Piezoelectric Osteotomy and Ridge Expansion Technique In Edentulous Mandibular For Dental Implants

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Abstract: Introduction:. Piezosurgery a new cuting technique was developed and tried by Vercelotti in 1999, in osteotomies of resorbed narrow ridges in order to overcome the problems associated with `traditional drilling techniques. **Aim of the work:** This work aims at evaluating the use of piezoelectric surgery osteotomy and bone expansion techniques for preparing the implant site in mandibular atrophic ridges. **Materials and Methods:** six male patients with narrow knife edge mandibular ridge class 2 Kent's classification were selected, based on specific inclusion and exclusion criteria. Insertion of the implants fixture in a surgically created site using Piezotome inserts, was followed by sequential bone expansion increasing in size. The assembled O-ring attachments housing was seated on the ball insert abutment after 3 months. **Results:** The clinical phase went uneventful, with no untoward complications. Statistical analysis at different follow up periods showed a significant increase in bone density, and significant decrease in marginal height after 12 months than the base line. **Conclusion:** piezoelectric ridge osteotomy technique is a promising osteotomy procedure successfully used with ridge expansion in narrow mandibular ridges without the risk of fracture, ensuring implant success since it takes place in protected and well vascularized environment. 120120.

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1. Introduction

The mandibular ridge is characterized by high resorption rate following teeth extraction in the early period, followed by a remarkably slowing rate within the first year, ending by a slower gradual continuous and irreversible decrease in resorption[1,2,3]. This may result in narrow ridges with associated problem of insufficient bone to accept future prosthesis [4].

Several classifications were reported in the literature [5-10] as regards ridge resorption in order to describe the anatomical variations in different anatomic levels and estimation of the bone height and width and amount of basal bone to be used by the clinician for establishing a relational plan of treatment.

Problems associated with management of edentulous resorbed ridges with insufficient bone thickness presents a challenge for prosthetic replacement. Various surgical approaches were reported including: soft –tissue vestibuloplasty; ridge augmentation with alloplastic or biologic materials; and implantation [11]

Placement of dental implants in narrow ridges using ridge split osteotomy may result in fracture during osteotomy [12].

Ridge expansion techniques were described by Dr. Summers using osteotomes [13], this was followed by other expansive techniques (split crest, edentulous ridge expansion [ERE], ridge expansion osteotomy [REO]) which were used in Class IV premaxilla and posterior mandibular levels they uniformly claimed that the osteotome technique whenever compared with traditional drilling techniques using burs carries several advantages specially in atrophic bone [13-17].

Trials on the development of ultrasonic devices throughout the literature started as early as 1934 by **Hayes** [18]**.** The true turning point occurred when in **1997 Vercelloti** [19]**,** used some ultrasonic instruments for ablation to remove an ankylotic root and immediately realized the limits in cutting bone not more than 1mm thick with marginal necrosis due to overheating.

Subsequently, **Vercelloti**[19] realized that the limited power enabled osteotomy only with thin sharp inserts, hence he underwent a scientific technological research project with a team which purpose was to develop an ideal ultrasonic technology for bone cutting and ended up with the development of an initial prototype called *"Piezosurgery"*.

Unfortunately, the higher power over ablators only slightly improved cutting performance and caused excessive overheating of the bone. Pursuing researches with a team of scientists extensive research ended up by the invention of new surgical techniques with new disciplines in 1999 "Piezoelectric Bone Surgery" the greek word piezo means pressure, it is the result of nanometric deformation of the crystal of an electric field [19].

The basic technology of these devices uses the piezoelectric phenomenon, generating ultrasound by exploiting the mechanical deformations of quartz or a piezo-ceramic disc. By applying electrical charges to a quartz plate, crystal compression results and by inverting the direction, the expansion results. A series of alternation occurs under the effect of alternating electric current result in vibrations [20].

Piezoelectric bone surgery is based on two fundamental concepts in bone microsurgery. *First;* minimally invasive surgery, which improves tissue healing and reduces discomfort for the patient. *Second;* surgical predictability, which increases treatment effectiveness. Ease of instrument control, reduced bleeding, precision of cut, and good tissue healing even in the complex anatomical conditions [21].

