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Original Research Article

Tissue expansion as an aesthetic alternative for facial resurfacing: a single centre series of 92 patients

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ABSTRACT

Background: The visibility, vulnerability and social stigmata of facial scars whether by burn, nevi or trauma can be compelling for the patient as well as challenging for the surgeon. Restoration to normal form and aesthetics require tissue replacement which has good colour and texture match and produce minimal visible scarring. Although many other options are available for a given defect, tissue expansion offers the best alternative which meets almost all the criteria of an ideal procedure.
Methods: Among 92 patients with deformities over various facial subunits were operated and expanders 50 ml to 300 ml inserted subcutaneously adjacent to the scar. Prior planning, accurate measurement and choice of ideal expander is extremely important. A precise and practical method of calculation for determination of amount and duration of expander was used. Any secondary deformity to adjoining vital structures was avoided.
Results: Results were meticulously and critically analyzed. Different shapes, dimensions and volume of expanders were used depending on the anatomical site which was to be expanded. A total of 118 expanders were inserted in 92 patients. The average volume of tissue expanders used was 170.33 ml. Majority of the expanders used had volume of 200 ml (62.71%). Post-expansion volume was 240.67 ml and the over expansion done was 41.3% over the pre-expansion volume of 170.33 ml. Surgical outcome and cosmesis was assessed by the patient's perspective and was considered fair by 57.61% patients.
Conclusions: The study underlines the clinical application, reasons for overexpansion as well as shortcomings and complications of tissue expansion.

Keywords: Aesthetics of face, Facial burns, Facial scars, Overexpansion, Tissue expander calculation, Tissue expansion

INTRODUCTION

The art of meticulous planning and perfect execution is best exemplified by the surgical technique of tissue expansion. Although Neumann first reported it for auricular reconstruction it was Radovan's epic work in 1984 that has propelled the technique of tissue expansion.[1,2] Since then it has come a long way to culminate in osmotic expanders which, a great number of times, yield uncontrolled expansion. The conventional tissue expanders remain the gold standard for replacing the scarred facial tissues by the expanded skin, thereby preserving the facial aesthetics and vital structures. The technique of tissue expansion gained momentum owing to the aesthetic demands of the face and the fact that a scarred face adversely affects the emotional and social psyche of the patient. The cluster of surgical options like serial excision, local or locoregional flaps and free flaps

have their own set of disadvantages. Tissue expansion has become a well-established surgical option for large defects where the expanded skin derived from the area adjacent to the defect can achieve acceptable cosmetic and functional results.[3-5] The use of tissue expanders allow the surgeon to repair the extensively damaged areas as well the donor site morbidity usually associated with local or free flaps.[5,6]

The study was undertaken to evaluate the scars and defects over the face and neck and to analyze the results of reconstruction by various sizes and volumes of rectangular tissue expanders, their outcomes and their complications. Hudson in 2003 gave forth a simple analogy to compare the expanded tissue to a (three-dimensional) cardboard rectangular box, which was to be made completely flat.[7]

METHODS

This prospective study was conducted on 92 patients with scars and defects of various etiologies (Figure 1 and 2) on the face and neck (Table 1).

Figure 1: 22 year female with a big congenital nevus on the forehead.

The study was carried out in the Department of Plastic and Reconstructive Surgery, Institute of Medical Sciences, Banaras Hindu University, Varanasi, India and Department of Oculoplasty and Ophthalmology, Heritage Hospitals, Varanasi between January 2014 to February 2019. Scars over the face and neck which could be managed by tissue expansion were included in the study. Pediatric patients who were not likely to co-operate and older subjects with co-morbidities were excluded from the work. Post burn alopecia of the scalp were not included in the study. Patients who proved to be reactive to viral markers were operated with extreme care and precautions. Anticoagulants were discontinued a week prior to surgery and long-standing diseases managed preoperatively.

In the preoperative visits dimensions of the scars or defects, anatomy and availability of donor tissue, the insertion site of the tissue expander, shape of the tissue expander, the required dimensions, and the incision site were planned for surgical execution.

Figure 2: 17 year female with burn scar involving a substantial area of the right cheek.

