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EFFICIENCY OF RIDGE EXPANSION USING SCREW-TYPE EXPANDERS WITH SIMULTANEOUS TRABECULAR IMPLANT PLACEMENT IN NARROW ANTERIOR MAXILLA (A CLINICAL AND RADIOGRAPHIC STUDY)

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ABSTRACT

Background: Bone augmentation of narrow residual alveolar ridges in anterior maxilla is mandatory for better esthetical results. Many attempts were done to achieve acceptable outcomes including bone expansion. Using screw-type expanders is an acceptable treatment modality, complication-free and less sensitive technique. With the increase of esthetic demands, it was the importance of implant's early loading which depends on its modified surface. The aim of this study was to evaluate clinically and radiographically the efficiency of placing Trabecular Metal Material implants with bone expansion in narrow anterior maxilla.

Materials and Methods: For this clinical trial, 20 patients requiring implant placement in the narrow anterior maxilla of sufficient bone height and of ridge width ≥ 3mm but < 6mm were selected. Bone expansion using screw-type expanders was performed with simultaneous placement of Trabecular Metal Material implants. The studied variables were the degree of facial swelling, marginal bone height and bone width. The follow-up period was six months. For statistical analysis, Friedman and Wilcoxon tests were used.

Results: A Significant decrease regarding marginal bone height and a significant increase regarding bone width were observed through the follow-up stage, while no significant difference was noticed concerning the degree of facial swelling when compared to base line measurements.

Conclusion: The results assured the efficiency of bone expansion using screw-type expanders with simultaneous placement of Trabecular Metal Material implant and highlighted their promising effects concerning esthetical considerations.

Keywords: Bone expansion, Screw-type expanders, Trabecular Metal Material implant, Narrow anterior maxilla.

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INTRODUCTION

Alveolar resorption following extraction, trauma or infection usually results in ridge with deficient width and decreased height[1]. This is prominent in anterior maxilla characterized by its soft bone quality (D2, D3 and D4) type of bone[2].

In maxilla, residual ridge shifts palatally at the expense of the buccal plate[3], ending with a narrow ridge of buccal concavity which increases the risk of dehiscence and fenestrations occurrence during implant bed preparation[4]. Sufficient bone volume and density are crucial factors for implant success[5].

For these reasons, placing implants in anterior maxilla remains a challenge for both surgeons and prosthodontists [6]. As modern implant dentistry does not only aim to provide stable osseointegration, but also satisfying esthetics [7], it was the importance of achieving long term esthetical peri-implant soft tissue appearance which depends on the underlying bone topography [8].

Consequently, bone augmentation to rebuild deficient ridges in anterior maxilla is mandatory [9] in order to enable successful implant placement.

Many attempts were done for bone augmentation in narrow ridges depending on the morphology of the defect including onlay bone grafts, membrane techniques, bone distraction, bone splitting and expansion [10].

Bone expansion is a highly predictable, relatively complication-free therapeutic method in contrast to other procedures accompanied with several drawbacks. The use of screw-type bone expanders results in lateral bone augmentation and condensation of soft bone to increase bone volume and density necessary for successful implant placement. It allows preservation of bone in surgical site with no damage to soft tissues. It offers strong primary stability, short surgical time, less financial costs and limited trauma to patients [1].

A basic issue that dentists face during rehabilitation of edentulous ridges in anterior maxilla, is the need for immediate or early loading. This depends on implant surface modified to decrease healing period. Recently, Porous Tantalum Trabecular Metal (PTTM) technology was introduced to enhance titanium dental implants. The three dimensional highly porous tantalum trabecular metal of similar characteristics to cancellous bone formed the middle third of the traditional tapered implant to allow bone on-growth and ingrowth in order to enhance both osseointegration and osseoincorporation and therefore reduces healing time and increases implant secondary stability. This implant enhances results in cases of simultaneous implant placement with horizontal or vertical bone augmentation [11].

Therefore, this work was done to evaluate clinically and radiographically the efficiency of placing Trabecular Metal Material implant with bone expansion in narrow anterior maxilla.

