Evaluation of a combined ridge expansion technique with simultaneous implant placement in narrow mandibular ridges

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ABSTRACT

Background Implant placement in the posterior mandible is sometimes problematic, due to loss of horizontal bone width after extraction of posterior teeth.

Aim of the study Evaluation of dental implants placed simultaneously with piezotomed ridge splitting and osseodensification in the posterior mandible.

Methods Eight patients with long span narrow edentulous ridge in the posterior mandible underwent piezotomed ridge splitting and osseodensification with simultaneous implant placement. Implant stability was assessed. Also, bone width gained, and bone density were measured around the dental implants using cone beam computed tomography.

Results The mean bone density and ridge width have increased significantly after ridge splitting and ossseodensification. The mean ISQ value at time of implant placement was 68.43 ± 5.40. At 4 weeks, it was 66.62 ± 5.79 and at 3 months, it was 70.93 ± 4.67. The difference was statistically significant.

Conclusion The combined ridge expansion technique using piezotomed ridge splitting and osseodensification is an effective method for simultaneous implant placement in the narrow posterior mandible, evidenced by increase of bone density, ridge width and good implant stability.

INTRODUCTION

Nowadays dental implants have become a cornerstone of dental treatment. The treatment of patient with atrophic ridge who needs implant surgery after loss of teeth and alveolar ridge resorption, represents a challenge to implant placement. For adequate implant placement, there should be a minimum thickness of 1-1.5mm of intact bone on both the buccal and lingual aspect of implant(s) to ensure a successful outcome.(1)

There are several methods that can be performed for bone augmentation in horizontally deficient ridges as block bone grafting, guided bone regeneration, and horizontal osteo-distraction. (2)

However, these methods have many disadvantages like long period of treatment, very high cost, patient refusing surgery in another site, morbidity of the donor site, limited availability of bone in the donor site, and unexpected reaction against allograft (if used). (3, 4)

Ridge splitting technique is one of the best methods for management of horizontally deficient ridges. It was developed by Scipioni et al , and Simion et al. (2, 5)

The Piezosurgery system works in the frequency of 25 to 29 kHz. This frequency, which creates microvibrations ranging from 60 to 210 µm in amplitude and provides the handpiece with power exceeding 5 W, cuts only mineralized tissue, whereas soft tissue such as nerves and arteries are cut at frequencies higher than 50 kHz. These delicate instruments allow preparation of split lines with a width of only 0.25 mm and 0.5 mm. (6, 7)

Piezosurgery has made the success of alveolar ridge split technique less dependent on the surgeon's skills and less affected by the type of procedure chosen. The applicability of the crest-split technique was narrowed down to crest-widths of 2 mm by the more bone-conserving primary osteotomy.(8, 9) The piezoelectric device ultrasonic cut has been reported to be more precise and has less distortion effect than the cutting disc. (10, 11)

In addition, Densah burs developed by Huwais have proved to produce a controlled bone plastic deformation, which allows the expansion of a cylindrical osteotomy without excavating any bone tissue. (12)

In this study, a combined technique for ridge expansion using piezotomed ridge splitting and osseodensification, with simultaneous implant placement in narrow posterior mandibular ridges was evaluated clinically and radiographically.

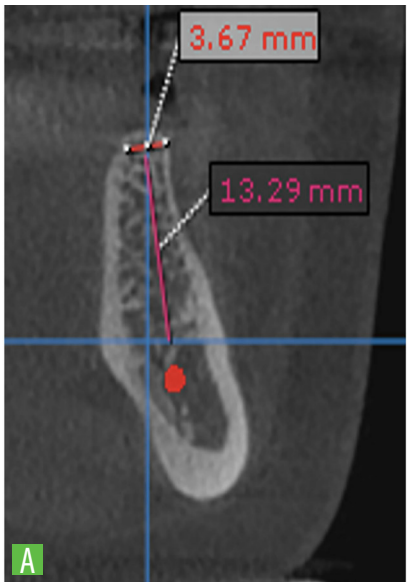

FIG. 1 A) CBCT showing bone dimensions preoperative B) Ridge splitting

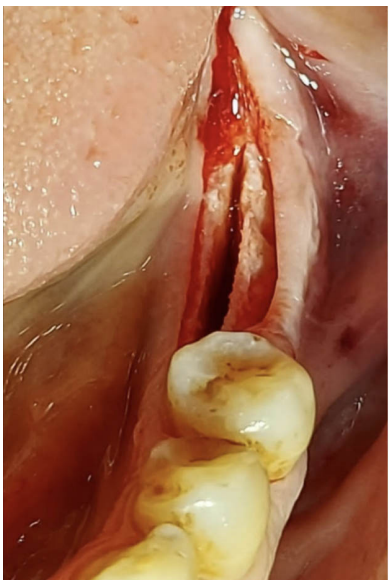

FIG 2 Ridge after splitting

PATIENTS & METHODS

Study design

This study is a single arm clinical trial. It has been registered on clinicaltrials.gov (ID: NCT05685576). The research protocol was approved by the Research Ethics Committee of Alexandria University Faculty of Dentistry (IRB No. 001056 – IORG 0008839)

