Tissue Expanders in Reconstruction of Maxillofacial Defects

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Abstract Tissue expansion in its natural ways had fascinated man from prehistoric times itself. But tissue expansion for medical purposes was first tried and reported only in the early half of twentieth century. Presently the principle of tissue expansion is being used in reconstruction of many hard and soft tissue defects of larger dimension, which were previously regarded as great challenge for maxillofacial and plastic surgeons. Making use of the viscoelastic nature of the skin, considerable amount of tissue expansion based tissue engineering is possible in the maxillofacial region. Here we present a case of a facial scar of large dimension with a central oro cutaneous fistula developed as a result of facial artery blow out in a 24 year old female for which esthetic correction was done using the excess tissue obtained from tissue expansion. In this case where other methods of reconstruction such as local flaps, free flaps and normal tissue grafts were assessed to be non viable, tissue expansion was found to be an apt solution for esthetic reconstruction.

Keywords Tissue expander · Tissue expansion · Scar tissue · Fistulous tract

Introduction

Neuman was the first to expand skin for reconstructive purpose by using an inflatable balloon placed subcutaneously [1]. In 1957 after gradual expansion over a course of

2 months, he could obtain sufficient expanded skin to cover a cartilaginous reconstruction of a subtotally avulsed external ear. But unfortunately, only after about 20 years tissue expansion was popularized through the independent works of Radovan and Austad, when both developed silicone tissue expanders [2, 3]. Radovan was the person who popularized the technique of tissue expansion for post-mastectomy breast reconstruction [4]. Austad and Rose later developed self inflating tissue expanders [3]. Over time tissue expanders were widely used in reconstruction of many head and neck defects [5–11]. More recent reports have described the use of tissue expansion even for a variety of intra oral reconstructions [12–14].

The unique advantage of tissue expansion is that it allows for reconstruction of head and neck defects with adjacent tissue of similar color, texture, sensation, thickness, and hair-bearing capability [15]. Though the technique of tissue expansion minimizes donor site morbidity, it requires multiple operations and a prolonged outpatient course. Patient education, acceptance and compliance are essential in this technique as there is a temporary but significant inconvenience and cosmetic deformity during the process of tissue expansion [16]. Some of the more common indications for the use of tissue expansion in the head and neck region include; correction of posttraumatic or postoperative alopecia, treatment of male pattern baldness, expansion of forehead skin prior to forehead flap total nasal reconstruction, expansion of postauricular skin prior to reconstruction of the external ear, expansion of cheek or neck skin to allow scar revision, burn excision, or other lesion removal when primary closure is not possible without undue tension [17].

Contraindications to tissue expansion include; unwillingness or medical inability to undergo 2 or more operations or to comply with the numerous outpatient visits

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Fig. 1 Frontal view (pre Op)

required for the expansion process, noncompliance, mental disability, poorly vascularized tissues from radiation therapy, active infection or open wounds, ongoing chemotherapy [16]. Expansion in infants and children is controversial. Possible complications include thinning and deformation of underlying bone and subsequent scar widening with growth [9].

Case Report

A 24 year old female patient presented with complaints of scar and fistula over right side of her face since 18 years and associated complaints of oozing of saliva and food debris from site (Fig. 1). History of Acute Lymphocytic Leukemia was diagnosed at the age of 5 years for which she underwent chemotherapy at the age of 6 years. During and after chemotherapy she had pain in lower gums which manifested as mucositis and following that she sustained a facial artery blow out in right cheek region. The skin and mucosa over right cheek became necrotic and eventually an orocutaneous fistula developed in the region over a period of time. She gave a history of limited mouth opening due to contracture and scar at the right oral commissure.