The piezosurgery surgical instruments carry several properties and characteristics (1) precise cutting action; due to mechanical vibrations with linear oscillation from 20-80 microns, (2) Selective cutting action due to the low frequency of the ultrasonic waves and on the sharpness of the insert used i.e. bone, being rigid, is cut easily by the high frequency micro-vibrations of the instrument tips (60 to 200 mm/sec), whereas oral soft tissues (mucosa, neurovascular bundles) are soft and pliable at these same frequencies, (3) intraoperative surgical control: piezosurgery requires 500 g with microvibrations while bone burs require 2-3 kgs of pressure on the handle for cutting with macrovibrations reducing sensitivity, (4) insert efficiency due to variable to specific designs optimized for every specific clinical indication, (5) blood free surgical site ensures good visibility due to the cavitation phenomenon resulting from vibration of the insert at ultrasonic speed. The formation of vapor bubbles within the coolant liquid implode generating a shock wave. This cavitation effect created by the interaction between the irrigating solution and the oscillating tip results in hemostasis. Moreover, the energy released against the tooth as a result of the implosion of the cavitational bubbles lyses bacterial cell walls and disrupts the microbial environment, (6) reduced operations stress [22].

Ridge splitting associated with expanders offers the advantage of making the implant site preparation and to expand the bone at the same time over drills which, might loosen bone instead of expand it. Threaded expanders are another group of instruments for bone expansion. They work by rotation, which differentiate them from the osteotomes. They have an aggressive conical shape and penetrate the bone easily. The principal advantage is that they are less traumatic to the patient and that they can be used in the lower jaw [23].

Aim of the work:

The present work aims at evaluating the efficiency of using piezosurgery for osteotomy and bone expanders in creating suitable space in mandibular narrow alveolar ridge to receive dental implants.

2- Materials and Methods:

This scope of the present study was mainly based on six males completely edentulous patients They were selected from the outpatient clinic of the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Alexandria University.

Proper selection of the patients was mainly based on defined inclusion and exclusion criteria ranging from being free from any systemic disease that could jeopardize surgery or interfere with the post-operative healing, no habits such as smoking and alcoholism, no local pathological lesions in the area of implantation, as revealed by the clinical and radiographic examinations, patients suffering from narrow knife edge mandibular ridge class 2 Kent's classification [24] with alveolar ridge deficiency in both height and width preventing them from wearing their dentures.

Pre-operative assessment:

A diagnostic built-up was achieved and recorded in a patient diagnostic chart, after comprehensive medical and dental history taking, thorough clinical and radiological examinations.

Radiological examinations:

Its objective is to view and assess surgical and prosthetic information to determine the quality of the remaining bone, the relationship of critical structure to the prospective implants sites and determination of the future implant position and orientation using standardized periapical radiographic film and high-speed multislice three-dimensional CT (C.T DentaScan).(Fig 1)

Standardized reference point will be recorded on a radiographic stent as follows:

Gutta percha marker were placed on a clear autopolymerized acrylic replica of the fabricated mandibular complete denture labially as reference points.

Preparation of the surgical stent :

At the desired implant location drilling was made through radiographic the stent to produce two parallel canals for guiding the surgical drill to its desired location in the mandibule at the optimum angulation.

Surgical procedure:

The piezosurgery equipment consists of a Piezoelecric handpiece and a foot switch that are connected to a main unit, which supplies power and has holders for the handpiece and irrigation fluids. It contains a peristaltic pump for cooling with a jet of solution that discharges from the insert with an adjustable flow of (0-60 ml/min) and removes debris from the cutting area.

The settings of power and frequency modulation of the device can be selected on a control panel with a digital display and a keypad according to the planned task. The unit uses a frequency of (25-29) KHz. In “boosted” mode, a digital modulation of this oscillation produces an alternation of high frequency vibrations with pauses at a frequency of up to 30HZ. This alternation prevents the insert from impacting the bone and avoids overheating while maintaining optimum cutting capacity [25].

The micro-vibrations that are created in the piezoelectric handpiece cause the inserts to move between 60 and 210 $_{u}$m, providing the handpiece with power exceeding 5W [26] under copious irrigation.