MATERIALS AND METHODS

Study design and setting

This study was carried out as a clinical trial. The calculated sample size was 16 patients; 20% was added to the sample size from the start of the study to eliminate the probability of drop out through the treatment protocol. Thus, a total of 20 patients who received 22 implants were included. They were selected conveniently from the outpatient clinic of Oral Surgical Sciences Department, Faculty of Dentistry, Beirut Arab University, Beirut, Lebanon according to a certain inclusion criteria (patients with age ranging between 20 and 45 years, needing implant placement in the esthetic zone of the anterior maxilla, with residual ridge of sufficient bone height and of bone width ≥ 3mm but < 6mm) and exclusion criteria (patients with uncontrolled systemic diseases, heavy smokers and those with poor oral hygiene). All patients were informed

about the procedure and signed a detailed informed consent form. This study started after obtaining the approval of the Institutional Review Board (IRB) of Beirut Arab University (code: 2016 H-0043-D-M-0158).

Materials used in this study: OSUNG Bone Expander Kit and Trabecular Metal Material implant.

Fig. (1) A: OSUNG Bone Expander Kit.

Fig. (1) B: Trabecular Metal Material Implant

Pre-operative stage

Medical and dental histories were registered, clinical and radiographic examinations were done through periapical X-rays (X-Mind AC/DC, France) and CBCTs (Kodak CS 9000 Extraoral Imaging System, US).

Operative stage

All surgeries were performed by the same surgeon under local anesthesia using Artecaine hydrochloride 4% with Adrenaline 1/100.000 (Ubistesin forte, 3M ESPE, US). Surgical templates were used to secure the proper alignment of implants (Fig. 2b). The point drill of 1.3mm diameter from the OSUNG expander kit (OSUNG MND, Korea) (Fig. 1a) was used at 1200 revolution per minute (RPM) to perforate the surgical templates downward to the bone and initiate the osteotomies at the planned implants' sites. The surgical templates were then removed and envelope buccal full thickness flaps were elevated to expose the narrow anterior maxillary alveolar ridges (Fig. 2c). Again, the point drill was used to the full depth that matches the length of the implants to be installed. A series of six screw-type bone expanders (OSUNG MND, Korea) of gradual increased diameters (2.3mm, 2.7mm, 3.1mm, 3.5mm, 4.3mm and 5.1 mm) (Fig. 1a) were used to widen the implants' sites to the desired width.

The screw expanders were carried to the osteotomy site with the help of the engine adapter which was replaced by the adapter wrench for gentle insertion of the screws to the full desired depth. This was done by finger pressure or using a ratchet when necessary. Before each half turn, a 20-30 seconds waiting time was required to allow bone to accommodate to expansion [12] (Fig. 2d). The slow clock wise manner of insertion was indicated to avoid buccal plate fractures.

Implants' beds were widened to the desired depth with the osteotomy sites being slightly narrower for better primary stability. Trabecular Metal Material implants (Zimmer Biomet, USA) (Fig. 1b) were installed (Fig. 2e) 2 mm subcrestally with an insertion torque of 35-40 Ncm. Interrupted sutures using 3-0 black silk suture material were done to approximate the tissues. Temporary crowns were made using Bis-acryl (Luxatemp Automix Plus, DMG, USA) filled in the prefabricated essix retainers (Essix retainer, Dentsply Raintree Essix, USA).