On examination, there was a hyperpigmented trapezoidal scar measuring approximately 5×5 cm, on the skin over the right mandible extending anteriorly from a point 5 mm behind commissure of mouth and posteriorly up to the anterior border of masseter muscle; superoinferiorly extending from 1 cm below ala tragal line to lower border

Fig. 2 Profile view (pre Op)

of mandible (Fig. 2). Skin contracture around the scar tissue was noted due to which she had drooping of right side corner of mouth on smile. A fistulous tract was noted at the center of the scar with intraoral communication. A colour doppler study of right facial artery showed adequate vascularity and normal position of facial artery up to the anterior border of masseter.

Treatment plan was discussed and an initial plan to perform excision of fistulous tract and closure of the defect primarily and later scar tissue excision and cheek reconstruction either with nasolabial rotational flap, submental flap, skin flap or platysmal flap to reconstruct the defect. The challenges in reconstruction included; the large size of the defect, the presence of orocutaneous fistula, the loss of tissue bulk, the need of donor tissue with adequate color matching, compromised vascularity of the region which would affect the wound healing, skinny nature of the patient and therefore inadequate bulk of adjacent tissue for reconstruction.

So a plan was made to use expanded adjacent tissue by means of tissue expanders. A three step procedure was planned.

Materials and Methods

The selected tissue expander was a rectangular type of silastic expander, of dimensions $61 \text{ mm} \times 35 \text{ mm} \times 32 \text{ mm}$, 50 ml in volume with a distant filling valve where the injection port that receives the needle during inflation is attached by a stem to the expander (Fig. 3).

Fig. 3 Rectangular type of tissue expander used

Fig. 4 Subplatysmal dissection

Step 1: Excision of fistulous tract along with primary closure and placement of tissue expander.

Excision of fistulous tract and primary closure was done. Along with the procedure, placement of tissue expander was also done. A linear skin incision was placed parallel to the lower border of mandible in the submental region. Tunneling of tissues in a plane below the platysma muscle in the right digastric triangle was done to create a pocket for placement of tissue expander (Fig. 4). The tissue expander was placed subplatysmally in this created pocket in order to create adequate tissue bulk for reconstruction. Intraoperatively 30 ml of saline was injected to inflate the tissue expander in order to avoid any folding of the expander within the tissue (Fig. 5). Then the tissue expander was deflated and 5 ml of saline was injected as the initial increment. The injection port was left outside and wound closure was done in layers.

Step 2: Postoperative periodic injection of saline.

Postoperatively periodic injection of 5 ml of saline into the injection port was done at 1st week review and then at

Fig. 5 Tissue expander in subplatysmal plane

Fig. 6 Tissue after 1 month of periodic expansion

2 weeks interval (Fig. 6). The desired expansion period calculated was 9 weeks, when altogether 30 ml of saline had been injected into the tissue expander (Fig. 7). A waiting period of 1 month was observed before surgical intervention for tissue maturation.

Fig. 7 Expanded tissue after 2 months

Fig. 8 Points marked for traspositioning

Step 3: Surgical management: scar tissue excision and cheek reconstruction using rotation advancement of expanded skin flap.

As the 3rd step and the 2nd surgical procedure, excision of the scar tissue and reconstruction of the defect using the expanded tissue flap was performed. Prior to surgery the limits of the scar were marked as points and the corresponding points on the expanded tissue were identified, so that optimal reconstruction was possible (Fig. 8).

Fig. 9 Marking for excision of scar

Fig. 10 Excision of scar tissue

Intraoperatively the margins of the scar tissue to be excised were marked (Fig. 9). Scar tissue was excised with only sufficient depth of removal, so as to leave the underlying apparently healthy connective tissue as a vascular bed (Fig. 10).

