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Use of Intra-Oral Osmotic Self-Inflating Tissue Expanders for Bone Reconstruction and Rehabilitation of the Jaws

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Additional information is available at the end of the chapter

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Abstract

Reconstruction of oral and maxillofacial defects is challenging. Insufficient soft tissues may render hard tissue reconstruction problematic. Several surgical techniques have been used over time to address this issue; these techniques are usually complicated and unpredictable. Soft tissue expansion is a physiological process that leads to the formation of new cells and growth of tissue and allows for soft tissue with similar color, texture and function to that of the adjacent tissues. In this article we present the applications of osmotic tissue expanders in facilitating bone graft augmentation. OSMED (Ilmenau, Germany) self-inflating tissue expanders were used prior to bone augmentation in our patients. After making a 1.5 cm full thickness incision, a subperiosteal tunnel was prepared and the tissue expander was implanted subperiosteally. The tissue expanders were removed approximately 6–10 weeks later in the course of augmentation surgery. In all patients after the use of the tissue expander, sufficient soft tissue was available for primary, tension-free, wound closure and there was no need for local or regional flap techniques. No complications such as infection, necrosis, or graft loss occurred and the functional and esthetic outcomes were acceptable. Use of this tissue expander prior to bone augmentation was effective in facilitating bone graft augmentation.

Keywords: Soft tissue expander, bone augmentation, reconstruction, soft tissue management, osmotic-tissue expanders

1. Introduction

Reconstruction of oral and maxillofacial defects is challenging. These defects may be congenital malformations, defects caused by severe atrophy, trauma or oncologic ablation. Such cases can cause considerable esthetics and/or functional problems and may require augmentation, grafting, and implantation procedures that may significantly affect the quality of life of the patients [1].

Insufficient hard and soft tissues may present esthetics or functional problems. Bone grafts, bone substitutes and guided tissue regeneration (GTR) techniques have been used for many years to rebuild the alveolar ridge [2]. Reconstructing large and complex defects are more complicated. One of the common problems is inadequate soft tissue for coverage of the graft. Several surgical techniques such as rotational flaps, pedicle flaps, free flaps and composite flaps have been used over time to address this issue [3, 4]; these techniques are usually complicated and they have limitations, such as donor site morbidity, necrosis and infection [4]. Another problem is the unpleasant functional and esthetics results due to the differences of the grafted tissues from the original tissue. One of the most common problems during reconstruction of bony defects of the jaws is soft tissue dehiscence which leads to the exposure of the bone grafts into the oral cavity and may result in loss of the bone graft [5–9]. Adequate soft tissue coverage of grafted bone is important to avoid graft exposure; thus, primary tension-free closure of the flap without compromising the vascularization is important [10–12]. When a large amount of bone augmentation is required, it is usually hard to achieve tension free soft tissue coverage. A periosteal incision is often used to make it possible to mobilize and stretch the mucoperiosteal flap. This, however, reduces the perfusion of the mucoperiosteal flap [11, 13–16]. Sufficient blood flow is important for tissue survival [17]. Even simple flap elevation can disturb flap perfusion and causes ischemia [18]. Extensive flap preparation and elevation can result in impaired perfusion and increased incidence of necrosis and tissue dehiscence [19, 20]. Inadequate perfusion and dehiscence of the soft tissue can jeopardize the success of bone augmentation.

One possible solution is soft tissue expansion. Tissue expansion was first described by Radovan [21, 22] as a method of creating soft tissue with similar color, texture, thickness, and sensation as the adjacent tissue with minimal scarring and little donor site morbidity. Neumann was the first who mentioned the potential to use tissue expansion for reconstructive surgery [22, 23]. Nowadays tissue expansion is a well-known technique for head and neck reconstructive surgery [24–27]. Soft tissue expansion is a physiological process that leads to the formation of new cells and growth of tissue [28] and allows us to gain extra soft tissue with similar color, texture and function to that of the adjacent tissues for covering grafts [29].