The closest expandable tissue to the scar area was considered as the donor tissue. The donor skin adjacent to the scar was evaluated to determine the pliability, mobility, stretch ability, expandability and adequacy for insertion of tissue expander. These were important parameters considering the type of the tissue expander, the shape and the required dimensions and maximum expandability of the tissue to replace the burn scar. Choice of the donor site depended on movement of the flap after expansion whether advancement or transposition.

Tissue expander insertion was performed under general anesthesia or local anesthesia. The skin was nicely scrubbed with povidone iodine and 1% lignocaine with adrenaline solution diluted to 1/100000 was used to infiltrate the incision site and the pocket which would subsequently be dissected. Incision was planned in such a manner that it could be excised during subsequent stages. The subcutaneous or subplatysmal pocket (Figure 3) was dissected about 2-3 inches more than the dimensions of the expander for easy expander insertion. This also provided more space for per-operative saline inflation. Another pocket was dissected in the postauricular region, in continuity to place the injection port which should be under the healthy skin to be easily distinguishable and easily accessible for the subsequent weekly injections into the expander port. Tension, kinking, and torsion was avoided during port insertion to avoid difficult expansion or failure to expand. The port could also be exteriorized (Figure 4). Fine hemostasis and thorough washing of the pocket was performed using normal saline. The rectangular tissue expander (Figure 5) was washed with Gentamycin and inserted. During the insertion procedure, knuckling or bending of the prosthesis was avoided, 10-15 ml saline was injected through the port to smoothen out the folds in the expander, check any leakage and achieve hemostasis by tamponade. Wound was closed in

layers. Drains were avoided over an implant to obviate any source of infection.

Figure 3: The patient highlighted in figure 2 had an expander of 200 cc inserted in the subplatysmal plane in the neck.

In all the cases rectangular tissue expanders and volumes from 50 ml to 300 ml were used. The rectangular shape expanded the overlying tissues more vis a vis the same volume of the other shapes. The injection port was exteriorized in 27 patients as they were more apprehensive and had lower pain threshold. Expansion was started on the 10^{th}-14^{th} post-operative day and then weekly, each time 10% to 20% of the expander volume injected through the port depending on the ease of saline injection without undue resistance.

Figure 4: The tissue expander in situ with the port exteriorised through one end of the incision.

On the completion of expansion which took about 2-3 months, a period of another 2 months was bought to erase the elastic memory of the skin. 39 patients were over-expanded by about 1.5 times the expander volume. The second stage, undertaken 4-5 month after the first, involved removal of the tissue expander, excision of the scar and final insetting and suturing of the expanded tissue used as an advancement flap or transposition flap as planned preoperatively. Preservation of the vascular pedicle was of paramount importance in the planning of transposition flaps, but they tend to resurface only narrow defects.[6] Advancement flaps, which were used most commonly, were random flaps and require expander insertion immediately adjacent to the scar.

Figure 5: An array of rectangular expanders of different sizes and volumes.

After the surgery, all the patients were analyzed and compared in terms of demographic variables, such as age and gender, cause of scar, location of scar, the largest and smallest lesion diameters, tissue expander insertion site, the mean initial volume and final volume of the prosthesis, the interval between implant placement and reconstructive surgery, complications of the prosthesis, scar formation in both reconstructed area and flap donor site, and patient satisfaction.

At the end of the study period in February 2019, statistical analysis was carried out. For interpretation of the quantitative variables mean, standard deviation, minimum, and maximum values were used. Z-test was applied to find the p value and its significance. Numerous studies have been carried out regarding choice of an ideal expander. Wagh and Dixit vividly discussed different criteria to choose the right expander.[8] Radovan and Morgan suggested that the expander base must be the same size as the defect to be closed.[2,9] Gibney recommended that the expander base should be at least 2.5-3 times the width of the defect.[10] Manders et al, recommended that the largest possible expander that will fit at the donor site should be used.[4] van Rappard et al, estimated that use of a rectangular expander provided the most effective surface area gained when compared to the round or crescent expander.[11] 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. Onder TAN emphasized a practical calculation method for expander cases where he used the technique daily during the expansion process to decide whether or not to complete the procedure.[12]

With a compass, he first measured the projection of expanded tissue the i.e. dimension of the area prior to expansion. Next the parameter that was measured was the convexity of the same distance by a flexible paper ruler, or the dimension of the same area after expansion. Pre-expansion value was subtracted from post-expansion value which represented the effective advancement of expanded tissue. This was applied to both the length and width of the area mentioned. This helped to objectively decide whether the area obtained following expansion was capable of closing the defect and the expansion procedure could be finished or not.