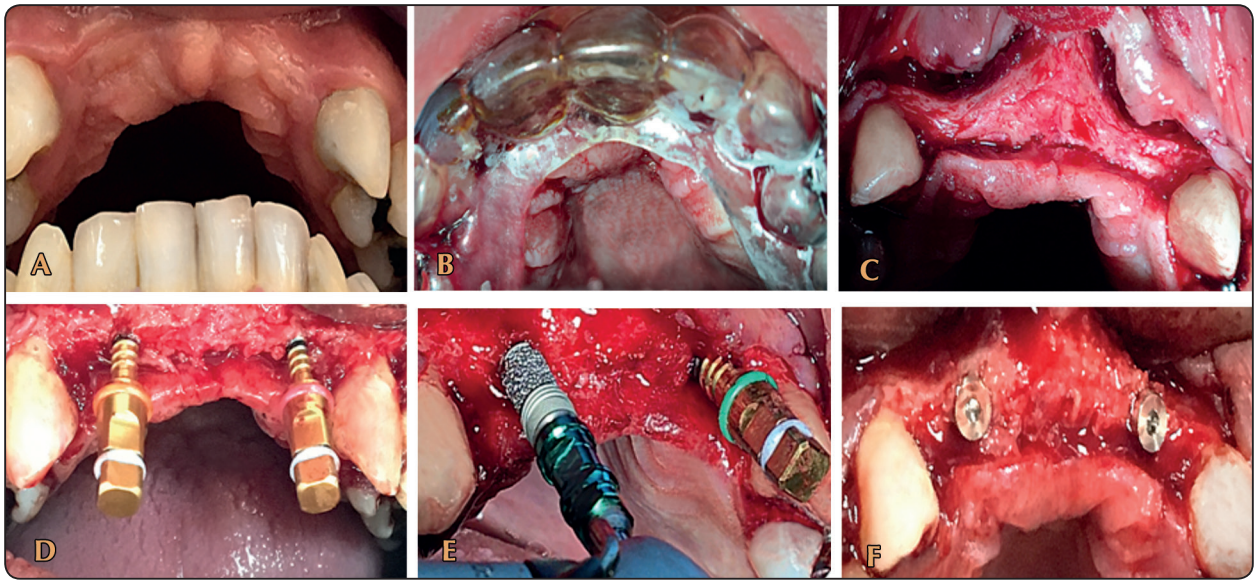

Fig. (2) A: Residual anterior maxillary ridge. B: Surgical template in place to indicate optimal direction of the implants. C: Buccal envelope flap exposing the narrow bone ridge. D: Screw-type expanders gently screwed to widen the implants' beds. E: Installation of Trabecular Metal Material implant. F: Two implants installed in the expanded ridge.

Post-operative stage

Immediately after surgery, patients applied extra-oral ice packs for 10 minutes each half an hour, replaced by warm saline rinses for the following 3 days.

The following medications were prescribed: Antibiotic (Augmentin 1g, GlaxoSmithKline, UK) for 7 days and NSAID (Voltfast, Novartis International, Switzerland) 50mg for 3 days. Chlorhexidine mouthwash 0.1% (Eludril, Pierre Fabre Medicament Production, France) for the following 7 days. Sutures were removed one week after surgery.

Follow-up stage

Immediate follow-up

Clinical evaluation was done at the 4th and 7th postoperative days to evaluate soft tissue healing and the degree of facial swelling by calculating the mean of the vertical distance measured from the tip of nose to the tip of chin and the horizontal distance measured between the two corners of the mouth. The obtained values were compared to base line values. Immediate post-operative periapical radiographs were done to check the implant axis with respect to neighboring teeth.

Late follow-up

Three weeks later, healing abutments were inserted. Implants were functionally loaded with Zirconia crowns at six postoperative weeks (Fig.3). All implant level impressions were taken using silicone impression material.

Clinical and radiographic evaluations were done at time of healing abutments insertion and after six months of loading the included implants with zirconia crowns.

Fig. (3) Final zirconia prosthetic crowns.

Clinically, peri-implants' soft tissue healing was evaluated and implants' mobility was examined according to the clinical implant mobility scale (0-4) [13]. An additional test was done to inspect the mobility by tapping the implants. A solid ring indicated that no mobility presented in contrast to the dull sound accompanied with mobile implants [14].

Radiographically, CBCTs were done to measure the distance between the implant neck and the first bone-to-implant contact in millimeters at the mesial and distal implant sides; the marginal bone height was the mean of the two readings. Also CBCTs were used to measure the bone width in millimeters between the buccal and palatal cortices at a distance of 5mm from the crest of the alveolar ridge. This method was applied to all successive CBCTs in order to standardize the site of measurement. Concerning bone width, the obtained values were compared to base line values (Fig.4a-c).