After the tissue expander is inserted, during the expansion process the tissue is under a persistent tensile stress; traction of the surrounding soft tissue leads to extra soft tissue volume [30–32]. Sub-periosteal implantation of the expander is usually preferred over extra-periosteal implantation because of its optimum soft tissue increase [33]. However, sub-periosteal implantation of the expander limits the nutritional supply to the bone [34].

Traditional tissue expanders are silicone envelopes with self-sealing injection ports. They are filled by serial saline injections through the ports at weekly intervals. Volume expansion of the expander puts tension on the overlying tissue [35]. These traditional tissue expanders are now known to be associated with complications because of their intermittent sudden expansion [36]; this led to the development of osmotic tissue expanders (OTEs). The OTE was first described by Austad and Rose [37]. It was made of a semi-permeable membrane filled with hypertonic saline which leads to the entrance of the water by osmotic forces from the surrounding tissues into the expander. Wiese developed an osmotic self-inflating expander [38], which has been used successfully to expand the orbit in the management of enophthalmos, microphthalmos, and cryptophthalmos [39–41].

The osmotic self-filling expander is made of polymeric methyl methacrylate–vinylpyrrolidone which gains volume by absorbing body fluids [42, 43]. The purpose of this chapter is to present some examples of the application of this expander before bone graft augmentation.

2. Technique

We used OTE in various patients. In our study, we used OSMED (Ilmenau, Germany) self-inflating tissue expanders (**Figure 1**) prior to bone augmentation and evaluated its complications and problems.

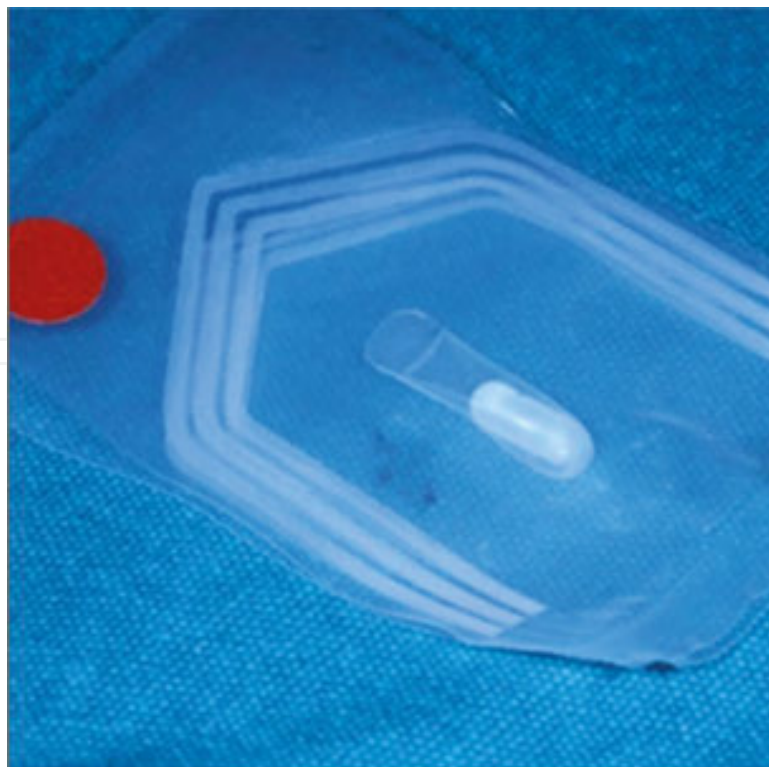


Figure 1. Osmed tissue expander.

2.1. Surgical technique

After making a full thickness incision, a sub-periosteal tunnel was prepared (**Figure 2**). After completion of the tunnel preparation, the tissue expander was placed under the tunnel flap while keeping the surgical field as dry as possible to reduce the risk of contamination with oral fluids. Wound closure was performed to minimize the leakage and contamination. The sutures were removed after 2 weeks. The tissue expanders were removed approximately 6–10 weeks later in the course of augmentation surgery; 1 g of intravenous cefazolin antibiotic was administered pre-operatively and continued every 6 h post-operatively for 24 h then it was replaced by 500 mg of oral cephalexin antibiotic taken every 6 h for the next 7 days. Chlorhexidine mouth-wash was used every 8 h post-operatively and was continued for 14 days.

