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Original Article

Our experience using tissue expansion in reconstructive surgery

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Abstract

Introduction: Expansion of tissues is a physiological phenomenon observed in processes such as pregnancy, breast growth, tumor development, and formation of seromas or hematomas. Over the last decade, there has been an increase in the number of patients with post-burn and post-traumatic defects and contractures. After Neumann introduced it in 1957, surgical treatment with tissue expanders has become an established method for managing major defects that do not have enough surrounding tissue to form a flap. This technique allows tissue defects to be covered with tissue that has similar color, thickness, and elasticity to the surrounding area. When combined with other plastic surgery methods, tissue expansion facilitates the coverage of large soft tissue defects of various etiologies with minimal formation of new scars and minimal donor site morbidity.

Aim: Our study aimed to demonstrate the role of tissue expansion in reconstructive surgery, particularly in the treatment of soft tissue injuries in the scalp.

Materials and methods: In this study we present ten cases treated for tissue defects using the expander technique. We used expanders of various shapes and sizes, with volumes ranging from 400 to 500 ml.

Results: Reconstruction was deemed successful in 9 out of 10 patients. In one patient with scalp carcinoma, treatment was not completed due to rapidly progressing multiple metastatic lesions in parenchymal organs. The study observed particularly good results in six patients, good results in two patients, and satisfactory results in one patient. The total duration of treatment ranged from 1.5 to 2.5 months.

Conclusion: Tissue expansion is an extremely suitable method for repairing the effects of thermal, mechanical, or combined injuries.

Keywords

soft-tissue defects, post-burn reconstruction, reconstructive surgery, tissue expansion

Introduction

Tissue expansion (TE), although not a contemporary method, is a significant technique in the domain of plastic surgery, eclipsing alternative approaches to soft tissue coverage.[1] Expansion of tissues is a physiological phenomenon observed in processes such as pregnancy, breast growth, tumor development, and formation of seromas or hematomas. The number of patients with post-burn and post-traumatic abnormalities and contractures has exhibited an upward trend over the past decade. Following Neumann's introduction of the procedure, surgical treatment with tissue expanders has become a routine method for managing large defects that do not have sufficient surrounding tissue to form a flap.[2] This technique allows for the coverage of defects with tissues of similar color, thickness, elasticity, and hair-bearing properties. Expanded skin comprises the tissue over the defect, adjacent tissues, and newly formed cells during expansion.

Expansion is a mechanical process in which interstitial fluid is displaced into the expanded tissue, leading to elastin fragmentation and fibrous reorganization of collagen. When combined with other plastic surgery methods, tissue expansion facilitates the coverage of large soft tissue defects of various etiologies with minimal formation of new scars and minimal donor site morbidity.

Aim

The aim of our study was to prove the place of tissue expansion in reconstructive surgery and, in particular, in the treatment of soft tissue injuries in the scalp area.

Materials and methods

This study included 10 patients who received a total of 11 tissue expanders. In six patients, expanders were placed in the scalp area for correction of post-traumatic alopecia. In two patients, the expander technique was used to cover large tissue defects resulting from extensive excision. In these two patients, recurrence of the tissue defect later revealed squamous cell carcinoma in the scalp area. One patient received two expanders for aesthetic reconstruction of the face and neck, and one patient had an expander placed in the lower leg area for aesthetic correction of a severe burn scar.

We used expanders of various shapes and sizes: one rectangular, two round, one square, and seven crescent-shaped expanders, with volumes ranging from 400 to 500 ml. All operations were performed under general anesthesia. We routinely administered perioperative antibiotic prophylaxis. For scalp surgeries, the expander was placed under the galea aponeurotica, and for other patients, it was placed in the supramuscular plane. The expander valve was tunneled to a location distant from the expander pocket to prevent migration of the expander. The incision for placing the expander was made considering the anatomical features of the area and potential zones of least tension post-expansion.

All patients had a redone drain placed in the newly created expander pocket, which was removed once exudate drainage ceased, typically within 24 to 72 hours. Intraoperatively, 10% of the expander volume was filled. The next saline injection was performed once the wound was healed, typically between 4 to 10 days postoperatively. Expansion frequency ranged from every 3 to 7 days. The volume added during each session depended on skin tension, blanching, pronounced expander edges, and the patient's subjective sensation of pain or discomfort. Full volume was achieved over 8 to 10 sessions, spanning 4 to 6 weeks, with the total treatment duration being between 1.5 and 2.5 months. Reconstruction was performed in a planned manner after reaching the full expander volume.

