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ASSESSMENT OF SOFT TISSUE EXPANSION USING OSMED SELF INFLATING HYDROGEL PRIOR TO MANDIBULAR RIDGE AUGMENTATION

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ABSTRACT

Objectives: This study was conducted to assess the ability of self-inflating tissue expander to produce proper amount and quality of mucosa prior to bone grafting and implants insertion and degree of bone graft survival in severely atrophied alveolar ridges.

Material and Methods: All patients included in this study were referred to the Department of Oral and Maxillofacial Surgery, Faculty of Oral & dental Medicine, Cairo University for rehabilitation with dental implants. Inclusion criteria comprised: Missing mandibular premolar or molar area with a buccal osseous and soft tissue defect. The adjacent teeth had to be uncompromised with healthy gingival conditions. The exclusion criteria were patients who did not need bone grafting before implant placement. There were 10 patients (6 men and 4 women), with a mean age of 32 years (range, 18-60 years), who fulfilled the inclusion criteria and were consecutively included in the study. All patients were healthy and had no systemic contraindications to implant placement. They received standard treatment planning and diagnosis and gave signed informed consent. All 10 patients had an osmotic soft tissue expander implanted in the area with osseous and soft tissue defect, prior to bone grafting using bovine bone graft. Linear and volumetric measurements of the bone grafts were recorded immediately following bone graft and 6 months post grafting using cone beam CT scans.

Results: 10 sites in 10 patients were treated with soft tissue expansion using self inflating hydrogels. Complications of soft tissue expansion were only perforation (two sites), and no infection was noted. Primary wound closure was easily attained during bone augmentation procedure with no incidence of graft exposure, infection, or loss. It also allowed for good vertical bone height gain for implant placement. Volumetric measurements showed that an average mean of 1.36 cm^3 mandibular ridge augmentation was established immediately Post bone grafting and 1.19 cm^3 6 months after bone grafting. These measurements concluded that only 15.7% bone resorption occurred 6 months after bone grafting indicating good survival of the xenogenic bone graft.

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Conclusion: The use of Osmed self-inflating tissue expander prior to bone augmentation and implants insertion allowed sufficient amount of mucosa that can cover the grafts and implants without tension or compromise to the periosteum and ensued minimal bone graft resorption in severely atrophied alveolar ridges.

KEYWORDS: Osmed self-inflating tissue expander, primary coverage, alveolar bone regeneration, ridge augmentation, bone volume, intraoral osmotic, soft tissue expansion, self-inflating expander, tissue expander.

INTRODUCTION

Critical alveolar defects may result as a consequence of trauma, extractions, cysts, and congenital abnormalities. Frequently, a significantly atrophic ridge must be reconstructed before placement of endosseous implants. To overcome this limitation, different bone reconstruction techniques such as block grafts, particulate grafts, ridge expansion techniques, guided bone regeneration(GBR), and distraction osteogenesis have been reported.[1-4] For achieving a successful bone augmentation, sufficient soft tissue is a prerequisite. Primary wound coverage must be accomplished in order to minimize the risk of infection and implant failure. [5]

Enlargement of soft tissue volume and surface is a natural phenomenon, noticed in obesity and pregnancy. Soft tissue expansion is a reconstructive surgical procedure that accommodates space for the development of additional skin, mucosa, or other tissues. [6-8]This space is provided by the insertion of tissue expanders in the defect site, which permits the enlargement of soft tissues to provide the adequate soft tissue closure.[9]

Tissue expansion involves a combination of Creep and Biological stretch. In "Creep", when a constant force is applied to stretch the skin, it continues to extend. In "Biological stretch", the skin or any other tissue enlarges whenever a force is applied. In tissue expansion, the tissue is stretched without affecting the quality of the original tissue. [10]

Tissue expanders are divided according to their forms into cylinder and cupola. The cylinder-shaped tissue expander is used for straight edentulous regions while the cupola form of tissue expander is utilized for curved frontal edentulous region with one or more missing teeth. Also they might either have or have not a silicone envelope. The types of tissue expanders vary from standard tissue expander, custom-built expander, differential expander and anatomical expander. Commercially the tissue expanders are branched into : Osmed self-inflating tissue expander (Osmed GmbH, Germany), Mentor tissue expander (Mentor Worldwide LLC, Minneapolis) and CUITM Brand Tissue Expander (Allergan, California).[11]