Study Sample and setting

Sample size was estimated assuming 5% alpha error and 80% study power. According to Mustafa et al., the mean (SD) bone density at baseline was 737.6 (265.8)(11), bone density is expected to increase by 67.23% (13) after 3 months to reach 1233.52. The minimum sample size was calculated to be 6 patients, and this was increased to 8 patients to make up for the loss to follow up.

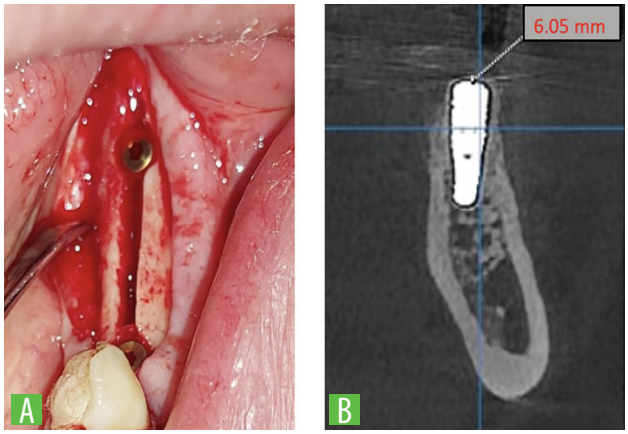

FIG. 3 A) After osseodensification and implant placement. B) CBCT 3 months postoperative

Software

Sample size was based on Rosner's method (13) calculated by Gpower 3.0.10

Patients of both genders, who were indicated for ridge splitting, were recruited from the outpatient clinic, Faculty of dentistry, Alexandria University.

Criteria of patients' selection

Patients enrolled in the study were selected after fulfilling the following criteria:

Inclusion criteria

- Patients with good oral hygiene (not more than score 2 plaque index);
- patients with long span posterior edentulous mandibular area (≥ 3 missing teeth);
- age range [45 – 65 years];
- patients who accept to participate in the study;
- minimum bone height 10mm from the crest of the ridge till the upper border of the inferior alveolar canal;
- minimum ridge thickness 3mm and less than 5 mm at the crestal region;
- if the patient is diabetic, should be controlled.

Exclusion criteria

- Immunosuppressive/ autoimmune disease patients;
- patients with osteoporosis;
- lack of sufficient amount of keratinizing mucosa at the crest of the edentulous saddle;
- patients with bleeding disorder disease;
- ridge width less than 3 mm;
- smokers;
- patients having periodontal disease;
- the presence of pathological lesion in the area of ridge splitting.

Bone density	Before	After	t	p
Min. – Max.	332.0 – 796.0	1109.0 – 2176.0		
Mean ± SD.	588.9 ± 135.7	1517.7 ± 279.1	14.065*	<0.001*
Median (IQR)	594.5(471.5 – 676.5)	1431.0(1383 – 1575)		
Difference (Mean ± SD.)	928.8 ± 264.2			

TABLE 1
Mean Bone density preoperative and 3 months postoperative

IQR: Inter quartile range SD: Standard deviation t: Paired t-test
p: p value for comparing between before and after
**: Statistically significant at p ≤ 0.05*

Bone width in mm		At Anterior implant	At Posterior implant	Overall
Before	Mean (SD)	3.61 (0.59)	4.10 (0.69)	3.85 (0.55)
	Median (IQR)	3.55 (0.6)	4.25 (1.2)	3.87 (0.70)
	Min - Max	3.0 – 4.0	3.0 – 4.9	3.10 – 4.90
After	Mean (SD)	5.77 (0.54)	6.12 (0.66)	5.95 (0.50)
	Median (IQR)	5.70 (0.5)	6.15 (1.1)	5.92 (0.58)
	Min - Max	5.0 – 6.9	5.0 – 7.0	5.30 – 6.95
Test (*p* value)		2.55 (0.011*)	2.536 (0.011*)	2.585 (0.010*)

**Statistically significant different at p value ≤0.05*

TABLE 2 Bone width before after ridge expansion

All these factors would interfere with implant stability and healing.
All patients were informed about the procedure details, and each participant signed a written consent.