Results

We evaluated the results based on a scale designed to assess early and late treatment outcomes. The criteria included success and durability of coverage, cosmetic outcome, operative time, hospital stay, complications, tumor recurrence, postoperative complications, and mortality. Reconstruction was deemed successful in 9 out of 10 patients. In one patient with scalp carcinoma, treatment was not completed due to rapidly progressing multiple metastatic lesions in parenchymal organs. We observed exceptionally good results in six patients, good results in two patients, and satisfactory results in one patient **(Figs 1, 2, 3)**.

Discussion

Tissue expansion is based on the fact that all living tissues dynamically respond to mechanical tension.[3] The literature describes both rapid (intraoperative) and long-term tissue expansion.[4] Sasaki[5] utilized intraoperative tissue expansion for the dissection and preparation of tissues, which resulted in an additional increase of flap length by 1-1.5 cm. However, we lean towards Hoffmann's[6] opinion that rapid expansion subsequently leads to increased wound tension and associated complications such as dehiscence and localized alopecia when used on the scalp. We apply long-term tissue expansion as a method for secondary aesthetic revision to remove old scars and to close tissue defects following the excision of tumors with uncertain biological behavior. We accept the findings of Johnson et al. and Pasyk et al.[7,8] demonstrating that this method induces histological and morphological changes in the tissues, resulting in a permanent increase in the expanded tissue.

A new era in tissue expansion in reconstructive surgery was ushered in with the application of osmotic expanders. A substantial body of evidence in the scientific literature

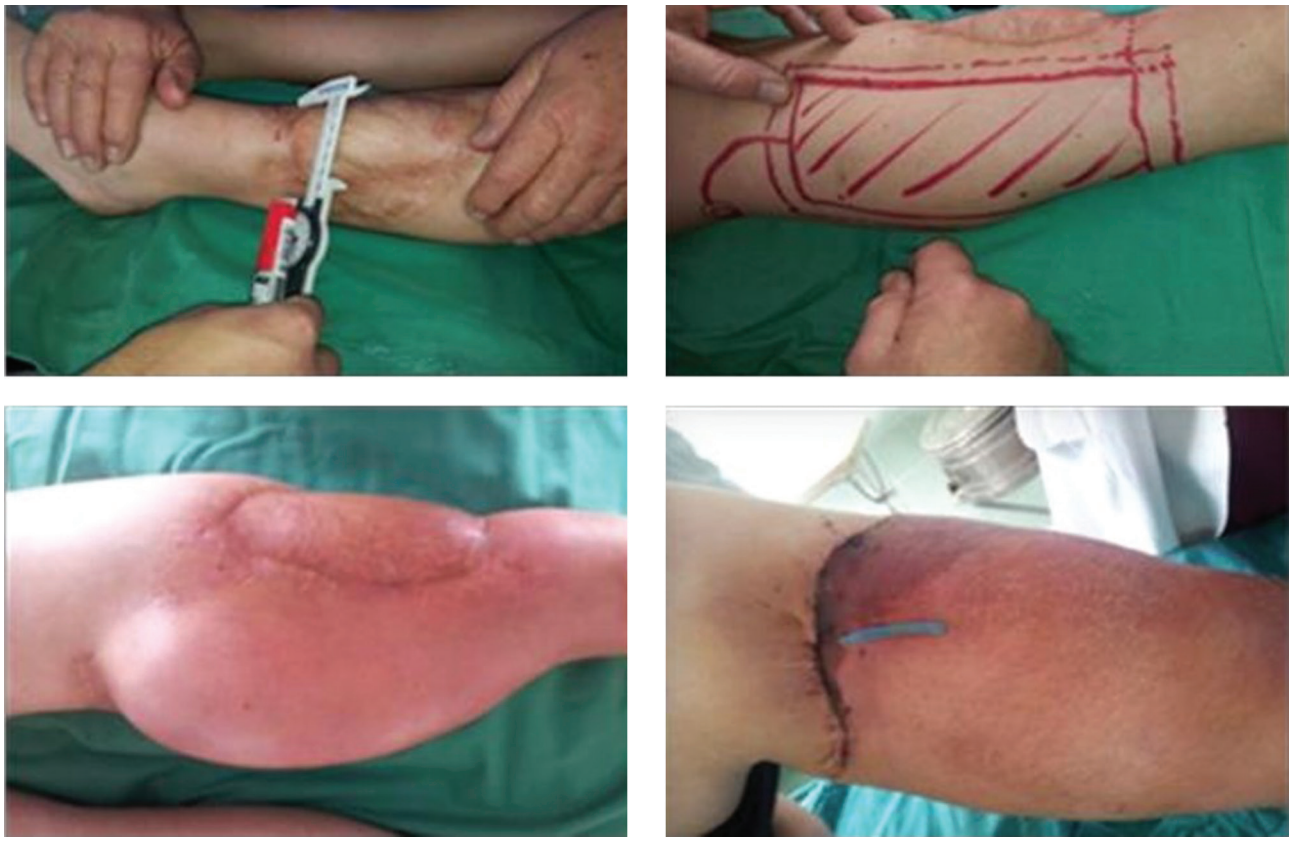

Figure 1. The case with post-traumatic hypotrophy scar on the left lower leg.

