Evaluation of Implant Stability after Conventional Versus Piezoelectric Alveolar Ridge Splitting with Immediate Implantation in Mandibular Posterior Region "A Randomized Controlled Trial"

Nermeen N. Mahmoud[1], Tarek El-Ghareeb[2], Elzahra F. Elbagoury[3]

[1]Assistant Lecturer Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Ahram Canadian University in Egypt, [2]Assistant Professor Oral and Maxillofacial Surgery Department Faculty of Dentistry, Cairo University, [3]Professor Oral and Maxillofacial Surgery Department Faculty of Dentistry, Cairo University

Abstract

Aim of the Study: The purpose of this study is to answer a clinical question whether the use of piezoelectric alveolar ridge splitting (ARS) with simultaneous implant placement will enhance implant stability in comparison with conventional motorized surgical disc and bur or not.

Materials and Methods: twenty four dental implants were placed in fourteen edentulous ridges and were divided into 2 equal groups (Group I & Group II). Patients in both groups underwent ARS for narrow edentulous posterior mandibular ridge with simultaneous implant placement. In Group I, 12 implants were placed in 8 edentulous ridges after ARS performed using piezoelectric saws. In Group II, 12 implants were placed in 6 edentulous ridges after ARS performed using conventional motor driven surgical disc and bur. Implant stability was measured by means of Osstell TM device, first intraoperatively, then at 6 months and 9 months postoperatively. Moreover, radiographic assessment of marginal bone loss (MBL) was done at 6 months postoperatively. Bone width gain was calculated from pre and post-operative cone beam CT.

Results: Regarding implant stability, there was a statistically significant difference between the two groups at all time intervals. Regarding MBL, and width gain, there was no statistically significant difference between both groups.**Conclusion:** Piezosurgery enhanced implant stability but didn't mitigate the bone loss associated with ARS or increase amount of ridge width gain.

Keywords: *Piezosugery, alveolar ridge splitting, dental implants, implant stability.*

Introduction

Alveolar ridge splitting (ARS) is a technique used to treat small to moderate alveolar ridge with deficiency. It was described by Simion as a longitudinal splitting of the ridge in two parts, provoking a greenstick fracture using small chisels. The created 4 walled defect provides the surface from which the osteogenic cells can be recruited [1]. But ARS has complications; like risk of buccal wall fracture, and more pronounced MBL around implants compared with those placed in pristine bone without ARS.[2]

Conventional ARS utilizes rotating instruments, such as bur, disc and saw. These motorized devices have certain drawbacks that include: overheating of bone and risk of soft tissue injury to important anatomical structures[3]. Moreover, the cutting action is the result

Corresponding author:
Nermeen Nasreldin Mahmoud
Email: nermeennasreldin83@gmail.com
Address: Abdeslasalam Amin st, first district, 7th avenue , 6 october city, Giza, Egypt. Postal code: 12573, Telephone number: +20-100398882

of macro or micromechanical shocks at different speeds. which may cause bone trauma and damage that may interfere with healing response [4].

Piezosurgery (PS) is performed by means of a device that uses microvibration at a frequency capable of cutting bone. PS has many benefits; due to its selective cutting property, it is safe to use near important soft tissue. Also, due to the cavitation effect, the operative field in PS remains almost free of blood during the cutting procedure. PS also possesses the advantage of micrometric cutting which is achieved by the microvibrations with limited amplitude. This offers highly precise cutting [5].

Some authors have reported its positive effects on the rate of bone repair and remodeling [6], and its contribution to better osseointegration outcome when drilling prior to implant placement [7][8][9].

The present study is to compare between PS and conventional ARS with simultaneous implant placement in enhancement of implant stability and mitigation of MBL by time.

Materials and Methods

This study was conducted on 10 patients with 14 thin edentulous mandibular posterior ridges attending the outpatient clinic in academic hospital of Faculty of dentistry - Cairo University department of oral and maxillofacial surgery.