The Osmed (Ilmenau, Germany) self -inflating tissue expander consists of an osmotic active hydrogel, a copolymer from methyl methacrylate (MMA) and vinyl pyrrolidone with a silicone envelope. The hydrogel can generate physical swelling pressure in vitro of approximately 235mmHg, which corresponds to 31.3 kPa.[12]

In 1957 Neuman[13] was the first to expand skin for reconstructive purpose by using an inflating balloon placed subcutaneously, he obtained sufficient expanded skin to cover a cartilaginous reconstruction of a subtotal avulsed external ear after 2 months of gradual expansion. Twenty five years later tissue expansion was revived through Radovan and Austad[14,15] work, in 1982 when both invented silicone tissue expanders. Radovan used tissue expansion technique for post mastectomy breast reconstruction.[16]

Austad and Rose developed self-inflating tissue expanders.[15] Later on tissue expanders were widely used in reconstruction of many head and neck defects.[17-23] As the main advantage of tissue expansion is that it favour for reconstruction of head and neck defects with adjacent tissue of similar color, texture, thickness, sensation and hair-bearing capability. [24] Among the common indications for the use of tissue expansion in the head and neck region are for; total nasal reconstruction, expansion of cheek or neck skin to allow scar revision, expansion of forehead skin prior to forehead flap, expansion of post auricular skin prior to reconstruction of the external ear, burn excision, or other lesion removal when primary closure is not possible without excessive tension. [25]Soft tissue expanders are used in ophthalmology as well for compensation of volume deficiency of the orbita, and for augmentation of the palpebral fissure by pushing the prosthesis forward. Also they are used in treatment of Post Enucleation Socket Syndrome (PESS). [26]

Other reports have mentioned the use of tissue expansion for a variety of intra oral reconstructions.[27-29] De Mey et al [30] and Van Damme and Freihofer [31] described single case reports using traditional tissue expanders on the hard palate. Kobus [32] used osmotic tissue expansion in the treatment of primary cleft palate repair. Tina F et al [33] used osmotic tissue expander for treatment of difficult anterior palatal fistula.

Pak et al [34] performed a study using cylinder type tissue expander before vertical bone augmentation to a severely atrophied ridge, the grafted bone became very rigid and intact after 6 months of its insertion and the adequate formation of soft tissue provided a tension-free closure of the augmented bone. Mertens et al [35] conducted a study on patients with acute bone atrophy of the maxilla or mandible, required implant-retained rehabilitation involving bone augmentation procedures, either horizontally or vertically, the tissue expanders implanted in all the patients achieved similar texture, color and thickness without any symptoms of inflammation or thinning of the keratinised mucosa.

Therefore the objective of this study was to demonstrate the ability of Osmed self-inflating tissue expander (Osmed GmbH, Germany) to produce adequate soft tissue expansion in the alveolar ridge prior to bone grafting and implants insertion and to determine the bone graft survivability.

MATERIALS AND METHODS

All patients included in this study were referred to the Department of Oral and Maxillofacial Surgery, Faculty of Oral & dental Medicine, Cairo University for rehabilitation with dental implants. Inclusion criteria comprised: Atrophic mandibular posterior atrophic ridges with a missing premolar or molar area that required vertical bone grafts greater than 4 mm and had a soft tissue defect. The adjacent teeth had to be uncompromised with healthy gingival conditions. The exclusion criteria were patients who are smokers, have uncontrolled diabetes mellitus, subjected to prior irradiation therapy, previous or current use of bisphosphonate medications, patients on long term therapy of corticosteroids, patients who have history of osteoporosis and patients who did not need bone grafting before implant placement. Also patients with periodontitis and bad oral hygiene were excluded from the study.

Thorough clinical assessment, preoperative radiological evaluation was completed using panoramic radiographs. Careful assessment of the soft tissue available, presence of scarring to determine the required size of the expander needed.

Expander Placement

Self inflatable hydrogel tissue expanders (Osmed GmbH, Illmenau, Germany) were used in this study. The suitable expander were chosen through the use of a stainless steel surgical template resembling the size of the expander before and after inflation (Figure 1,2).

Fig. (1) Stainless steel Surgical templates for Osmed expanders before and after expansion

Fig. (2) Surgical Template matching to recipient site.

