at immediate post-operative radiograph. However, at 3 months and 6 months, statistically significant higher bone density values in the study group was recorded. The highest bone density measurement was recorded in both groups after 6 months with values (213.5±4.3) and (197.6±9.9) in the study and control groups respectively and highest p- value 0.001 **(Table 5)**.

Results of total radiographic bone density (mesial, distal and apex) around the implant for both groups, there was a statistically significant increase in bone density with time within each group. From immediate to 3 M, the changes were 8.5% and 5.2%, from 3 to 6 M the changes were 16.0 % and 9.4% and 18.2% and 8.8% from immediate to the end of follow-up period in the study and control groups respectively. There was statistically significant difference between the study and control groups after 3 and 6 months P<0.05 while there was no significant difference at immediate post-operative. The highest mean values were recorded in the study group after 6 months (195.7±4.1) and in the control group (180.4±6.8) **(Table 6)**.

There was no statistically significant difference between mesial and distal aspect in each of the study and control groups at different time periods, except in control group at immediate follow-up only (P=0.020). Additionally in the study group the bone density was higher in the mesial aspect compared with the distal aspect, while in the control group the distal aspect was higher in comparison to the mesial at each follow up **(Fig. 5)**.

Table (5): Radiographic bone density at the apex for both groups at different follow-ups and comparison between groups.

	Study		Control		*T-test*	*P value*
	Mean	SD	Mean	SD		
Immediate	190.0[c]	8.0	183.8[c]	5.9	***1.78***	***0.097***
3. months	199.6[a]	8.3	188.9[b]	9.0	***2.48***	***0.026*****
6. months	213.5[b]	4.3	197.6[a]	9.9	***4.17***	***0.001*****
F test	***22.17***		***5.53***			
P value	***<0.001*****		***0.012*****			
	Mean difference	% change	Mean Difference	% change		
IM-3 months	9.6	5.1	5.1	2.8		
3-6months	13.9	8.8	7.0	4.6		
Im-6 months	23.5	13.9	12.4	7.6		

***: different superscript letters means significant difference at P<0.05*

Table (6): Total radiographic bone density around the implant for both groups and comparison between groups

	Study		**Control**		***Indep. T-test***	***P value***
	Mean	**SD**	**Mean**	**SD**		
Immediate	165.6[c]	5.1	165.8[c]	3.9	***0.129***	***0.900***
3. months	179.7[a]	4.7	171.0[b]	6.2	***3.11***	***0.008*****
6. months	195.7[b]	4.1	180.4[a]	6.8	***5.51***	***<0.001*****
F test	***83.78***		***12.58***			
P value	***<0.001*****		***<0.001*****			
	Mean difference	% change	Mean difference	% change		
IM-3 months	14.1	8.5	5.2	3.1		
3-6months	16.0	8.9	9.4	5.5		
Im-6 months	18.2	18.2	8.8	8.8		

***: different superscript letters means significant difference at P<0.05*

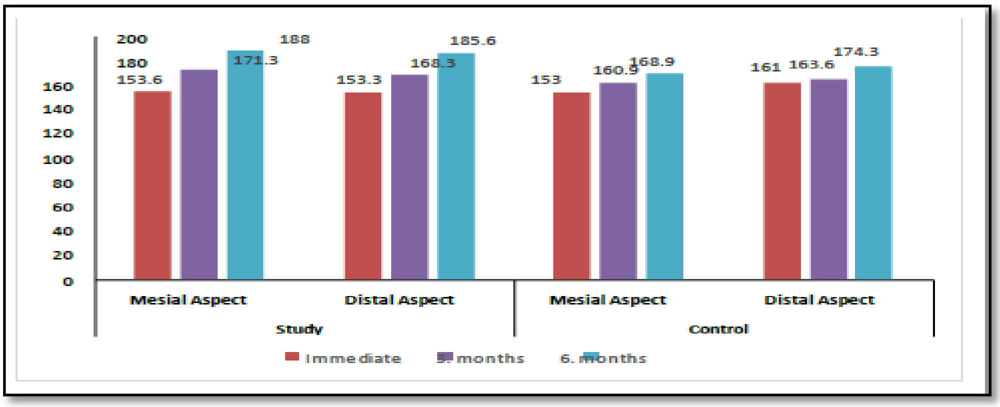

Fig. (5): Histogram showing Comparison between radiographic bone density at mesial and distal aspects in study andcontrol groups at immediate, 3 and 6 months post-operatively.