A linear incision parallel to the margin of the tissue expander was made at the region adjacent to the excised scar tissue to remove the tissue expander and consecutively the expanded flap was raised (Fig. 11). The capsule formed around the expander was retained within the flap so that adequate bulk could be obtained to compensate for the loss of bulk at the recipient site (Fig. 12). Scoring of the capsule

Fig. 11 The expanded flap

Fig. 12 Capsule around the expander

Fig. 13 Scoring of the capsule

was performed so as to achieve proper mobilization of the flap (Fig. 13). A back cut was given for further flap advancement and proper adaptation of the flap was achieved without traction (Fig. 14). Flap edges were

Fig. 14 Back cut for flap advancement

Fig. 15 Immediate post Op

sutured with 5- 0 polypropelene without tension at the margins (Fig. 15). Suture removal was done 1 week post operatively, when a viable flap without complications could be obtained (Fig. 16). Post operative reviews were made up to 4 months during which no flap complications were observed other than the minimal scarring with hypopigmentation over the edges of the flap for which derma abrasion procedures and scar revision had been planned (Figs. 17, 18, 19).

Discussion

Tissue expanders are available in standard round, rectangular, or crescent shapes. Use of the rectangular expander

Fig. 16 Viable flap with adequate bulk at 1 week post op review

Fig. 18 Lateral view 1 month post op

Fig. 17 Frontal view 1 month post op

Fig. 19 Four months post op

provides the most effective surface area gained when compared to round or crescent. Rectangular expanders gain 38 % in tissue area of the calculated surface increase of the expander, whereas round expanders gain 25 % and crescent expanders gain 32 % of calculated surface increase [18].

Expanders are available in various volumes ranging from a few cubic centimeters to several thousand cubic

centimeters. In the head, face, and neck, most expanders used are in the 1–250-ml volumetric range. There is a considerable margin of safety in selecting the proper volume since expanders can be overinflated at least 15 times the vendors stated maximum volume [19]. A disadvantage of overinflation is increased leakage from the dome of the injection port. Nordstrom et al. found that the average pressure necessary for leakage from the injection port of an expander was 32 mmHg (range 8–110 mmHg) [20]. Thus,

overinflation will predispose to leakage. To circumvent the potential problem of leakage, it is best to select the largest expander that can reasonably be inserted beneath the region of expansion or to consider the use of two or more expanders to gain the needed tissue. In any event, the proven safety of limited overinflation allows a margin of error in the initial choice of implant volume, and later permits continued expansion if more tissue is needed.

Van Rappard et al. studied surface area increases of a number of expanders of different size and shape. They recommended that when using a rectangular or crescentric expander the appropriate expander would be the one in which the surface area of the expander base is 2.5 times as large as the defect to be closed. In the case of round expanders, the diameter of the expander base rather than the area of the base should be 2.5 times as large as the defect. Another method of selecting an expander is based on the circumference of the balloon portion of the expander. The expander must be of sufficient volume so that the apical circumference of the dome of skin overlying the fully inflated expander is two to three times the width of the defect. Even if the chosen expander creates excessive skin, suturing the expanded flap of tissue without tension will keep widening of the postoperative scar to a minimum [21].

The physiology of expansion by prolonged tissue expansion is not just a matter of stretching skin, but the actual formation of additional new skin which has all the attributes of the original tissue. Austad et al. postulate that tissue expansion causes a decrease in cell density in the basal layer of the skin and that cell density may regulate skin mitotic activity [22]. A lower cell density results in a greater cell proliferation, resulting in growth of additional skin. Inflation of the tissue expander was found to cause a threefold elevation of epidermal mitotic activity within 24 h, followed by a gradual return to normal baseline over 2–5 days. Conversely, deflation of the expander caused a transient decrease in epidermal mitotic activity. The increase in mitosis returns to normal 4 weeks after expansion. On histologic studies, the epidermis has an increase in its thickness and the rete pegs become flattened when compared to nonexpanded skin [23].

A capsule forms around the expander as with most foreign body reactions. These capsules are thickest after 2–2.5 months of expansion. Within 7 days there is a 2 layer capsule consisting of an inner layer of macrophages and an outer layer of fibroblasts and some lymphocytes. Over time the outer layer becomes richer in collagen fibers. The bordering layer around the capsule becomes richly vascularized. Pasyk, Austad, and Cherry noted that the capsule has four histologic zones, as follows [24]:

- Inner zone—adjacent to the expander. Contains fibrin-like filaments and a cellular layer with macrophages.