Materials

- Implant system: 2 pieces screw type, titanium dental implant (Neodent, Brazi);
- Piezotome: Using specialized Crest splitting tips (Acteon Group, France);
- Densah Bur kit: used to perform bone densification (Densah Bur Kit; Versah LLC, Jackson, MI, USA).

Methods:

Pre-surgical phase: included taking the past medical history, past dental history and chief complaint of the patient, in addition to clinical examination both extra oral& intra oral. Primary measurement of the buccolingual width of the edentulous ridge was done by caliber. Cone Beam computer tomography was performed to verify bone width, implant position and depth, and the intended position of ridge splitting. Measurement of the buccolingual thickness in the crestal area, and density of the cancellous bone was done.

Surgical Phase: all patients were operated under local anesthesia. No.15 Bard parker scalpel blade was used to incise the mucosa [crestal incision] and a vertical incision was done mesially if needed. Midcrestal osteotomy of the crestal bone was then performed using piezotome, with sequentially wider crest splitting tips. Ridge splitting was followed by bone densification and gain of width using Densah burs, precisely following the drill protocol provided by the manufacturing

ISQ		Anterior implant	Posterior implant	Overall
At time of implant placement	Mean (SD)	68.00 (6.25)	68.88 (4.79)	68.43 (5.40)
	Median (IQR)	68.00 (11.0)	68.00 (7.0)	67.75 (8.63)
	Min - Max	58.0 – 75.0	60.0 – 75.0	59.0 – 74.50
4 weeks	Mean (SD)	66.13 (6.53)	67.13 (5.19)	66.62 (5.79)
	Median (IQR)	66.0 (12.0)	66.50 (8.0)	66.25 (10.0)
	Min - Max	56.0 – 73.0	58.0 – 74.0	57.0 – 73.5
12 weeks	Mean (SD)	71.13 (5.16)	70.75 (4.43)	70.93 (4.67)
	Median (IQR)	71.50 (11.0)	70.00 (7.0)	70.50 (8.38)
	Min - Max	64.0 – 77.0	63.0 – 76.0	63.5 – 76.5
Test (*p* value)		13.613 (0.001*)	15.548 (<0.0001*)	16.000 (<0.0001*)

**Statistically significant different at p value ≤0.05*

TABLE 3 Implant stability at time of implant placement, at 4 weeks and at 12 weeks postoperative

company.
Following implant insertion, a periosteal releasing incision was performed in the periosteal side of the mucosa in order to close the flap without tension. Closure was done using 3-0 vicryl suture.

Post-surgical Phase

Post-operative instructions:

- Cold fomentations applied extra orally, at regular intervals during the first day;
- chlorohexidine mouthwash twice a day for one week starting the day after surgery;
- oral hygiene instructions.

Postoperative medications:

- Amoxicillin clavulanate (Augmentin: Amoxicillin 875 mg + Clavulanic acid 125 mg: GlaxoSmith-Kline, UK) 1 gm twice daily for 5 days.
- Metronidazole (Flagyl: metronidazole 500mg: GlaxoSmithKline, UK) 500mg every eight hours for 5 days.
- Diclofenac potassium (Cataflam: Diclofenac Potassium 50mg: Novartis-Switzerland) 50mg every eight hours for 5 days
- Chlorhexidine (Hexitol: Chlorhexidine 125mg/100ml, concentration 0.125%: Arabic drug company, ADCO) Antiseptic mouthwash.

Clinical evaluation

- Early follow up was done after 3 days, 1 week and 2 weeks for any signs of infection/edema and to check for proper wound healing. Postoperative Pain was assessed on a 10-point Visual Analogue Scale [VAS] (0-1= None, 2-4= Mild, 5-7= Moderate, 8-10= Severe). Pain was measured for two weeks after surgery.
- Primary stability of the implants was measured using insertion torque and resonance frequency analysis by Osstell ISQ device (Osstell ISQ, W&H, Sweden) and the ISQ readings were taken again at 4 weeks and then at 3 months.

Radiographic Evaluation

3 months after surgery, CBCT scan was taken to measure the bone width gained, and density of bone around the inserted implants.

Prosthetic protocol

Loading of the implants was done at 3 months after surgery.

Statistical Analysis

Data was tabulated and statistically analyzed. Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). The Shapiro-Wilk test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.
Paired t-test was used to compare bone density between two periods of time. Change in bone width before and after intervention was assessed using Wilcoxon Sign Rank test. Differences in ISQ values across time intervals were assessed using Friedman test.