Study group: 8 edentulous ridges received 12 implants simultaneously after ARS was performed using piezoelectric saws.

Control group: 6 edentulous ridges received 12 implants simultaneously after ARS was performed using motor driven disc and bur.

Eligibility criteria: Adult patients with thin edentuolous ridges who had sufficient alveolar bone height and were free from any systemic diseases that may affect bone healing.

Preoperative patient assessment: Preoperative CT was performed to determine the suitable implant size. Study casts with wax-up were prepared for planning for future implants placement and surgical guides' fabrication.

Surgical phase:

· At the edentulous site, a full thickness crestal incision was performed followed by two buccal vertical releasing incisions at the mesial and distal ends of the site located 2 mm away from the papillae of the neighbouring teeth.

· Split thickness flap elevation using a mucoperiosteal elevator was performed to expose the bone buccally.

· A mid-crestal bony incision was done at least 1-2 mm from neighbouring teeth using a piezoelectric US1 saw insert (US-ll LED Guilin Woodpecker Medical Instrument Co.,Ltd.) for the study group and motorized disc for the control group. Fig (1)

· Two vertical cuts were made with the piezoelectric saw in the study group and conventional fissure bur for the control group at both ends of the midcrestal bony cut on the buccal surface of the alveolar ridge, ending 2-3 mm short of the preplanned implant length.

· Ridge splitting osteotomes were introduced inside the crestal cut and gradually malleted to expand the ridge in a lateral direction. Implants were inserted.

· Xenograft (OneXeno Graft®, Germany) was used to fill the gap and PRF was used as a membrane to promote healing.

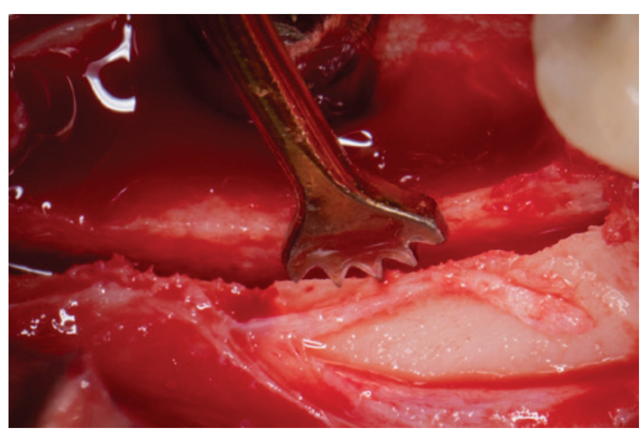

Figure (1): Photograph showing mid crestal osteotomy using piezoelectric saw in case no 10 in the study group

Outcomes:

1- Implant stability was estimated by Osstell™

(Integration Diagnostics, Göteborg, Sweden), first intraoperative, 6months and 9 months postoperatively. The values were expressed as numbers between 1-100 ISQ. Fig (2)