supports the efficacy of this method of expansion, including the initial small size, which allows for a small surgical incision, and the short overall operative time. The expansion period is shorter and more convenient for the patient. The risk of infection is reduced by eliminating the need for external filling injection of the expander. In addition to their advantages, osmotic expanders are accompanied by certain drawbacks. One of them, and perhaps the major one, is the inability to control the filling rate and the need to remove the expander in cases of damage to the overlying tissues. This was the reason why we did not include this type of expanders in our study.

According to Leonard and Small[9], the expander technique can be applied to almost all parts of the body, but the best results have been achieved in chest and scalp reconstruction. In our study, eight reconstructions were performed in the scalp area, one involving expanders placed in the anterior chest wall, one was for facial reconstruction, and one was for the lower leg area. We adhere to the views of Hudson and Grob[10], who identify several key factors for successful tissue expansion: the selection of expander size and shape, the incision for expander insertion, the size of the pocket created, drainage, expander filling, the technique of flap formation from the expanded skin, and the use of antibiotic therapy. Lentz and Bauer[11] consider rectangular expanders to be the most applicable type for all body areas due to the greatest expansion of the tissue. They recommend crescent-shaped expanders for areas with uneven surfaces to minimize the "dog-ears" during flap preparation. We disagree with this and instead support Hoffmann's[6] opinion that crescent or "croissant"-shaped expanders, as well as round ones, are most suitable for scalp tissue expansion. We have used crescent expanders in 60% of our patients. We find this expander shape to be the most appropriate given the shape of the head and the potential for maximum enlargement of the tissues surrounding the defect.

We address conical deformities following tissue rotation in a subsequent stage, if necessary. We support Sasaki's[5] recommendation that the optimal ratio of defect size to expanded tissue size should be 1 to 2-2.5. However, we believe that in some cases, this ratio can be reduced in favor of the expanded tissues. This is due to the rich blood supply of scalp tissues, for example, and the additionally formed fibrous capsule, which enhances the resilience of the expanded tissues when stretched to achieve final defect closure.

Proper planning of the incision site for expander placement is considered a crucial prerequisite for successful expansion. We plan and make the incision at the site with the least expected tissue tension after the expander is inflated. We share the opinion of Lentz and Bauer[11] that the incision should be made along the edge of the lesion that is to be removed. We agree with Manders and Konior[12,13] and place the expander in a subgaleal plane in the scalp area, as this is technically the easiest method, ensuring protection of the hair follicles, reducing operative time, and minimizing blood loss.