RESULTS

The present study included eight patients of both sexes (five females and three males); their ages ranged between 47-65 years (Average age 59 years).
In these 8 patients, a total of 16 implants were placed (two implants in each patient).

Bone density

The mean bone density before ridge expansion was 588.9 ± 135.7, three months after ridge splitting and osseodensification, it increased to 1517.7 ± 279.1, and the difference was statistically significant ($p < 0.001$).

Ridge width

The overall mean ridge width before surgery was 3.85 ±0.55 mm. After surgery, it increased to 5.95 ± 0.50 mm, and the difference was statistically significant ($p=0.010$).

Implant stability

The insertion torque at time of implant placement ranged from 30 to 50 N/cm. The mean ISQ value at time of implant placement was 68.43 ± 5.40. At 4 weeks, it was 66.62 ± 5.79 and at 3 months, it was 70.93 ± 4.67. The difference was statistically significant.

DISCUSSION

After tooth extraction, the crestal bone loses about 50% of its original width within the first year.(14) A minimum of 1-1.5 mm of bone is required on both the buccal and lingual aspects of the implant to ensure predictable implant prognosis. (2)
In this study, eight patients with mandibular alveolar ridge thickness ranging between 3 and 5 mm were included to examine the ridge expansion technique using a combination of piezotomed ridge splitting and osseodensification.
Piezotomed ridge splitting has been successfully used in previous studies in narrow ridges to allow for ridge expansion and simultaneous implant placement. (10, 11) Using the piezotome has the privileges of precise splitting and bone preservation in addition to its safety on soft tissue and vital structures. The only disadvantage is the relative

slow cutting rate. (15)
Performing crestal splitting as a first step helps in horizontal bone distraction without fracture or microcracks formation. After crestal splitting of the alveolar ridge, several methods could be used to gain the required horizontal ridge width as osteotomes, wedges or expanders. (11, 15, 16)
In the present study, Densah burs have been used to achieve the expansion effect after splitting and get benefit from the densifying effect on implant stability and peri-implant bone density. The combined ridge expansion technique allowed for simultaneous implant placement with adequate primary stability, thus obviating the need for bone grafts and reducing the treatment cost and time.
A recent research article has revealed that the ridge expansion effect obtained by Densah burs compared to standard drills is more obvious in narrower ridges and becomes less obvious as the ridge becomes wider. Also, the use of Densah burs has been associated with shallower implant insertion depth due to the bounce back effect of bone. (17) In the current study, undersizing the osteotomy has been avoided to overcome this problem in addition to the use of countersink drill to help the implant seat fully to the desired depth.
Increase of bone density has been detected in previous studies after osseodensification. It usually appears as a radiopaque halo of higher bone density around dental implants in axial cuts of cone beam computed tomography scans. Higher bone density and increased bone to implant contact are believed to consequently result in better implant stability. (18) This has been observed in the present study where mean bone density has increased significantly after the use of ossedodensification combined with crestal ridge splitting for ridge expansion.
The compaction autografting achieved by Densah burs during osteotomy preparation depends on the viscoelastic nature of bone and plastic bone deformation characteristic, thus allowing expansion of the ridge with bone preservation and compaction. This leads to higher implant stability values.(18) Also, a histologic evidence of ossedensification superiority to conventional drilling exists in terms of bone to implant contact and bone area fraction occupancy. (19)
The use of osseodensification by Bergamo et al has demonstrated higher primary stability when compared with conventional drilling, regardless of implant size and type measured by insertion torque and resonance frequency analysis. Also, secondary implant stability at 6 weeks was superior with osseodensification. However, the ISQ value has dropped from the time of implant insertion to 3 weeks then raised again at 6 weeks postoperative. (20) This conforms with the results of the current study, where mean ISQ value at time of implant placement was 68.43 $\pm$ 5.40, at 4 weeks it decreased to 66.62 $\pm$ 5.79 and it then raised again to 70.93 $\pm$ 4.67 at 3 months after surgery.
However, the present study has some limitations. These include the relatively small sample and the short follow up period. Further clinical trials with larger samples, and longer follow up periods are required. Also, the presence of control group comparing the effect of osseodensification with other ridge expanding methods is advised.

CONCLUSION

Within the limitations of the current study, it can be concluded that the combined ridge expansion technique using piezotomed ridge splitting and osseodensification is an effective method for simultaneous implant placement in the narrow posterior mandible, evidenced by increase of bone density, ridge width and good implant stability.

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