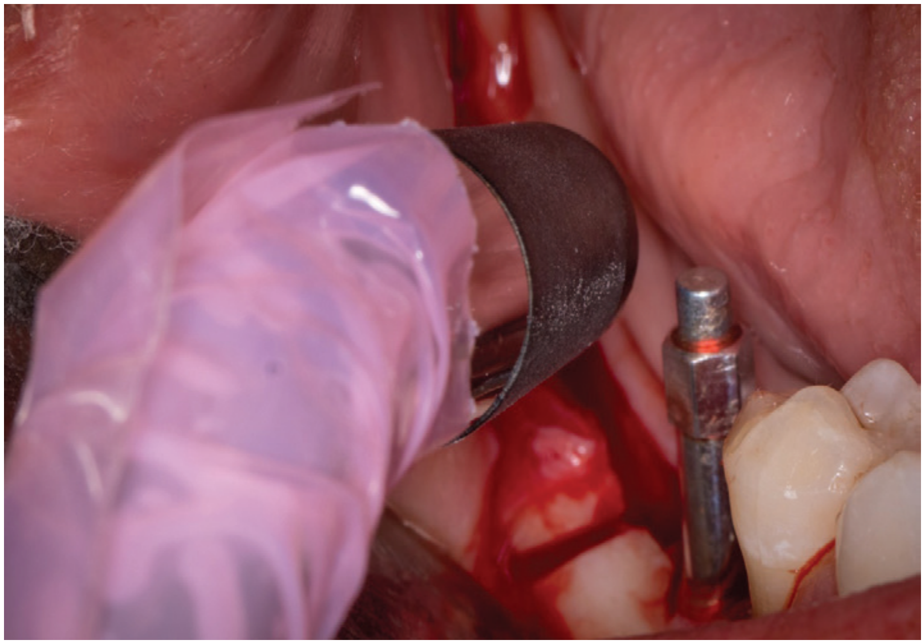

Figure (2): Photograph showing implant stability measuring using Osstell device in case no 10 in the study group

2- Cone Beam assessment was done immediately, and 6 months postoperatively to evaluate the MBL and the ridge width gain.

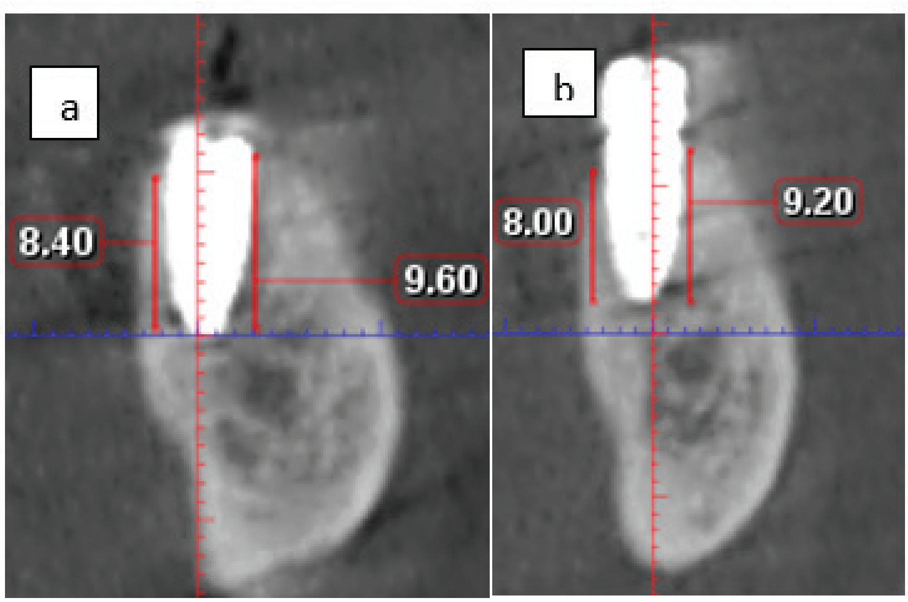

Figure (3): CBCT showing alveolar bone height measurements buccally and lingually in lower first molar region in study group case no 8 immediately (a), and after 6 months postoperatively(b)

Statistical Methods

Data were explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests, data showed parametric (normal) distribution. Independent sample t-test was used to compare between two groups in non-related samples. Paired sample t-test was used to compare between two groups in related samples. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Results

Table (1) Shows comparison between the mean, standard deviation (SD) values of implant stability values (ISQ) in both groups at different follow up times:

Group	Point of comparison	0 Mon	6 Mon	9 Mon
Control group	Mean	65.00	70.33	69.63
	SD	8.283	5.29	5.88
Study group	Mean	68.69	75.79	74.98
	SD	6.12	4.26	5.06
t-test	Standard error of differences	2.97	1.96	2.241
	Mean difference	3.68	5.45	-5.35
	95% Confidence interval of diff.	From -9.9673 to 2.6007	From -9.5534 to -1.3633	From -9.99793552471 to -0.70206447529
	t-value	-1.23832	-2.77916	2.3871
	p-value	0.114325	0.00547	0.0260

The result is significant at *p* <0.05.