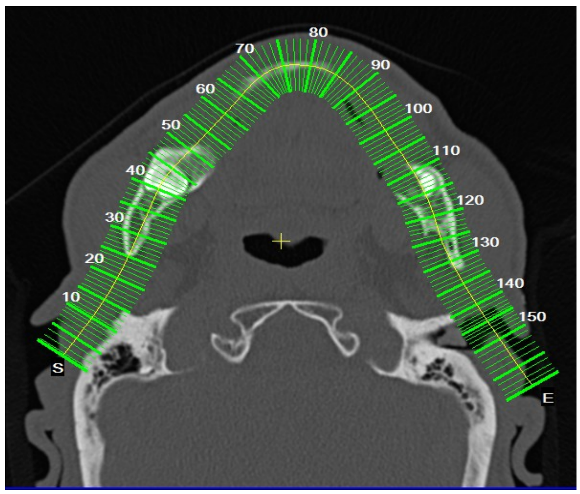


Fig 1: CT dentascan divided mandible in multiple segments.

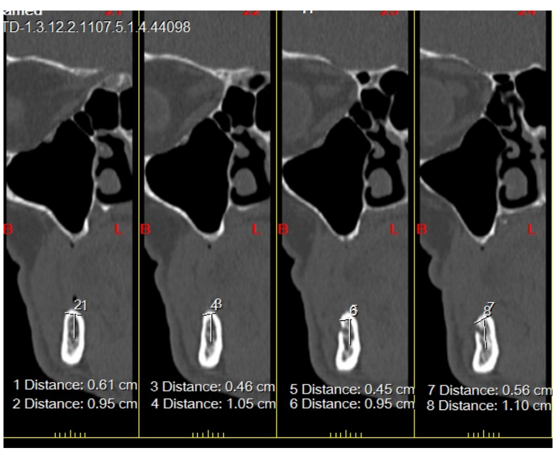


Fig 2: CT dentascan showing the distance from the alveolar crest to mental foramina.

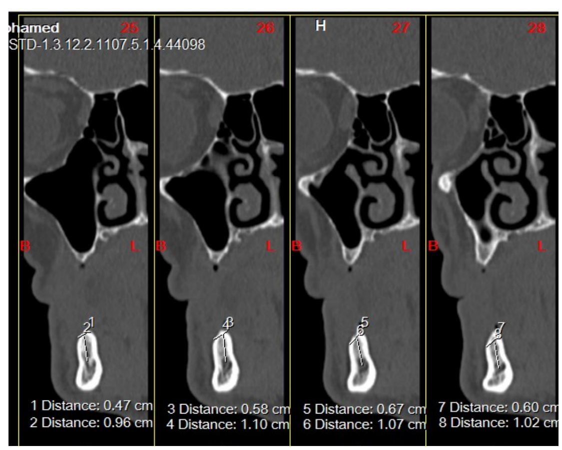


Fig 3: CT dentascan showing the distance of the alveolar crest (linguo – buccal) space

The handpiece was guided over the bone firmly, but without excessive force. The sound of the cutting can be used as acoustic feedback for the force to be used.

Stage I surgery:

Pre-operative care included mouth preparation with proper hygiene measures, and prophylactic antibiotic therapy one day before surgery using Amoxycillin trihydrate*, one gram in a single dose. Chlorohexidine HCl*** mouth wash 0.02% was used immediately before surgery. After local anesthetic administration, a crestal incision was carried out and a mucoperiosteal flap was reflected). A thin crestal osteotomy was initiated using a Piezotome saw device number 5 (BS 5) for lamellar cortical splitting (Fig 4) finalized with osteotomes and Piezotome blade number 6 (BS 6) (Fig 5). Bone expansion was then started using expanders sequentially increasing in size with precaution to avoid fracture of the buccal bone. After centrally screwing the expanders in osteotomy site, the expanders were for approx.1min to apply their expanding effect on the bone (fig 6). Insertion of the implants fixture was achieved according to manufacture instruction, gaining primary stability of the implant and fixation in its position (fig 7 & 8). The flap was repositioned and sutured with non-resorbable suture 3-0 black silk sutures. The temporary denture was delivered to the patients after refitting with tissue condition material.

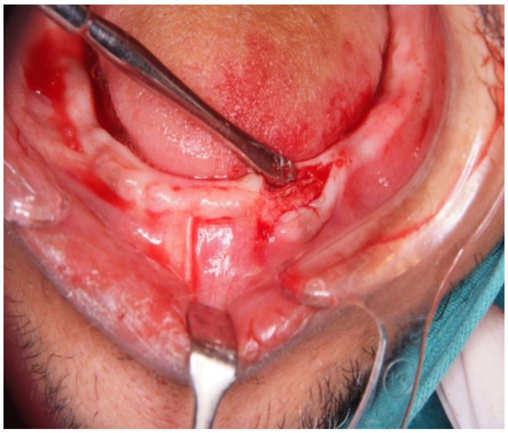


Fig 4: Crestal incision in the interforaminal region of the mandibular arch.