RESULTS

The demographic variables of all the 92 patients were studied and we inferred that 71.77%, were females and the mean age was 21.95±5.24 years, minimum age was 16 years and maximum age was 34 years. Most of these young females sought opinion in the immediate pre-marital period. 73.91% patients suffered from facial scars due to thermal burns (Table 1) and the size of the scar ranged from 9 cm to 28cm along the long axis with a mean of 13.2±3.89 cm (Table 2).

Table 1: Etiology of facial scars.

Etiology	Anatomic units	No. of patients	Percentage
Burn scars	Zone 3 cheek (unilateral±bilateral)	22	23.9
	Zone3 cheek and neck	13	14.1
	Unilateral mandibular region	11	12
	Bilateral mandibular region with chin	14	15.2
	Zone 2 cheek	5	5.4
	Forehead	3	3.3
Trauma		17	18.5
Nevus		7	7.6

The longest scar involved the whole beard area between both the ear lobules and also involving part of the neck (Figure 6-8). A total of 118 expanders were inserted in 92 patients. Multiple expanders (2 in number) were used in only 26 patients. Only one expander was inserted in rest of the 66 patients.

The volume of expanders used were between 50 to 300 ml with an average volume of 170.33±59.03 ml with median volume being 200 ml. This was because we inserted majority of the expanders with the volume of 200 ml (62.71%) and 100 ml (27.11%). Smaller expanders of 50 ml were used in areas such as narrow forehead and preauricular areas (Figure 9). Inflation of the expanders were started on 10th to 15th day of surgery (mean 12.43±1.34 days) in the absence of hematoma, infection or wound dehiscence.

Figure 6: Frontal view of a 25-year young boy with 6-year-old scarring due to thermal burn spanning one ear lobule to another, the scar measuring 28 cm X 5 cm.

Figure 7: Left lateral preoperative view of the same patient depicting measurement of the burn scar, 9X5 cm, and the proposed site of insertion of expander depending on the availability of neck skin.

Figure 8: Right lateral preoperative view with measurement of the burn scar, 10x5 cm.

Table 2: Detailed analysis of tissue expanders used in the study of 92 patients.

Variable		No. of patients	%
Sex	Females	71	77.17
	Males	21	22.83
Age (mean 21.95years)	<20 years	39	42.39
	20-30 years	42	45.65
	>30 years	11	11.96
Number of expanders (118)	1	66	71.74
	2	26	28.26
Volume of expander (mean 170.33 ml)	50 ml	6	5.09
	100 ml	32	27.11
	200 ml	74	62.71
	300 ml	6	5.09
Size of the lesion	9 cm-28 cm Mean 13.2 cm		
Post-operative volume of tissue expanders (240.67±71.1 ml)	80-180 ml	38	32.20
	180-280 ml	43	36.44
	280-380 ml	37	31.36
Complications (9 patients)	Expander extrusion	3	2.54
	Haematoma	4	3.39
	Infection	2	1.69
Patient's assessment of cosmesis	Excellent	5	5.44
	Good	28	30.43
	Fair	53	57.61
	Poor	6	6.52

However, 6 patients had minor complications which were managed conservatively. Implant was exposed in 3 patients which required re-suturing. In these 9 patients, the initiation of expansion was delayed. Post-expansion volume was 240.67±71.1 ml (80-380 ml) and the over expansion done was 40±13.41% over the pre-expansion volume of 170.33±59.03 ml (Figure 10).