Table (2) shows comparison between mean, standard deviation of MBL between the 2 groups:

Group	Point of comparison	0-6 m
Control group	Mean	-0.44 a
	SD	0.53
Study group	Mean	-0.25 a
	SD	0.58
p-value	0.495ns	

Means with different small letters in the same column indicate significant differences; non-significant (p>0.05

Discussion

Piezosurgery (PS) was selected in the present study to test the possible mitigation of bone loss and enhancement of osseointegration; PS had showed very promising results in studies on bone healing after surgical drilling and on osseointegration after dental implants(10). evaluated the level of alveolar bone crest after osteotomy with piezosurgery and burs using a model of dog alveolar ridges: histological analysis showed a bone level gain in the group treated with piezosurgery, and bone loss in the diamond and carbide bur groups. Also, in their study, Anesi et al**,**found out that on making osteotomies in rabbits skulls, the cutting of the piezosurgical tips produced double the amount of bone inside the created gaps when compared with rotary burs[11]. As for implants, ***Garcıa-Moreno et al*** conducted a systematic review to assess the primary and secondary stability of dental implants placed at sites prepared with PS and conventional drilling (CD), they deduced that PS preparation improves secondary stability after 2 and 3 months in comparison to CD, with similar implant survival rates[12].

RFA analysis was used as a reliable method to test and monitor the quality of bone-implant interface and consequently, provided clinical evidence of implant stability. This agrees with Turkyilmaz et al, who found statistically significant correlations between bone density and ISQ values in a human cadaver study. A significant influence of the peri-implant bone loss on ISQ values was also observed[13].

All cases in the current study were successfully split except one case in the control group that showed buccal plate fracture and was excluded from the study. This agrees with results of Sohn who reported malfracture of the buccal segment in 5 out of 23 cases in immediate splitting of the mandible. They recommended the delayed technique in the mandible in patients with high bone quality and a thick cortex and narrower ridge in the mandible to avoid complete fracture of the buccal segments[14]**..**However, Chauhan et al used conventional drills for ARS in the mandible and reported 100% success with immediate implant placement [15].

At 6 months postoperatively, the mean ISQ value in the control group was 70.3, while in the study group was 75. This was similar to results obtained by El-Halawany et al (68.7 for control group, 73.3 for study group) who performed conventional cutting in their study[16]. Also, close results were obtained by ***Kamel et al*** who used PS [17]. The results were slightly higher than those reported by ***Altaweel et al***[18]. These results are not very different from ISQ values of implants placed in unsplit alveolar ridges at 6 months postoperatively (mean 70); like those reported by ***Nguyen et al*** [19].These ISQ scores indicate that the implants placed after ARS are clinically stable and are near to implants placed in pristine bone.

The study group showed statistically significant higher ISQ values than the control group at 6 months. This could be explained by the positive effect of piezosurgery on bone healing as proved by many studies. This effect ranged at the molecular level from superior osteoblastic activity and more osteoclasts indicating faster remodeling, to increased expression of BMP-4 and TGF-b2 as well as reduction of proinflammatory cytokines[7] .On the macro level, PS leaves thinner bone gaps after osteotomy, which leads to easier and faster recovery because the osteoblasts are closer to the blood caplillaries, increasing the supply of growth factors. Also, the less heat generation achieved by the better cooling system contributes to the better healing in piezosurgery cases[11][9]. Our results are also in accordance with Da Silva Neto et al., who used resonance frequency analysis to evaluate the implant stability quotient (ISQ) of dental implants that were installed in sites prepared by either conventional drilling or piezoelectric tips. The results showed significant increases in the ISQ values for the piezosurgery group immediately postoperatvely, at 9 days, and 150 days postoperatively[8].

However, Esteves et al, who evaluated bone healing in rats' tibiae after osteotomies with piezosurgery and traditional bone drilling, analyzed the collected samples histomorphometrically, immunohistochemically, and on molecular basis at different time intervals. Histologically and histomorphometrically, bone healing was similar in both groups. Immunohistochemical analysis didn't detect significant differences in expression of all the proteins and most of the genes tested [20].