The correlation between clinical data represented by implant stability measurements using ostel device and radiographic data represented by radiographic bone density values. Results show no significant correlation at immediate (base line period), however after 6 months a positive and significant correlation between clinical and radiographic data was recorded for both groups **(Table 7)**.

Table (7): Correlation between clinical and radiographic results

		Clinical data	
		immediate	6.months
Radiographic data	R	-0.108	**0.568**
	P value	0.691	**0.022****
	R^2	0.012	0.323

*r; correlation coefficient, R2; Determination coefficient, **; means significant at P<0.05*

DISCUSSION

Restoring masticatory function and replacing missing teeth with minimal pain and discomfort are the most important issues for the patient and clinician. Nowadays dental implants became the most popular line of treatment to replace missing teeth offering patients a comfortable long-lasting prosthesis.[14] Factors affecting long-term implant success and proper osseointegration are the presence of viable bone in intimate contact with the implant and the absence of implant movement when it is fully inserted. The up rise of piezoelectric devices in dentistry proved their efficacy in maintaining the vitality of the bone due to their selective cutting.[15] The method utilized in the preparation of implant osteotomy is one of the several surgical factors that may affect osseointegration. 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 affect implant stability.[16]

Piezoelectric surgery has been introduced as avaluable alternative to avoid disadvantages associated with the traditional rotating instruments. Using piezosurgical tips allowed us to compare them to conventional bone drilling methods implant stability and osseointegration 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.[17]

Piezo-surgery suggested new possibilities in implant site osteotomy preparation: in fact, compared to the negative bone healing response related to twist drills (heat generation, imprecision in implant oste- otomy), it was supposed that the ideally atraumatic preparation of the recipient bed using piezo-surgery could be an important factor to fasten osseointegration and improve peri-implant bone level maintenance.[18]

According to certain research, piezoelectric bone surgery stimulates cell proliferation and bone synthesis, speeding up the healing process. These benefits lead to safer crestal osteotomy, as the waving phenomena that are usually present in rotational handpieces are eliminated by the shape of the piezoelectric pivoting handpiece. Thus, it makes the initial crestal osteotomy more accurate through its cavitational phenomenon . Furthermore, micro-vibrations and the cavitation action of saline solution may aid in the rapid migration of osteoprogenitor cells into a fresh wound by successfully eliminating bone fragments and tissue remains left over during osteotomy and thus promoting early healing . Because of its selective cut, cavitational effect, and soft tissue preservation, piezo-surgery has been used in implantology for implant site preparation . It ensures implant placement , osteointegration, and bone vitality.[19]

Ultrasound technologies are safe, reliable, and helpful intraoperatively for surgeons in certain cases. Clinical advantages were noted intraoperatively and postoperatively. The day following surgery, postoperative edema was lower than in areas treated with standard procedures, and patients had improved intraoperative comfort and postoperative outcomes.The piezoelectric approach is used in multiple implant rehabilitation protocols for both , difficult clinical circumstances like ridge expansion (split crest) or maxillary sinus lift, as well as simpler cases like single implant site preparation .[20]

Even with nonadvanced implantology, several clinical circumstances make the initial stages of surgery problematic. The rotation of the cutter and macromovements make it difficult to properly stabilize the implant at the operator's chosen spot, making initial implant site preparation with only the pilot drills on the implant kit's handpiece challenging.[21] Nowdays, ultrasonic surgery techniques are considered superior to traditional, rotating, or manual instruments due to greater cutting precision, the possibility of more conservative surgical access, no risk of soft tissue damage, less operator fatigue, and minimal risk of bone thermonecrosis, despite a slower execution speed. Piezoelectric bone surgery (PBS) is proposed to improve surgical control, safety, and bone healing. Piezo electric devices adjust an active tip's ultrasonic vibration, allowing accurate and controllable cutting, selective action on mineralized tissues, and enhanced intra-operative conditions.[22]

The benefits of piezoelectric surgery include stable guide insert placement on the crestal profile for the first implant site , correct implant axis facilitates implant-prosthetic rehabilitation , possibility of Intraoperative implant axis corrections , the ergonomically pivoted piezoelectric handpiece makes cortical crestal osteotomy safer by eliminating the early "waving" of rotational systems , cavitational process with continual irrigation allows for less traumatic initial osteotomy and better visualization of the surgical field , in addition , patient emotional impact is reduced because drill vibrations on the handpiece are not felt.[23] Additionally there are several technically linked biological benefits which include bone-tissue thermal stress reduction, improved bone vitality, better postresective bone response and osteoblastic turnover respect, and preserving soft tissues and noble anatomical features (inferior alveolar nerve, Schneiderian membrane, etc.) near the osteotomy site.[24]