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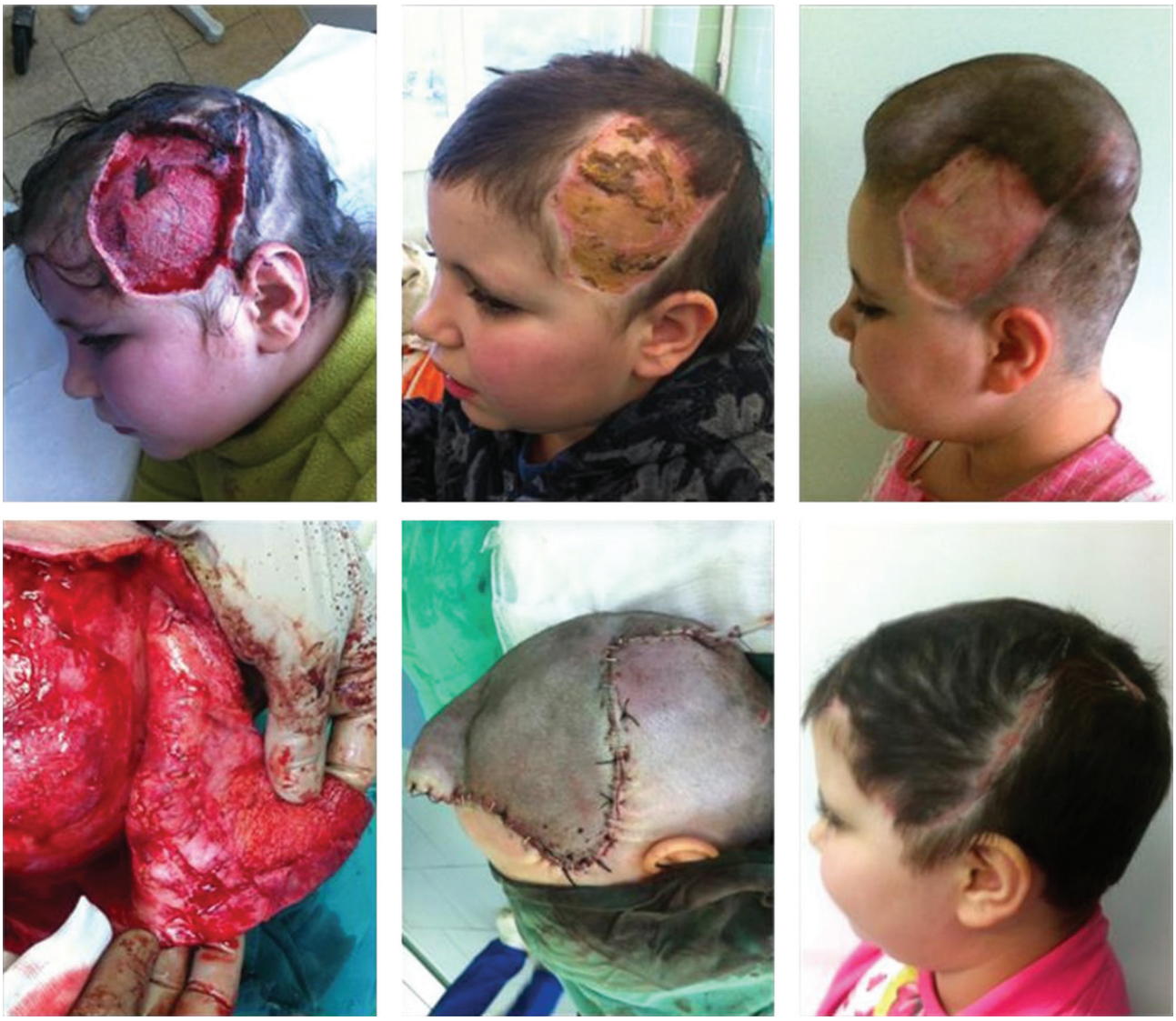

Figure 2. The case with post-traumatic alopecia.

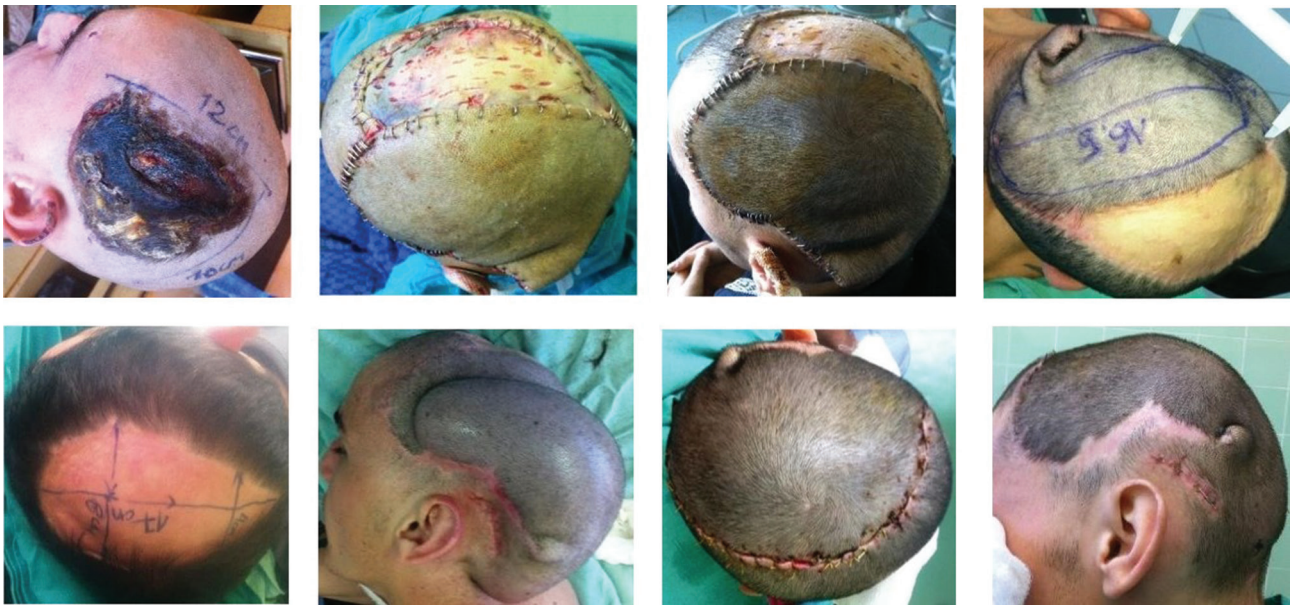

Figure 3. The case with post-burn alopecia.