All surgical procedures were performed under local anesthesia by the same operator. Local anesthesia Articaine 4 percent with epinephrine 1:100,000 (Septanest, Septodont) was injected as inferior alveolar nerve block and as infiltration in the sulcus of the recipient site. A small vertical incision was made with a number 15 blade at the apex of the neighboring tooth about 5- 10mm from the location of the expander margin to avoid tissue perforation. Then reflection of a full thickness mucoperiosteal flap was performed creating a subperiosteal pouch in the area where the tissue expander will be placed. The osmotic tissue expander is then introduced at the planned site and fixed in position with a titanium mini-screw (Biomet, USA) (Figure 3-6) and the wound was closed with 3-0 polyglycolic suture PGA (Assut sutures, Switzerland).

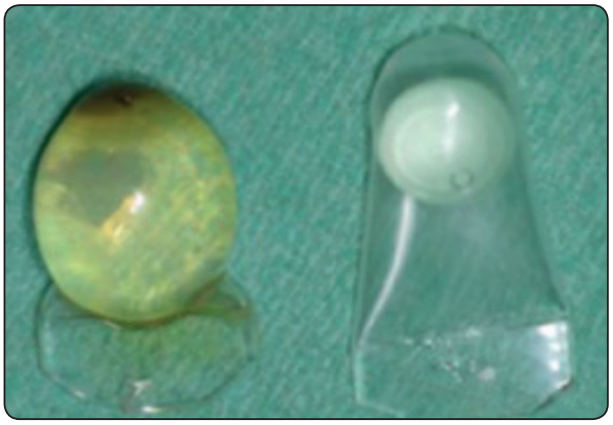

Fig. (3) Osmed Tissue Expander before and after 4 weeks swelling.