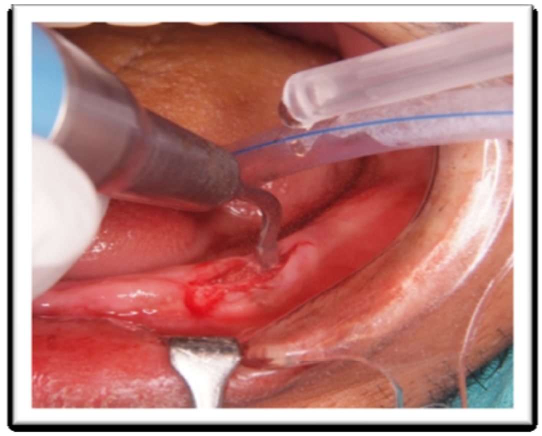


Fig 5: Lamellar cortical splitting associated with ridge splitting using Piezosurgery Blades.

Fig 6:using of the Expander For Bone expansion.

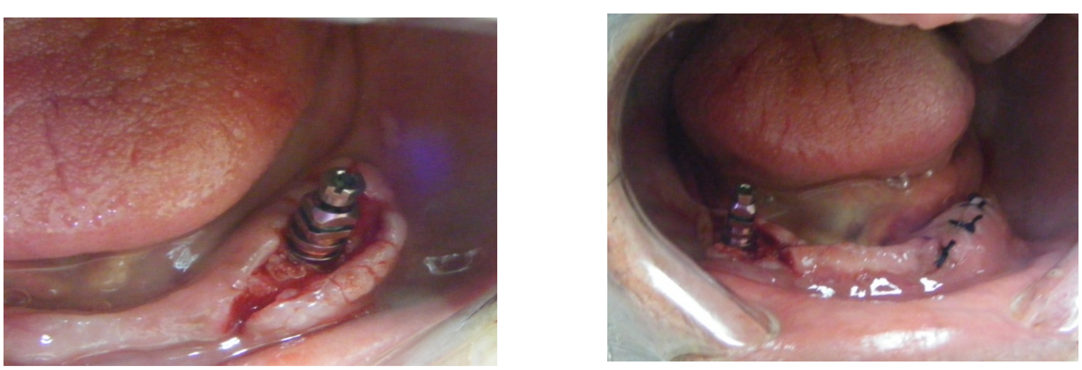
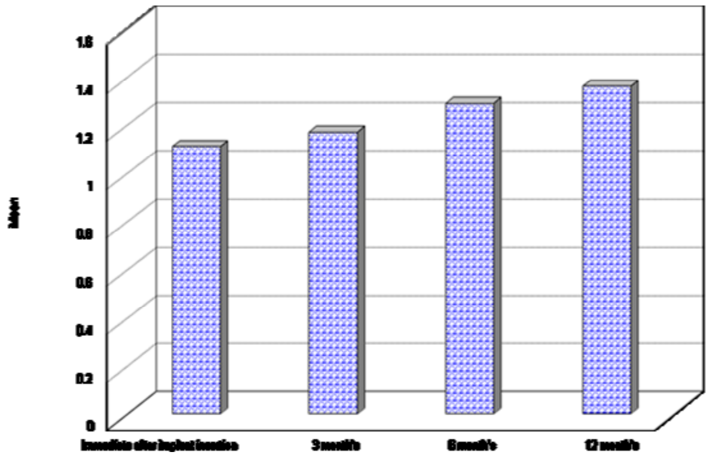