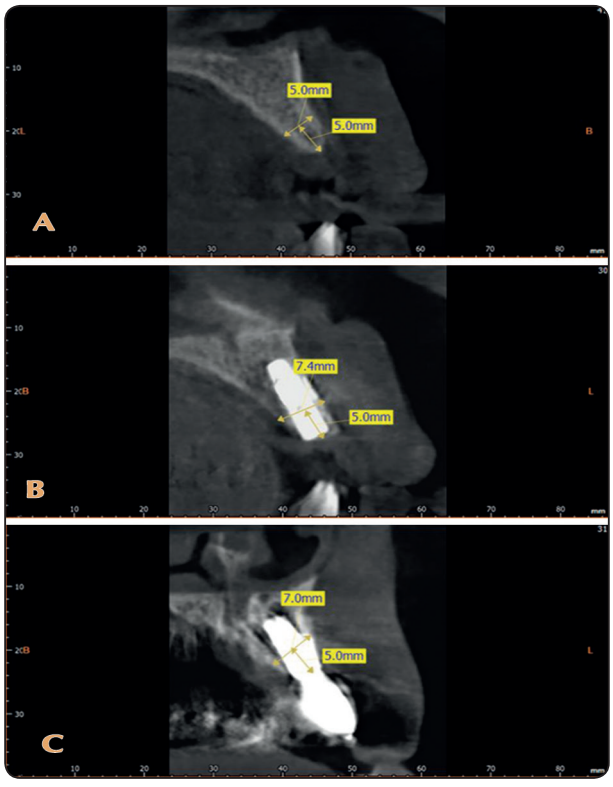

Fig. (4) A: Baseline bone width. B: Gained bone width at third postoperative week C: Bone width after six months of implants functional loading

Statistical analysis

In this study, nonparametric tests were used to compare the studied variables at different periods of time because of the small sample size. Descriptive statistics were calculated as medians and mean ranks. Friedman test was used to study changes in the following variables (degree of facial swelling and bone width) at three different periods of time. Wilcoxon test was used to study changes in marginal bone height at two different periods of time.

Box plot and line graphs were used to describe the obtained results.

Significance level was set at the 5% level. Statistical analysis was performed using SPSS version 24.0.

RESULTS

A total of 20 patients (12 males and 8 females) having missed teeth between the two upper canines with a narrow maxillary residual alveolar ridge ≥3 mm but < 6 mm and in need for implant placement were selected for this study. Two patients having dropped-out, one of them because of a fenestration in the buccal plate that occurred during surgery which was corrected by using bone graft and membrane to protect the implant. The other one didn't come back for follow-up. Thus, a total of 18 patients who received 20 implants were included in this study. Their ages ranged between 20 and 45 years with mean age of 31.64 years. All patients were followed up for six months. The results were registered as regards clinical and radiographic variables.

Clinical results

None of the patients showed any post-operative side effects. Healing was uneventful with no complications, healthy non inflamed marginal areas presented with normal pink color. All implants were

successfully osseointegrated with no signs of failure (dehiscence, infection or mobility).

- Degree of facial swelling

TABLE (1) Descriptive Statistics of facial measurement

	N	Percentiles		
		25th	50th (Median)	75th
Base line facial measurement(cm)	18	6.8750	8.0250	8.5850
Facial measurement at 4th day (cm)_swelling	18	7.6875	8.2750	8.4250
Facial measurement at 7th day (cm)_swelling	18	7.0250	8.1500	8.7750

The median of facial measurements at base line was 8.0250 cm. By the 4th day, the median increased to 8.2750 cm and then decreased to 8.1500 cm at the 7th post-operative day. Statistically there was no significant difference (p= 0.098 >0.05) between baseline, 4th and 7th postoperative days (Fig. 5).

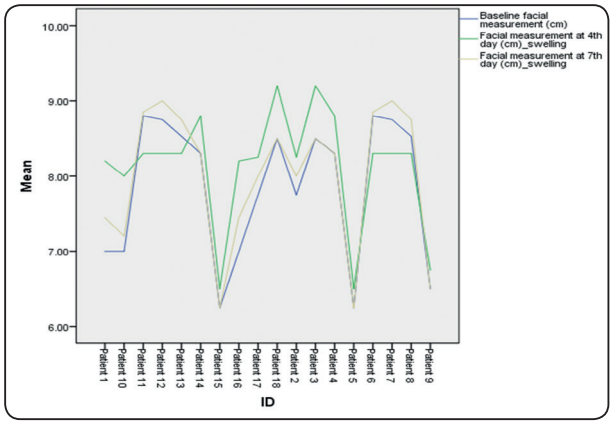

Fig. (5) Line graph showing the variation of facial measurements across baseline, 4th and 7th postoperative days.

Radiographic results

- Marginal bone height:

TABLE (2) Descriptive Statistics of marginal bone height

	N	Percentiles		
		25th	50th (Median)	75th
Marginal bone height at 3 postoperative weeks (mm)	20	1.4300	1.5200	1.6500
Marginal bone height 6 months after loading (mm)	20	.9000	1.0000	1.1200

At three post-operative weeks, the median of marginal bone height was 1.5200 mm. It decreased to 1.0000 mm after six months of loading the implants with permanent zirconia crowns. There was a statistical significant difference p=0.001 < 0.05 when comparing the values at three post-operative weeks and after six months of loading the implants (Fig. 6).