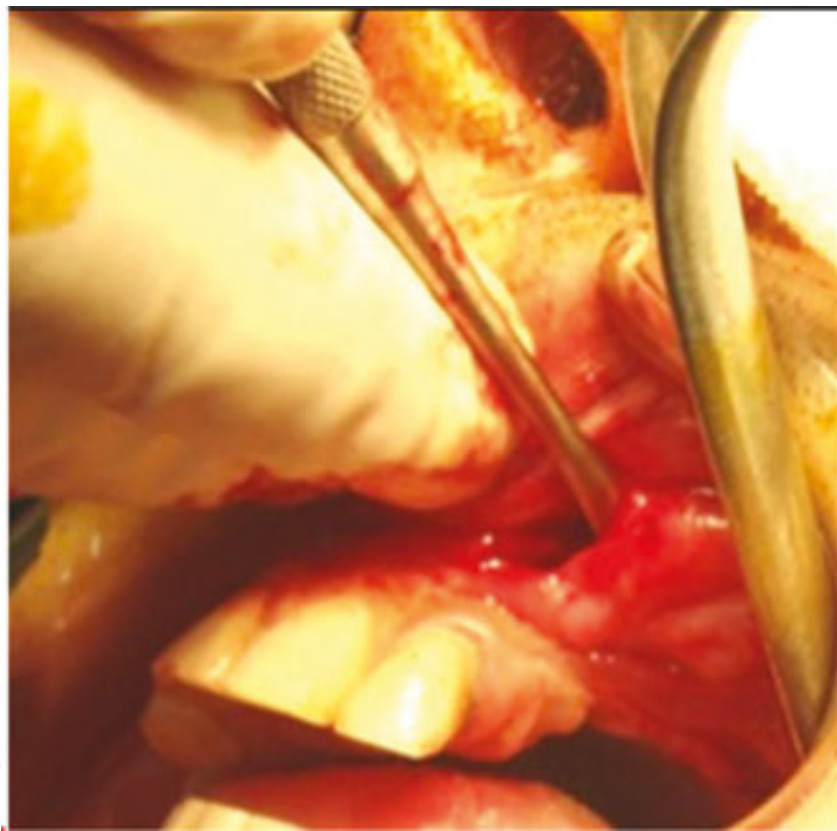


Figure 2. Subperiosteal tunnel preparation.

3. Cases

3.1. Patient 1

A 23-year-old male had partial maxillectomy surgery on the left side due to central giant cell granuloma 12 years ago (**Figure 3**).



Figure 3. Partial maxillectomy of the left side.

In the first operation, an OSMED tissue expander cylinder 2.1 ml, with initial volume of 0.42 ml and final volume of 2.1 ml was placed sub-periosteally in the defect (**Figure 4**).