- Central zone—next to the inner zone. Contains elongated fibroblasts and myofibroblasts oriented parallel to the surface of the implant.
- Transitional zone—on the outside of the central zone. Has loose bundles of collagen fibers.
- Outer zone—most superficial layer. Has established vessels loosely interspersed with collagen fibers.

Once an expander is removed, the surrounding fibrous capsule rapidly thins.

As the procedure of expansion proceeds, there is an increase in the number and size of the vessels within flaps supplied by random-pattern vessels and, if present, axial vessels. These changes correspond to the demonstrated increase in blood flow to expanded flaps [25]. In the study by Saxby, this lead to surviving lengths after expansion being 50 % greater than the delayed controls and nearly 150 % greater than comparable flaps raised acutely [26]. Specimen angiograms of expanded skin showed evidence of increased vascularity compared with control skin. The authors recommended including the expander capsule in the flap at the time of transfer for its contribution to the blood supply, and postulated that mechanical forces are in some way related to the increased vascularity.

There can be a number of advantages for expanded tissue flaps over free flaps, especially in the reconstruction of maxillofacial defects. The so said advantages of vascularized free flaps such as the wide variety of available tissue types, large amount of available composite tissue, tailored to match defect, wide range of skin characteristics and more efficient use of harvested tissue, are also true in the case of expanded tissue flaps. For the major disadvantages of free flaps such as the technically demanding nature, need for complex vascular anastomose, increased operating room time, increased flap failure rate and donor site morbidity, expanded tissue flaps can be a solution. Moreover expanded tissue flaps have good color and texture match of the skin used for coverage and the flaps are simple and reliable.

An experimental form of tissue expansion is continual tissue expansion by using a pressure-dependent continuous infusion device. Studies show that continuous tissue expansion achieves significant amounts of additional tissue when compared to intraoperative expansion. Schmidt et al. found that continuous tissue expansion using a device that infuses saline at a constant infusing pressure less than capillary filling pressure will expand in 3 days to amounts similar to a model of conventional expansion. It is believed that much of the skin achieved in true tissue expansion represents stretch and reorganization of dermal collagen fibers rather than new skin created by mitosis [27].

The overall complication rate of tissue expansion is 5–7 %. The rate can be reduced by appropriate patient

selection and surgical experience. The most serious complications are overlying skin necrosis, implant exposure, and extrusion. This may occur secondary to infection, trauma, and erosion of flap due to folds in the expander, overly aggressive expansion, or placement of the valve over a bony prominence. If the situation is noticed early and thought to be caused by a fold in the expander, the surgeon can attempt to salvage the implant by deflating it and observing the skin. If skin viability returns, the device can be slowly re-inflated. If skin necrosis or expander extrusion occurs, the implant should be surgically removed, the wound cultured and debrided and the area managed conservatively. Broad-spectrum antibiotics are initiated and frequent wound care and dressing changes are important [16, 17]. Other potential complications of tissue expansion include infection, hematoma, seroma, pain, and neuropraxia. These problems undoubtedly delay the reconstructive process and may necessitate implant removal, but do not signal a catastrophe with dire consequences to the patient. Infrequent reports of erosion and deformation of bone underlying an expander have appeared in the literature, specifically rib concavity with thoracic skin expansion and calvarial erosion with scalp expansion. Paletta describes rupture of an expander placed in the scalp of a child caused by erosion of the outer table of the skull and bone spur formation from pressure by the expander [28]. Austad noted a remarkable absence of disasters in a survey of more than 50,000 tissue expansion procedures and points out that the overall incidence of complications associated with tissue expansion has decreased as surgeons have become more knowledgeable and experienced in the routine use of expanders [29].

Conclusion

The development of tissue expansion has enabled the head and neck surgeon to manage defects that cannot be closed primarily without undue tension. Where other methods of reconstruction such as local flaps, free flaps and normal tissue grafts are assessed to be non viable, tissue expansion is an apt solution for esthetic reconstruction in the head and neck region.

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