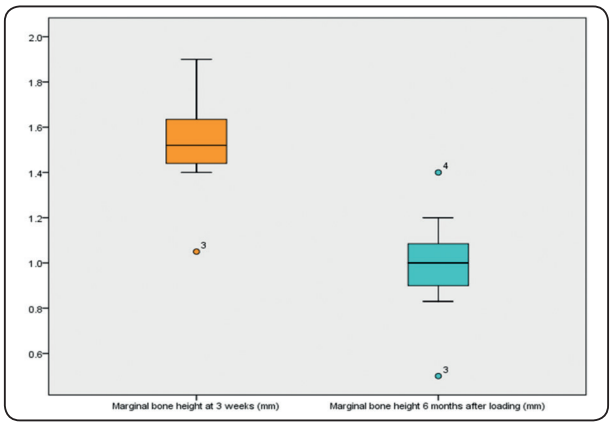

Fig. (6) Box Plot graph showing the variation of marginal bone height between three postoperative weeks and six months after loading.

- Bone width:

TABLE (3) Descriptive Statistics of bone width

	N	Percentiles		
		25th	50th (Median)	75th
Base line bone width (mm)	20	4.6000	5.1000	5.5000
Bone width at 3 postoperative weeks (mm)	20	7.3000	7.7000	8.2000
Bone width 6 months after loading (mm)	20	6.6000	6.9000	7.4000

At the time of implant placement, the median of bone width was 5.1000 mm. It increased to 7.7000 mm at three post-operative weeks, then it decreased to 6.9000 mm after six months of loading the implants with permanent crowns. There was a statistical significant difference $p=0.001 < 0.05$ when comparing the values at base line, three post-operative weeks and six months after loading the implants (Fig. 7).

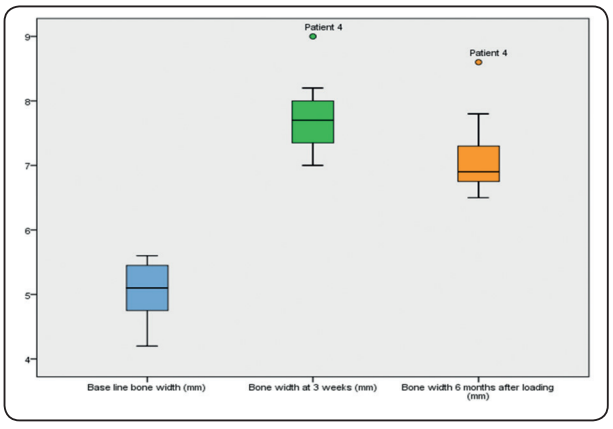

Fig. (7) Box Plot graph showing the variation of bone width across three periods of time (baseline, three postoperative weeks and six months after loading).

DISCUSSION

Bone expansion has been considered a viable procedure for bone augmentation of narrow ridges. Screw-type bone expanders offer many advantages over other expansion methods. They transmit relatively low amounts of force, allow bone expansion sequentially in deep areas and have been considered to be more effective in preventing buccal cortical bone fractures. In addition, malleting is avoided, thus head-echo and resulting headaches and temporomandibular joint injuries are minimized [15].

In this study, the dose received by each patient from the digital periapical X-Rays and CBCTs was within the limit of maximum permitted dose according to the national council on radiation protection and measurements (NCRP) [16].

Full thickness flaps were performed to allow better visualization and better handling of the different surgical steps in accordance to Koo et al (2008) [17] and Kim & Kim (2014) [15].

An initial drill was used to perform the bone osteotomy to the full depth that matches the length of the implant to be installed before the use of a series of screw-type bone expanders with gradual increased diameters. These expanders were used to widen the implants sites by the aid of finger pressure followed by the use of a ratchet to reach the complete desired depth. A 20-30 seconds waiting time before each half turn was necessary for the bone to accommodate to expansion in accordance to Siddiqui & Sosovicka (2006) [12] and Nishioka & Souza (2009) [1].

Trabecular Metal Material implants were chosen to benefit from their three dimensional middle section that resembles cancellous bone and favors both bone ongrowth and bone ingrowth. This increases implants secondary stability and decreases healing time, therefore, enables early implants loading.

The implants were placed approximately 2 mm subcrestally in harmony with Chen et al (2007) [18].

The primary stability was achieved by leaving the osteotomy sites slightly narrower than the implants' diameters in agreement with Santagata et al (2015) [19].