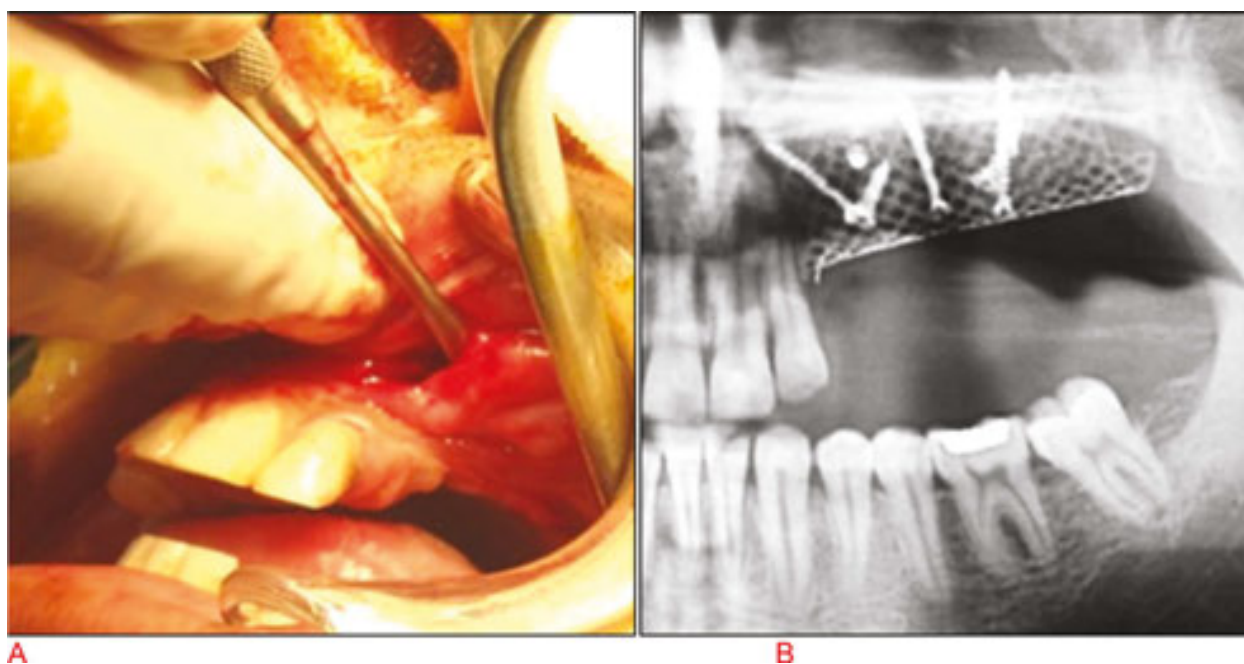


Figure 4. (A) OSMED tissue expander was placed sub-periosteally. (B) 10 weeks later, the tissue expander was removed and the bone was augmented.

In the second operation, done 10 weeks later, the tissue expander was removed and the bone was augmented by iliac bone graft (**Figure 5**).



Figure 5. The tissue expander was removed and the bone augmented by iliac bone graft.

In the third operation, done 5 months later, the titanium mesh and fixation screws were removed and three dental implants were inserted (**Figure 6**). No post-operative complications were observed.



Figure 6. The titanium mesh and fixation screws removed and three dental implants were inserted.

3.2. Patient 2

A 54-year-old woman had severe mandibular atrophy. She had been edentulous for 30 years and had bone augmentation with iliac bone graft on the right side of the mandible 20 years ago. In the first operation, because of the lack of enough soft tissue and the presence of scar tissues from previous surgery, we used an OSMED tissue expander cylinder 1.3 ml, with initial volume of 0.25 ml and final volume of 1.3 ml (**Figure 7**).

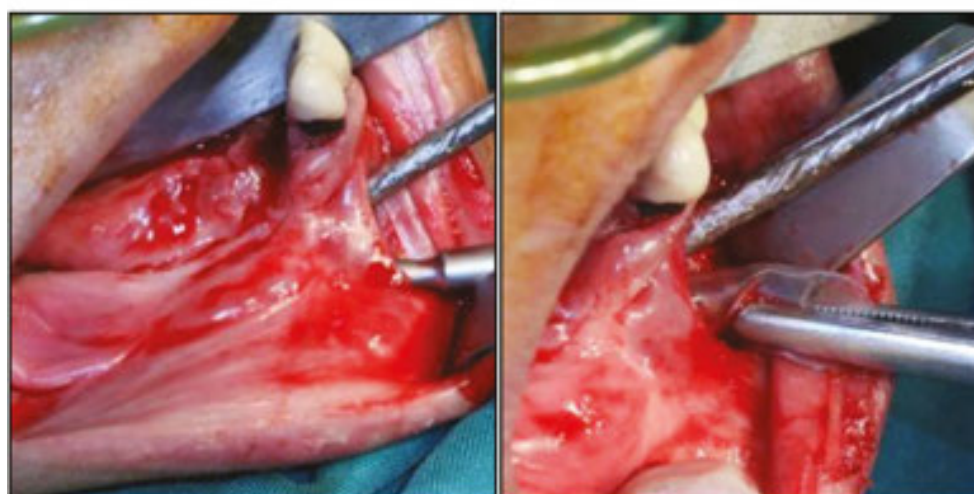


Figure 7. Severe mandibular atrophy. OSMED tissue expander cylinder placed in a sub-periosteal tunnel.