The mean alveolar bone loss from time of insertion till 6 months is (0.44mm) in the control group and (0.25mm) in the study group. These results are similar to those of kamel et al who reported bone loss of 0.3mm-0.4mm over a period of 6 months from time of insertion. Bassetti reported higher MBL of 1.19mm. This may be explained by the less initial bone width in their study (2.9) than that in our study [21]**,** As Ella et al reported more bone loss in in the narrow ridges, but was more obvious in the non-grafted ridges than the grafted one [22].

There was no statistically significant difference between both groups regarding MBL. The use of bone graft and PRF may have interfered with evaluation of the true effect of the piezosurgery in the initial healing period considering that they can both affect bone healing and remodeling.

The mean amount of gain in the study group was (2.96 mm) which is higher than that of the control group (2.54 mm), the difference of which was found statistically non-significant. Our results were similar to Shahakbari et al, who reported a mean gain in ridge width in the conventional group of 2.72 mm and in the piezosurgery group of 3.37mm(23).Nonetheless, PS facilitated the splitting greatly. The micrometric precise cutting of the tips allowed the cutting into very narrow alveolar ridges with ease and without their fracturing. Therefore, it's preferred in the mandible where the splitting is harder.

Conclusion

Piezosurgery improves implant stability, but doesn't reduce amount of MBL around dental implants after ARS.

Funding: The study was self-funded

Competing Interests: No conflict of interest

Ethical approval: The Ethics and research committee, Faculty of Dentistry, Cairo University approved the study and patients' consent was obtained.

References

1. Simion M, Baldoni M, Zaffe D. Jawbone Enlarqement Using Immediate Implant Placement Associated With a Split-Crest Technique and Guided Tissue Regeneration. period rest dent. 1992 Jan;12(6):462–73.
2. Bassetti MA, Bassetti RG, Bosshardt DD. The alveolar ridge splitting/expansion technique: A systematic review. Clin Oral Implants Res. 2014;27(3):310–24.
3. J -Y Giraud, S Villemin, R Darmana, J -Ph Cahuzac AAJ-PM. Bone cutting. Clin Phys Physiol Meas. 1991;12(1).
4. Simonetti M, Facco G, Barberis F, Signorini G, Capurro M, Rebaudi A, et al. Bone characteristics following osteotomy surgery : an in vitro SEM study comparing traditional Lindemann drill with sonic and ultrasonic instruments. Poseido J. 2013;1(3):187–94.
5. Sohn D-S, Ahn M-R, Lee W-H, Yeo D-S, Lim S-Y. Piezoelectric osteotomy for intraoral harvesting of bone blocks. Int J Periodontics Restorative Dent [Internet]. 2007;27(2):127–31.
6. Trisi P, Carlesi T, Colagiovanni M, Falco A, Bovi M, Perfetti G. paolo trisi ultrasonic vs drill osteotomy.pdf. J Osteol Biomater. 2011;2(1):21–31.
7. Preti G, Peirone B, Navone R, Manzella C. Cytokines and Growth Factors Involved in the Osseointegration of Oral Titanium Implants Positioned Using Piezoelectric Bone Surgery Versus a Drill Technique: A Pilot Study in Minipigs J Periodontol. 2007;78(4):716–22.
8. Da Silva Neto UT, Joly JC, Gehrke SA. Clinical analysis of the stability of dental implants after preparation of the site by conventional drilling or piezosurgery. Br J Oral Maxillofac Surg [Internet]. 2014;52(2):149–53.
9. Pereira S, Batista DS, Costa C, Fa Ã, Garcia R, Jacob M, et al. Comparative Evaluation of Cell Viability Immediately After Osteotomy for Comparative Evaluation of Cell Viability Immediately After Osteotomy for Implants With Drills and Piezosurgery : Immunohistochemistry Analysis. J Craniofac Surg. 2018;(May).
10. Enislidis G, Ewers R. Preliminary Report on a Staged Ridge Splitting Technique for Implant Placement in the Mandible : Int J Oral Maxillofac Implants. 2006;21(3):445–50.
11. Anesi A, Ferretti M, Cavani F, Salvatori R, Bianchi M, Russo A, et al. Structural and ultrastructural analyses of bone regeneration in rabbit cranial osteotomy: Piezosurgery versus traditional osteotomes. J Cranio-Maxillofacial Surg [Internet]. 2018;46(1):107–18.
12. García-Moreno S, González-Serrano J, López-Pintor RM, Pardal-Peláez B, Hernández G, Martínez-González JM. Implant stability using piezoelectric bone surgery compared with conventional drilling: a systematic review and meta-analysis. Int J Oral Maxillofac Surg. 2018;47(11):1453–64.
13. Turkyilmaz I, Company AM. Sensitivity of resonance frequency analysis method to assess