However, current investigations have found no statistically significant differences in primary implant stability between piezosurgery and dedicated drill- preparedimplant sites.[25] Several Egyptian studies have compared piezoelectric implant site osteotomy to conventional drilling , among which, the present study, whose aim was to evaluate the effect of using Piezoelectric bone surgery for implant osteotomy preparation on implant stability and ossteointegration compared with conventional drilling techniques.[26]

In anterior maxillary region, the risk of complications related to increased heat and pressure with piezosurgical osteotomy is known to be 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 subconsequent reduced values of marginal bone loss specially during the early months of healing ,hence the choice of the current study to place implants in the anterior maxilla.[27]

In our study, implants were placed at anterior maxillary arch, at study group the osteotomy was done using the ultrasonic piezotome device and the control group the osteotomy was done using conventional surgical drills of the implant supplier kit.[28]

In the present study the clinical follow up visits were assigned immediatelly after implant months after implant insertion then again after 6 months after implant insertion. Radiographic evaluation was carried out immediatelly after implant insertion and again after 3 and 6 months.[29]

Clinical and radiographic follow up was performed in the current study in line with the recommendations of several authors assessed measurement of bone density around implant clinically and radiographically .[29,30]

Clinical follow up was performed using Ostell device (Electric Technology Resonance Freguency Analysis) .The electronic technology combines the transducer, computerized analysis and the excitation source into one machine. Implant stability quotient (ISQ) is the measurement unit (ISQ of 0 to 100) used. When used at the time of implant placement it provides baseline reading for future comparison and postsurgical placement of the implant. Currently, Osstell , a commercialized product utilizing the concept of RFA, has translated the resonance frequency ranging from 3000 to 8500 Hz as the ISQ of 0–100.[31]

Radiographic follow up was performed using digital radiography , in order that the information from radiographic images would be collected more easily and in a more objective way , thus improving the performance of the diagnostic process. Direct Digital radiography has the advantage of substantially reducing the X-ray exposure time due to the greater sensitivity of the image detectors compared with conventional radiography ; therefore , decreasing the radiation dose delivered to the patientsn . In addition , digital radiographic systems have the practical utility of needing no step of darkroom processing .[32]

Digital intraoral parallel periapical radiographs were performed since it is considered the practical detection method for bone density, periapical tissues, periodontal status, osseous defects, and changes in the surrounding structures . They were captured using parallel device to enable reproducible, standardized and comparable radiographs suitable for follow-up analysis.[33]

Before radiographic assessment of radiographs , images were standardized in terms of brightness and contrast using image editing software to allow for optimum visualization . Bone density was evaluated using Digora software to assess remineralization and osseointegration.[34] The Digora digital radiography system is capable of measuring the optical density of pixels with asufficient degree of sensitivity to detect small differences unnoticeable to the human eye . Morever , it is safe , fast and user friendly for radiodensity evaluation . Therefore , the software of the Digora system was used for evaluation the radiographic changes through the follow up period in this study.[34]

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[35] .

Regarding clinical implant stability using ostel, results of the current study showed statistically significant increase in implant stability in both groups between immediate post-opertive and six months readings. Additionally, although there was no significant diffierence between groups immediately post- opertive regarding ostell readings, comparison between both groups showed statistically significant higher ostel readings in the study group at six –months follow-up period denoting better implant stability in the piezoelectric drilling group.[36]

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.[37]

Upon assessing the correlation between clinical and radiographic findings of the current study , a significantly positive correlation was seen after the six months follow-up period in both groups . This finding was revealed by the increased implant stability manifested by higher Ostel readings, which was accompanied by higher bone density values radiographically indicating better osseointegration at the bone-implant interface .[38]

CONCLUSION

Improved implant osseointegration is expected surrounding implants inserted in bone using piezoelectric techniques. Piezoelectric drilling of implant osteotomies in the anterior maxillary region can be a successful option for increasing implant stability values throughout the healing period in comparison to conventional drilling techniques.

Further clinical trials should be conducted that include a variety of piezosurgical tip and implant designs. Further studies are recommended for different areas in the maxilla and mandible (especially posterior areas) using additional biochemical markers, and for longer follow-up periods. This should be done in order to determine implant stability values throughout the healing period. Evaluation of marginal bone loss should be evaluated for longer follow-up periods for osteotomies prepared with piezoelectric surgery.

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