In the second operation, done 6 weeks later, the tissue expander was removed and the bone was augmented with iliac bone graft (**Figure 8**) and later dental implants were inserted (**Figure 9**). In this case, despite of the lack of enough soft tissue and the presence of scar tissues, the hard tissue was augmented vertically and desirable outcome and adequate bone volume for implant placement was achieved.



Figure 8. The bone was augmented with iliac bone graft.



Figure 9. Later dental implants were inserted.

3.3. Patient 3

A 41-year-old woman had previous partial mandibular resection surgery due to an ameloblastoma (**Figure 10**).

In the first operation, an OSMED tissue expander cylinder 2.1 ml was used. In the second operation, done 8 weeks later, the tissue expander was removed and the bone was augmented by iliac bone graft prior to dental implant insertion (**Figure 11**). In this case, due to the tension free closure of the soft tissue overlying the bone graft, postoperative complications were reduced and good results obtained.

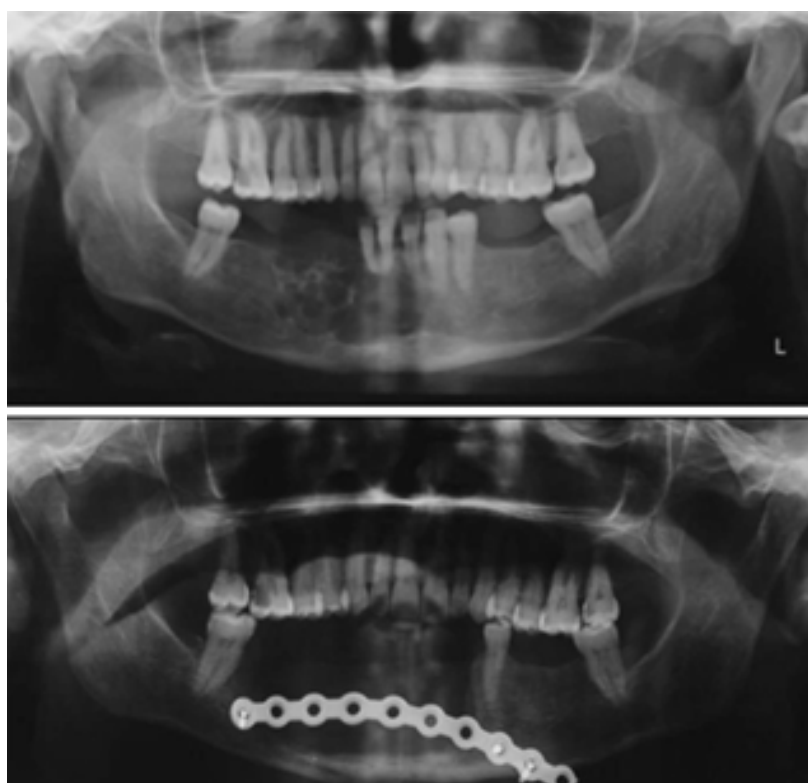


Figure 10. Ameloblastoma of the lower jaw. Resected.



Figure 11. Left, Sub-periosteal tunnel preparation for tissue expander implantation Right, Bone augmentation was performed 8 weeks later Bottom, Panoramic view of the patient after bone augmentation.