implant stability. N Y State Dent J. 2011;77(5):44–9.

14. Sohn D-S, Lee HJ, Jeung-Uk Heo, Moon JW, Park I-S, Romanos GE. Immediate and Delayed Lateral Ridge Expansion Technique in the Atrophic Posterior Mandibular Ridge. J Oral Maxillofac Surg. 2010;68:2283–90.
15. Chauhan H, Lakshmi S, Aurora JK, Potlia I, Komal A, Purohit N. Comparison between immediate vs. delayed lateral expansion technique to augment narrow alveolar ridges for placement of implants - A pilot study. J Oral Biol Craniofacial Res [Internet]. 2020;10(2):78–82.
16. El-Halawany SM, El-Ghareeb T, Elbagoury EF, Ibrahim SM. Evaluation of implant stability after application of platelet rich fibrin in mandibular posterior ridge splitting and simultaneous implant placement versus xenograft application: A randomized clinical trial [Internet]. Vol. 11, Indian Journal of Public Health Research and Development. 2020. p. 1145–51.
17. Kamel AM, Mohammad AK, Edrees MF. Efficacy of Regenerative Materials and Ultrasonic Ridge Splitting Technique with Simultaneous Implants Placement into Narrow Alveolar Ridge. AADJ. 2019;2(1):21–9.
18. Altaweel A, Abdullah B, Elsayed SA. Effect of Nano-hydroxyapatite and platelet-rich fibrin covered by the amniotic membrane on osseointegration after mandibular piezoelectric ridge splitting. Saudi Dent J. 2019
19. Nguyen VG, Weigl P. Lateral Alveolar Ridge Expansion in the Anterior Maxilla Using Piezoelectric Surgery for. Int J oral Maxillofac Implant. 2016;31(3):687–99.
20. Esteves JC, Marcantonio E, de Souza Faloni AP, Rocha FRG, Marcantonio RA, Wilk K, et al. Dynamics of bone healing after osteotomy with piezosurgery or conventional drilling - histomorphometrical, immunohistochemical, and molecular analysis. J Transl Med . 2013 Jan
21. Bassetti R, Bassetti M, Mericske-Stern R, Enkling N. Piezoelectric Alveolar Ridge-Splitting Technique with Simultaneous Implant Placement: A Cohort Study with 2-Year Radiographic Results. Int J Oral Maxillofac Implants. 2013;28(6):1570–80.
22. Ella B, Laurentjoye M, Sedarat C, Coutant J-C, Masson E, Rouas A. Mandibular ridge expansion using a horizontal bone-splitting technique and synthetic bone substitute: an alternative to bone block grafting? Int J Oral Maxillofac Implants. 2014;29(1):135–40.
23. Shahakbari R, Eshghpour M, Mianbandi V, Pourgonabadi S, Tohidi E, Seyedi SJ, et al. The Comparison of Utilizing Piezotome and Surgical Disc in Ridge Splitting of Atrophic Edentulous Maxillary Ridge. J Maxillofac Oral Surg. 2019.