Fig 7 & 8: Seating of the implant



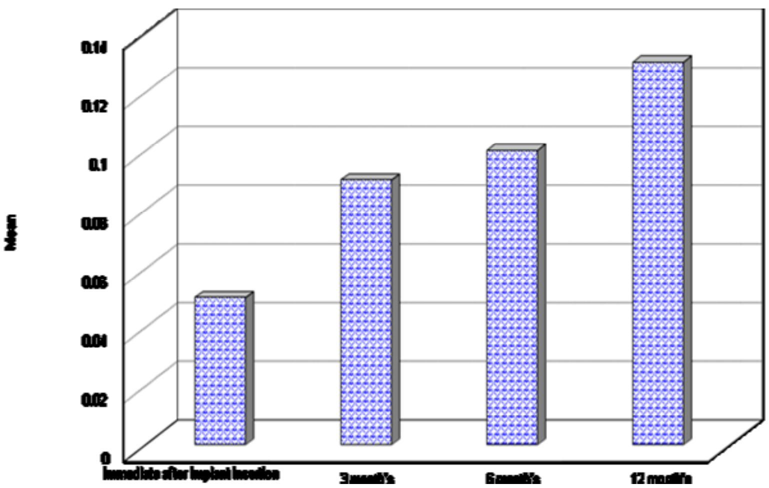


Fig: 8

Fig 9: showing the abutment in its position

Stage II surgery:

At the 3rd month post-operative period: The implant fixture was exposed using punch technique. Implant cover screw was removed and the healing cap connected and left for healing period of two weeks, then the implant ball abutment supra-structure was inserted.

Post operative phase:

Routine post-operative care and instructions were given for all the patients, including post-operative antibiotics and anti-inflammatories. Sutures were removed after one week. The patients were given to detect the presence or absence of any possible complications such as: Pain, tenderness, peri-implant infection, suppuration and edema.

At the end of the of 3 months post-post-operative period unscrewing of the healing screw and preparation of the suprastructure was performed.

Fig 10: Showing the O-ring attachments incorporated into the existing mandibular complete

Prosthetic phase:

The O-ring attachments were incorporated into the existing mandibular complete denture as a direct clinical procedure in the mouth. The assembled O-ring attachments housing will be seated on the ball insert abutment.

A clinical remount procedures and occlusal equilibration were then be completed and the denture will be delivered to the patient.

The patient was instructed about the care of the denture and the oral hygiene procedure.

Clinical assessment: all patients were given an appointment at the end of the first week to to detect the presence or absence of pain rated according to the WongandBaker[28]pain rating scale© Mosby, tenderness, edema, signs of infection and parasthesia.

Radiographic assessment: Accurate measurements of the bony changes were performed at standardized points at mesial and distal surfaces of all 12 implants at the intervals of; immediate, 3, 6 and 12 months post-operatively.

Linear measurements were taken from the marginal bone loss taking place between the collar of the implant and the alveolar crest mesially and distally from the 4 implants surfaces and their mean recorded to assess the marginal bone level (MBL). While, assessment of the mean bone density (BD) around the implants: was recorded from radiographs post-operatively at the immediate, 3rd month 6th and

12th month post loading period using a graphic editing computer program.

Clinical mobility according to McKinney and Koth[27] test was assessed at the same intervals.

Statistical analysis using Statistical Package for Social Sciences (SPSS/version 17) software using mean and standard deviation for numerical data, number and percent, Fisher exact test for analysis of categorical data and Wilcoxon matched pairs signed ranks test. The 5% was chosen as the level of significance.

3. Results:

All the patients fell in the age range between 38-60 years old with a mean of 47.29±8.08 years. And willing to accept implant over-denture modality.

Table (1): Age distribution among the studied group.

Age group	Number	Percent
≤ 40	3	42.9
> 40	4	57.1
Range	38 - 60	
Mean	47.29	
S.D.	8.08	

Surgical procedures were standardized for all the patients and the patients were followed-up clinically and radiographically as follows:

Clinical results:

6 patients received 12 implants, 2 implants in each side of the anterior mandibular region. The immediate follow-up period went uneventful for all the patients with no complications of pain, infection, edema, wound dehiscence or parasthesia as observed in the daily appointment given to the patients.

Delayed clinical follow-up:

After implant loading. Implant mobility showed there are was no recorded mobility during the whole follow-up period.

Intraoperative assessment of piezo surgery:

The edges of the osteotomy were all sharp to the edge, there was no need to split the bone with a chisel, or danger of a break out. During the osteotomy there were no disturbing vibrations in the area of operation. As the device selectively cut bone, nerve lesions were and minimal invasion surgeries were possible. Using the fine tip enabled curved cutting and provided an opportunity for new osteotomy technique.

Radiographic results:

Statistical analysis of marginal height in the studied patients at different period of follow up, proved that there was no significant changes after 3rd and 6th months from the base line, while it was found that there was a significant decrease in marginal height after 12 months than the base line (p = 0.029) as presented in table 2 and fig 8 .