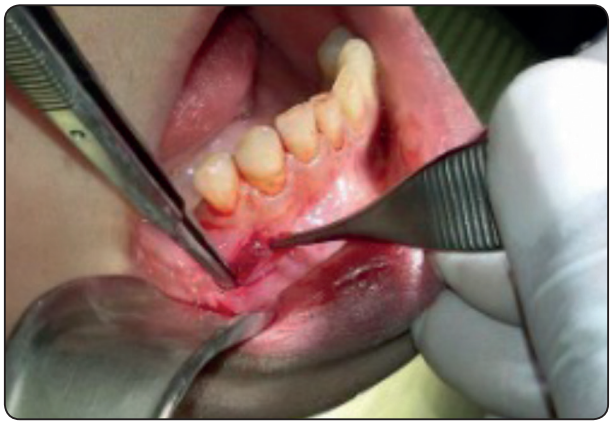

Fig. (4) Insertion of expander

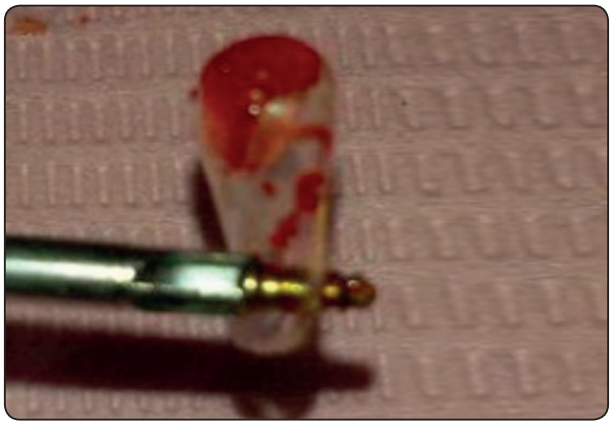

Fig. (5) Fixation of Osmed expander with titanium screw

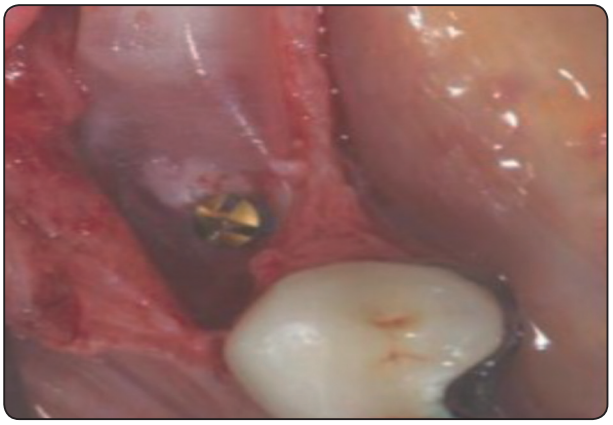

Fig. (6) Hydrogel expander after periosteal expansion prior to bone grafting

The patient was prescribed Augmentin (amoxycillin + clavulanate potassium, GSK) 1gm bid for 5 days. The patient was followed up at 1 week, and 2 week and after 4 weeks, the patients were scheduled for the bone grafting procedure. The field of operation was rinsed with chlorhexidine hydrochloride (Hexitol, Adco) and anesthetized with Articaine 4% with epinephrine 1:100,000. At the recipient site, a crestal incision was made, Oblique releasing incisions were made, and a mucoperiosteal flap was raised. The alveolar bone was well exposed on the buccal aspect and some of the lingual side to allow for the bone grafting. The osmed self inflating osmotic expander and the titanium mini-screw were recognized and removed.

A small round bur was used to establish small holes in the buccal aspect and allow for bleeding to help in the integration of the bone graft. Xenogenic bone block (Smart bone, IBI, Switzerland), the block was shaped to the desired shape to fit the recipient site and was fixed in placed using one or two titanium mini-screws (Biomet, USA) and the wound was closed with 3-0 polyglycolic suture PGA (Assut sutures, Switzerland) (Figure 7-10). Augmentin (amoxycillin + clavulanate potassium, GSK) 1gm twice daily for 5 days and Cataflam (diclonfenac potassium) 50mg every 6 hours were prescribed All patients were instructed to use chlorhexidine hydrochloride rinse (Hexitol, Adco), for 1 minute 3 times a day for 2 weeks. 4 months post bone grafting, Osstem Dental implants (Osstem, Korea) were placed