In cases of significant bleeding, despite applied hemostasis, and due to the nature of the scalp which does not always allow visual revision of the bleeding source, we place an aspiration drain for a period of 24 to 72 hours. Casanova et al.[14] suggests leaving the expander valve above the skin in patients with thin subcutaneous fat to avoid additional fibrosis in the subcutaneous tissue, especially when expanding in the limb area. It is also believed to reduce the risk of secondary infection due to repeated punctures during filling. We disagree with this opinion and instead align with the experience of the majority of authors, such as Zanzov, Lentz, and Ghanime[4,11,15], placing the expander valve at a distance from the pocket (at least 3-4 cm), preferably on a bony base, but always in a supra-fascial or subgaleal position. We have not recorded any secondary infections in any of our cases.

We begin filling the expander a few days after insertion when the wound heals primarily and no other complications are present. We do not agree with the timelines cited by some authors, such as Hudson and Grob[10], who recommend starting expansion at least two weeks after expander placement. We support the opinion that the initially intraoperatively injected volume should be 10% of the expander's total capacity.

For final reconstruction after achieving the desired volume, we use a technique to shape the flap through advancement and/or rotation of the expanded tissues, aiming to cover the existing defect without tension. We consider it important to preserve the capsule of the expanded tissues and the vessels at the base of the flap. In some cases, to improve mobility and advancement of the flap, as some authors like Ghanime et al.[15] suggest, we perform capsulotomies and galeotomies according to specific rules that protect the underlying tissues.

As with other studies, only two cases of complications were identified: hematoma, seroma, and infection. These complications resulted in skin flap necrosis and extrusion.[16,17] For final surgical outcomes, it is important to perform thorough assessments of the problems that arise during TE.[17] According to the literature, the placement of expanders in the limbs is often accompanied by complications, which vary but are consistently high (8-23%). Elshahat[18] categorizes expander placement into limb zones and non-limb zones. He reports 30% complications in limb interventions and 10% in non-limb zones. He attributes the higher complication rate in limbs to the greater mobility, cylindrical shape, difficulty in forming the expander pocket, and the uneven amount of soft tissue from different sides, which increases the risk of dehiscence. He also notes that the incision for expander placement is almost always part of the expanded tissue.

According to Manders' complication scale[19], we observed one major complication, an expander extrusion without hematoma or infection, and one minor complication, a patient with a seroma in the expander bed. Expander extrusion is the most common complication, observed in 48% of cases according to Antonyshyn et al.[20], and 17% according to Babak et al.[21] In our case, the extrusion was associated with the presence of scar tissue in the expansion area.[22] A common issue with post-burn injuries, as in this case, is the lack of sufficient healthy surrounding tissue. The fibrous scar tissue nearby is difficult to mobilize and does not respond well to expansion due to its low elasticity.[23] In our case, about three-quarters of the expander's volume was achieved before extrusion, which allowed for premature reconstructive intervention. The final outcome was deemed satisfactory.

In one case involving tissue expansion of the lower extremity, we observed a seroma in the capsule, nearly half the size of the expander. Postoperative results for this case included venous stasis and epidermolysis in a specific area, which we attribute to increased tension at the wound edges. During the late follow-up, spontaneous directed epithelialization resulted in a normotrophic scar. We observed transient postoperative alopecia at the expansion site in one patient with scalp defects, which we do not consider a complication.[24,25]

We believe that to avoid complications, the incision for expander placement should be as far as possible from the expander pocket, at a site with the least tension during expansion.[26] The pocket itself should be made 1.5-2 cm wider than the expander, but no more. The placement should be planned for a supra-fascial or subgaleal plane, and the expansion and incision should be performed on non-scarred tissue.

Conclusion

Slow tissue expansion is a highly suitable method for reconstructing the consequences of thermal, mechanical, or combined injuries. We associate its use in areas with limited mobility of surrounding tissues, such as the scalp and the tibial surface of the lower leg, with particularly good results.

The advantages of the expander technique are:

- Absence of donor sites
- Use of surrounding tissues with identical characteristics
- Minimal incision lines
- Good long-lasting aesthetic results

The disadvantages are:

- Multiple stages of treatment
- Prolonged treatment duration and cost
- Difficult social adaptation for patients

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Competing interests

The authors have declared that no competing interests exist.

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