Table (2) Statistical analysis of MBL

	Marginal bone level			
	baseline	3 month's	6 month's	12 month's
Range Mean S.D.	0.6–1.5 1.11 0.61	1 - 1.8 1.17 0.62	1.3 - 1.9 1.29 0.63	1.4 - 2.2 1.36 0.68
W p		1.01 0.319	1.88 0.145	2.98 0.029*

Statistical analysis of bone density in the studied patients group at different period of follow up, found that there was a significant increase in bone density from base line and all follow-up periods as presented in table 3 and fig: 9.

	Bone density			
	baseline	3 month's	6 month's	12 month's
Range Mean S.D.	0.0 - 0.09 0.05 0.03	0.0 - 0.12 0.09 0.04	0.0 - 0.14 0.10 0.05	0.0 - 0.18 0.13 0.06
W p		4.98 0.0028*	5.01 0.0024*	6.11 0.001*

4. Discussion:

Selection of male patients in the present study was mainly in accordance with previous suggestions (29) to avoid physiologic and hormonal factors related to females on the normal healing mechanisms. Furthermore In the present study particular care was directed towards s selecting patient being free from systemic conditions that would jeopardize the procedure, this conforms with regulations and indications adopted by previous researches. (30)

The clinical observations revealed good results suggestive of successful procedure, which could be attributed to good infection control measures, oral hygiene care, proper instructions, prophylactic antibiotic therapy and This agrees with previous results and interpretations (31,32).

No implant mobility was observed clinically and this was further confirmed by the radiographic results as a sign of proper osseointegration.

Radiographic examination is valuable to the overall evaluation of implant status, it is important to remember that radiographic images are not without diagnostic problem. In the present study, radiological assessment did not depend on panoramic radiography based on previous interpretations of displaying poor resolution capabilities that might detect gross changes in hard tissue but lacks sufficient accuracy for assessing alveolar bone height and subtle-peri-implant bony alteration (33). Assessment using periapical intraoral radiographs was not used as well in accordance with previous work advocating that it can be very difficult to obtain them in completely edentulous patients, as a result of the very superficial insertion of the muscles of the floor of the mouth. In this situation, parallel placement of the film may not capture the apical extent of the implant [34]. In this study A new version of multi-slice high speed three dimension CT (Dentascan) was used, and carried several advantages over the conventional film radiographly to determine accurately the quantity and quality of bone at the specific sites for implant placement, and the follow-up evaluation for MBL and BD. This dentascan, exposes the patients to a minimum amount of radiation, and from this device we obtain a transaxial view which was reformatted later on to obtain coronal, cross sectional and panoramic images in three dimensional views. This goes hand in hand with **Friberg et al** [35] work.

In the present study, intraoperative use of piezo surgery in osteotomy before expanders resulted in precise and easy controlled osteotomies that allowed successful implantation. This could be attributed to **Vercellotti et al**findings [20,22,23,25,26]

Who stated that the advantages are due to that the modulated ultrasonic frequency, which generates micro-vibrations of (60 – 200) mm/sec, cuts mineralized tissue exactly and smoothly while adjacent soft tissue and nerves remain unharmed and that [23,25] peizosurgerys accuracy and selectively renders it superior to conventionally rotating instruments in operations where the area of interest is adjacent to nerves [25].

This study showed that the marginal bone loss occurring in the both implants right and left side did not exceed 3mm during the observation period after insertion of the overdenture .The marginal bone loss in the first 3 months was higher than the next intervals from 3 to 6 and 6 to 12 months. This is was mostly due to the proper preparation of the implant site and bone remodeling during osseointegration.

There was a significant difference between the marginal bone level changes of both sides at the 12 month within the normal range during this study. This study in agreement with **Blus et al**[36]**,** that using the ultrasonic bone surgery (piezosurgery) to split the ridge crest and insert implant immediate in mandible.

This study showed a significant changes in the measurement of bone density around the implant throughout the period of evaluation which indicating successful integration. This is in agreement with **Bergkvist et al** [37] Twenty-one patients received 137 implants. Bone mineral density (BMD) was significantly correlated with bone quality classification in both arches ($P < .001$). Mean BMD was also significantly correlated with stability values ($P < .001$).

5. Conclusion:

The piezoelectric ridge osteotomy technique is a new effective and a promising procedure for ridge expansion especially in narrowing mandibular ridge without the risk of fracture because of excessive trauma. The implant success is very predictable because it takes place in protected and well vascularized environment.

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