Fig. (7) Smart Bone Xenogenic bone trimmed to desired shape

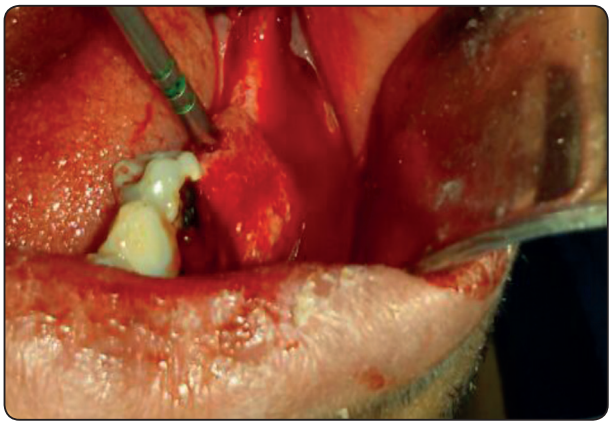

Fig. (8) Bone Block fixed in place

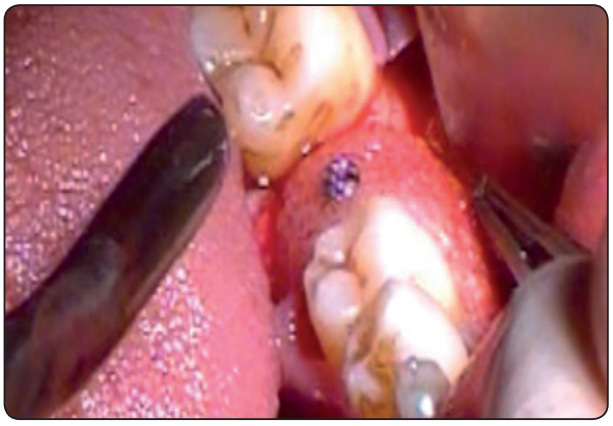

Fig. (9) Bone Block in place with titanium screw

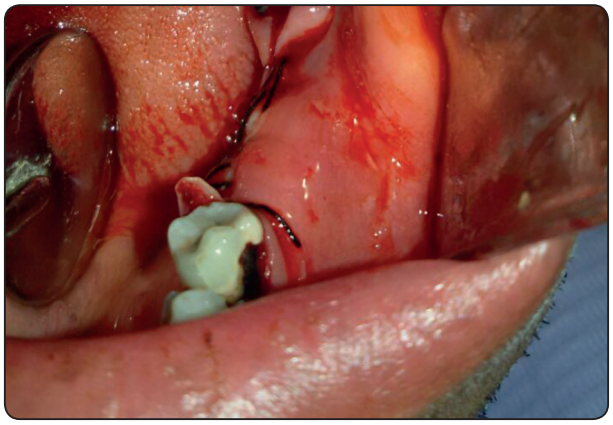

Fig. (10) Expanded Soft tissue sutured with 3-0 PGA

Radiologic Analysis

Cone Beam CT Scans (Cranex Machine, Soredex, Finland) of the mandible were obtained within 1 week post bone grafting and 6 months post bone grafting before implant placement. Linear measurements of the vertical and horizontal bone gain were recorded. Also, the outline of the bone graft, on each scan was plotted and the area automatically calculated using the Ondemand3D Software (Cybermed Co, Korea.). The volumes of the grafts were calculated by multiplying the areas of the bone graft plotted with the thickness of the CT Scan and number of sections.

The volumes of grafted bone were expressed as cm^3 mean and range. The changes between 0 and 6 months and the reduction in volume of the bone grafts at 0 and 6 months post grafting were analysed and percent of bone graft lost during 6 months calculated.

RESULTS

10 sites in 10 patients (6 men and 4 women, aged 18-60 with a mean age of 32) were treated with soft tissue expansion using self inflating hydrogels prior to mandibular ridge augmentation. Complications of soft tissue expansion were only minor perforation (two sites) (Table 1), and no infection was noted. The minor perforations represented small protrusion close to the incision line measuring 4 X 5mm in 1 case and 4 X 7 mm in another. In spite of the minor perforation, there was still adequate expansion of the mucoperiosteum to allow for bone grafting. Primary wound closure was easily attained during bone augmentation procedure with no incidence of graft exposure, infection, or loss. The bone grafts were well integrated in all cases.

TABLE (1) Clinical Assessment

Case	Gender	Bone Quality	Complications Recipient Site
1	Male	II	None
2	Female	II	Minor Exposure 4mm X 5mm
3	Male	III	None
4	Male	IV	None
5	Female	III	None
6	Female	II	None
7	Female	III	None
8	Male	II	None
9	Male	III	Minor Exposure 4mm X 7mm
10	Male	IV	None

Radiographic analysis (figure 11) showed that a 3.2 mm vertical Bone augmentation immediate post grafting (range 2 to 4 mm, standard deviation

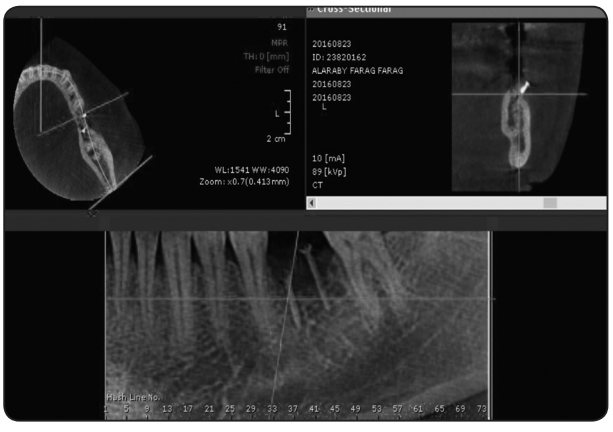

Fig. (11) Cone Beam CT and measurements on Ondemand 3D software

(SD) 0.79) and a 3.8 mm Buccal bone augmentation (range 3 to 6 mm, SD 1.03) were established (Table 2). While 6 months post grafting revealed that a 2.7 mm vertical Bone augmentation immediate post grafting (range 2 to 4 mm, standard deviation (SD) 0.82) and a 3.2 mm buccal bone augmentation (range 3 to 5 mm, SD 0.92) were shown.

TABLE (2) Linear Measurements

Case	Post Grafting		6 months after grafting	
	Vertical	Buccal	Vertical	Buccal
1	2	3	2	2
2	4	6	4	5
3	4	3	3	3
4	3	3	2	3
5	3	4	2	3
6	4	5	3	4
7	3	3	2	3
8	4	4	4	3
9	2	3	2	2
10	3	4	3	4
Mean	3.2	3.8	2.7	3.2
SD	0.79	1.03	0.82	0.92
Range	2 to 4	3 to 6	2 to 4	3 to 5

Satisfactory bone volume was clinically observed for the placement of dental implants. Volumetric measurements showed that an average mean of 1.36 cm^3 mandibular ridge augmentation was established immediately within first week of bone grafting and 1.19 cm^3 was achieved 6 months after bone grafting. These measurements concluded that a 15.7% bone resorption occurred 6 months after bone grafting (Table 3).