Temporization was done using Bis-acryl injected in the prefabricated essix retainers. Provisional restorations may reduce the amount of ridge contour change [20].

The immediate clinical follow up at 4th and 7th post-operative days showed an uneventful healing with healthy non-inflamed marginal areas. The degree of facial swelling was also evaluated at the same periods of time. The results showed no statistical significant difference across baseline, 4th and 7th postoperative days.

During the late follow up done three weeks later at the time of insertion of healing abutments and after six months of loading the implants with permanent zirconia crowns, peri-implants soft tissues were of normal pink color. None of the patients reported pain or any subjective sensation. All implants were successfully osseointegrated, none of the implants showed clinical mobility.

Marginal bone height (distance between the implant neck and the first bone-to-implant contact) was measured mesially and distally using CBCT at three postoperative weeks considered as baseline measurement and after six months of loading the implants with final crowns. The results showed a statistical significant decrease between the two periods of time. Our results run parallel with Tolstunov & Hicke (2013) [21] who used in their case reports the one stage expansion in maxilla by separating the two cortical plates using a scalpel and placing the implants simultaneously, the gaps were filled with Bio-Oss. A two staged ridge expansion was used in the mandible where they performed a rectangular buccal cortectomy in the first stage. Four weeks later, osteotomes were used to expand the bone and prepare the implants' beds. They found a significant marginal bone loss through the follow up phase.

Also, the obtained results of this study run in line with Gracez-Filho (2014) [22] who recorded a significant marginal bone loss of 0.47 mm (SD ± 0.9 mm) at six months of follow up after using ridge split and bone expansion to install narrow diameter implants in atrophic posterior maxilla.

Moreover, the results matched with Stricker et al (2015) [23] who conducted their study to evaluate the role of periosteum in preserving the buccal bone after ridge expansion with simultaneous implant placement. They compared changes in marginal bone height at different periods of time ranging from six to twelve postoperative weeks between two groups of miniature pigs. A significant marginal bone loss was observed in the control group where mucoperiosteal flaps with complete denudation of the bone were done, this was relied to the detachment of the periosteal blood vessels in contrast to the test group where mucosal flaps were elevated and insignificant marginal bone loss was observed.

The bucco-lingual bone width was measured by CBCT before surgery, considered as base line measurement and then at three postoperative weeks. The results showed a significant gain in bone width. This in parallel with Rahpeyma et al (2013) [24] who placed 82 dental fixtures with simultaneous bone expansion using osteotomes in different quadrants of 25 patients, they found a significant gain in mean bone width of 2±0.3 mm after expansion.

The obtained results also matched with Kim & Kim (2014) [15] who placed 11 implants in 6 patients after inserting screws of gradually increasing diameters to expand bone in anterior maxilla, they recorded a significant gain in bone width following expansion.

Moreover, this is in harmony with Santagata et al (2015) [19] who studied the gained bone width upon performing a modified edentulous ridge expansion

using the 64 beaver blade as a chisel to outline the crestal and vertical bony cuts and separate the two cortical plates, followed by the use of osteotomes to prepare the implants' sites. Thirty-three laser lock implants were placed simultaneously in the maxilla of 13 patients. A significant gain in bone width of mean 3.5 mm was recorded.

Fairly similar to the study done by Kim & Kim (2014) [15], Jung et al (2017) [25] used engine driven ridge spreaders to expand the mandibular premolar area in 23 pigs, a pronounced increase in alveolar crest width was evident.

The CBCT was repeated six months after implants loading. A significant decrease in gained bone width resulted. This is in line with Li et al (2017) [26] who placed 43 implants in 18 patients and found a pronounced decrease in gained bone width after expansion due to bone remodeling and in agreement with Vinh Giap et al (2016) [27] who investigated the efficacy of ridge splitting with piezo surgery and expanding the bone associated with immediate implant placement, they found that the immediate gain in bone width may not be stable and some hard and soft tissue augmentation may be necessary in the esthetic zone.

CONCLUSION

Within the limitations of this study that appear in the small sample size and the short follow-up period, it can be concluded that edentulous ridge expansion using screw-type bone expanders with simultaneous implant placement may be a predictable surgical procedure that is safe and less technique sensitive. This technique allows adequate horizontal bone gain and enhances bone quality for proper osseous support of implants with an acceptable esthetic outcome. The use of Trabecular Metal Material implant may enhance the results and favor early functional loading.

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