4. Discussion

Soft tissue expansion has been used successfully for the reconstruction of soft tissue defects [44–47]. In case of inadequate normal soft tissue, new tissue should be created with the same color, texture and function as the adjacent tissue, which was first described by Neumann [48] for auricular reconstruction. In the head and neck area, tissue expansion has been used successfully for scalp, nose and ears [29, 30, 49, 50]. Intraoral soft tissue expanders have also been used prior to the bone augmentation in the case of inadequate soft tissue for primary tension free wound closure [51–56]. In their study they used classic forms of tissue expanders which were inflatable expanders inflated by weekly injections of saline. However, because of their sudden and intermittent volume increase, tissue hypoxia due to decreased blood flow to the area was reported [57]. Two types of expansion regimens are used clinically for classic tissue expansion namely ‘conventional, prolonged expansion’ for 1–3 months and ‘intraoperative sustained limited expansion’ [58, 59]. Some studies suggest that ‘conventional, prolonged tissue expansion’ can also be performed for 1–2 weeks without complications [60, 61]. The most common complications of soft tissue expansion are infection, dehiscence, hematoma, necrosis and failure [46, 47, 62–64]. When infection occurs, the expanders are usually removed to control the infection. Although several methods have been reported to salvage tissue expanders [65–67], usually substitution of the infected tissue expander with a new one is required.

By making a small incision as far as possible from the intended site for tissue expander insertion, the risk of dehiscence and failure is minimized [22, 29, 45]. Generally, in the same conditions, the smaller tissue expander is preferred over the larger one. Larger tissue expander usually require larger incisions with wider dissection and more undermining, which may increase the risk of dehiscence and also may cause scar expansion instead of normal tissue expansion [68]. As mentioned earlier, the expansion rate is important. Use of self-inflatable osmotic expander, has a gradual rate of expansion [43]. The early osmotic implants were made of a semi-permeable envelopes containing hypertonic liquid. Their expansion rates were rapid and were completed within the first 24–48 h following insertion and they were associated with more complications such as tissue ischemia and failure. Subsequent tissue expanders were made of dehydrated hydrogel in a silicone envelope with a more gradual expansion rate and lower complications [43, 69]. The OSMED self-inflating tissue expanders are made of a specially developed hydrogel that use the osmotic principle to gain volume. The hydrogel is made of co-polymers based on methyl methacrylate and N-vinyl pyrrolidone. Pre-operatively they are in their pre-expanded state and therefore are small, hard and easy to handle. After implantation, they start to absorb body fluid and grow consistently to a predefined shape and size. Their final volume depends on the product type and is between 3 and 12 fold their initial volume. The increase volume of the implant leads to an increase of soft tissue. Their expansion speed also differs by the product type. In some the tissue expander is delivered in a silicone shell, with an exact number and size of holes to assure gradual and consistent swelling of the device.

In this study, we used OSMED self-inflating tissue expander cylinder which is delivered in a silicone shell. The tissue expanders were placed sub-periosteally. It is reported that sub-periosteal implantation causes significant resorption of the underlying bone by impairing the micro-circulation of the underlying bone [33, 70–72], which was not observed in our patients. Periosteal-releasing incisions may reduce the blood supply to soft tissue flaps and increase the risk of dehiscence. The periosteal expansion facilitates a tension-free wound closure without the need to use any periosteal-releasing incisions [16]. Another strategy for minimizing the risk of intraoral dehiscence and infection [29] is keeping the incision small and away from the tissue expander, which may explain the low incidence of complications in our study and other reports [43]. It has been reported that slow and continuous expansion results in safe and effective generation of soft tissue and decreased incidence of intraoral dehiscence [38, 73]. In our study, the rate of expansion was slow enough not to cause any perforation of the soft tissue [74]. After expansion, the quality and quantity of expanded soft tissue was good enough to permit easy primary tension-free wound closure after major bone augmentation. The slow expansion will lead to slow and proper formation of new tissues over the time period [73].

5. Conclusion

In conclusion, our cases demonstrate that the use of tissue expander prior to bone augmentation can reduce the complications associated with non-OTE and lead to more predictable results.

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