TABLE (3) Volume of Bone Augmentation

Case	Post Grafting	6 months after grafting	Percent loss in bone graft
1	0.46	0.37	19.57
2	3.07	2.82	8.14
3	1.45	1.26	13.10
4	1.03	0.88	14.56
5	1.26	1.09	13.49
6	1.74	1.57	9.77
7	0.98	0.84	14.29
8	1.78	1.64	7.87
9	0.61	0.44	37.70
10	1.24	1.01	18.55
Mean	1.36	1.19	15.7
SD	0.74	0.71	8.66
Range	0.46 - 3.07	0.37 - 2.82	7.87 - 37.7

DISCUSSION

Expansion of alveolar ridges can be done through different surgical procedures of augmentation including onlay grafts, vertical or horizontal ridge augmentation, autogenous bone block grafts, allogenic bone blocks and distraction osteogenesis.[36,37] Tissue expansion is a recent procedure for the development of additional tissue without involving tissue flap transfer [35] while providing adequate amount of soft tissue for alveolar bone augmentation.

Self-inflatable osmotic tissue expanders application before bone grafting procedures has been suggested to expand both soft tissue and periosteum. [38, 39] The ability of the tissues to adapt to progressive expansion has been described in breast and forearm surgeries. [40, 41] Rapid expansion may cause mechanical tissue damage to the

periosteum due to the high strain and force results in aggravation to the blood supply. Therefore, the size increase should be continuous and slowly, leading to safe and effective growth of soft tissue. (42)

Tensile stress to the periosteum has been proposed to decrease vessel width, and previous soft tissue expansion was a favorable factor in bone graft healing in a rat model. (43) In an earlier study with the osmotic expander on rabbits, the raised expanded periosteum produced new bone.(44) This was not shown in this clinical study due to lack of histologic analysis. In this study the expander was removed after 4 weeks. In an earlier experimental investigation on dogs, expanders were left in position for more than 60 days, it was evident that the periosteum was replaced with a fibrous capsule that surrounded the expander.(45) In another study, seroma formation was detected but lacking any undesirable effects on the bone graft site. (46)

Expanders have been utilized in the Extra-oral region and have revealed that soft tissue expanders should be positioned slightly distant from the incision line to prevent migration through the incision line.(47) Intraorally, the same concept applies, in our study 2 cases had small perforations in the vestibule inspite of the fact that all expanders were secured with titanium min-screws. This may be due to expander being placed too close to incision line in these cases or due to fast expansion of the osmotic expander not leaving enough time for soft tissue expansion and tissue histogenesis. Also the mucosal biotype in these cases could have been too thin, thus allowing easier fenestration of the expander. Both these cases healed well.

Soft tissue expansion has proved to be favorable for bone graft healing, more soft tissue has been shown to be available to cover the bone graft both vertically and laterally.(27) In this study, xenogenic bone blocks were chosen for ridge augmentation. A valid alternative is to pre-contour a titanium mesh with particulate autogenous bone graft. In previous bone augmentation studies where a titanium mesh was used have been associated with a degree of soft tissue dehiscence over the titanium mesh and a percentage of bone lost.(37)

In this study, Volumetric measurements showed that an average mean of 1.36 cm^3 mandibular ridge augmentation immediately Post bone grafting and 1.19 cm^3 6 months after bone grafting which concluded that a 15.7% bone resorption occurred 6 months after bone grafing. These results are in agreement with another clinical study where the mean volumetric augmentation decreased to 23.5% in the vertical dimension at 6 months post bone grafting (44). However, in comparison to where bone grafting was performed without prior soft tissue expansion, the mean volumetric bone loss can reach up to 42%. The differences in graft resorption clearly favors the placement of soft tissue expanders prior to ridge augmentation and suggest that the periosteal flap tension to be a major contributing factor in increased bone resorption in cases where soft tissue expansion is not attempted. All Cases included in this study had dental implant placement after successful bone grafting.

CONCLUSION

Soft tissue expansion of the periosteum utilizing Osmotic Self Inflating Hydrogels is a valid method capable of attaining successful soft tissue elongation and expansion as it also allow for tension free closure to cover bone grafts with minimal complications.

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