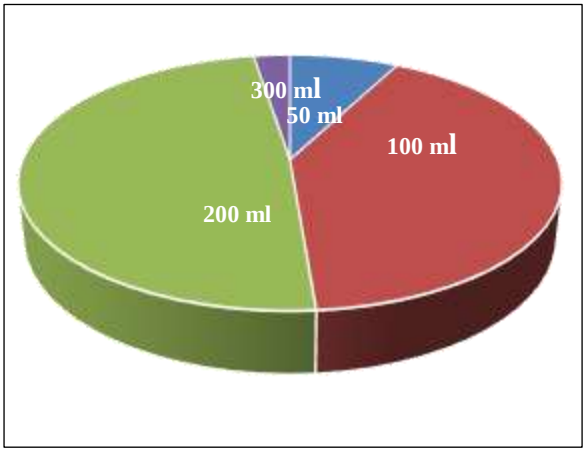

Figure 9: Volume of tissue expanders used (n=118).

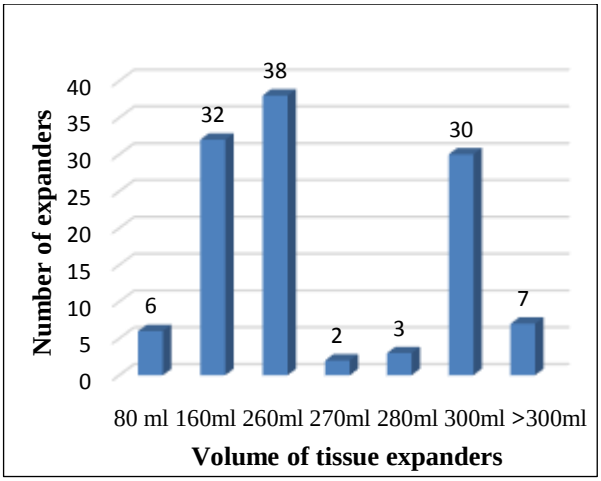

Figure 10: Post expansion volume of expanders (n=118).

Surgical outcome and cosmesis was assessed by the patient's perspective and were considered fair by 57.61% patients and good by 30.43%. Only about 5% patients were extremely happy with outcome. Patients with smaller and not so conspicuous lesions, 6.5% were not satisfied.

DISCUSSION

The development of tissue expansion has added another technique to the armamentarium of the plastic surgeon, whereby such defects are successfully managed which otherwise could not be closed primarily without undue tension.

Figure 11: Left lateral view with inflated expander in situ and port exteriorised. Please note that the incision given at the lower border of the scar for a second stage advancement.

Figure 12: Right lateral view with inflated expander in situ. Tissue expander inserted radial to the incision.

Figure 13: Incision placed on the lower margin of the scar on either side and 200 cc of rectangular expanders inserted and ports exteriorised through lateral ends of the incision.

In addition, the expanded tissue provides optimum colour, texture, thickness and sensation to excised areas with retention of hair bearing capacity to the moustache and beard areas. The observation that living tissues dynamically respond to mechanical forces placed upon them forms the foundation of the technique of tissue expansion.

Local flaps also fulfil the requirements of good tissue match but at the expense of new scars which may deform vital structures. Free flaps usually achieve good contour and sufficient bulk, but poor colour match and can be thought of as an extensive and exaggerated surgery. Tissue expansion is an effective technique that enables facial tissue to be transferred from the adjacent areas.[10]

Figure 14: Postoperative frontal view.

Figure 15: Postoperative worm's eye view.

Figure 16: 19 years young female with extensive hypertrophic scarring of the neck with dendritic projections.

Furthermore, face and neck are ideal sites for tissue expansion. (Figure 6-8,11-21) due to the rich blood circulation and the rigid support of the facial bones.

The lateral facial areas and neck contain essentially the same type of skin and hence, tissue expansion allows optimal aesthetic reconstruction by the use of a similar adjacent tissue without major donor site morbidity.[12]

Figure 17: 200 cc tissue expander under the adjacent skin of the neck and this is 4 months after the first surgery of expander placement. This is the worm's eye view.

Figure 18: The patient in frontal view.

In addition to the traditional advancement flaps, reasonably large flaps with narrow pedicles remain well vascularized and can be transposed to cover very large defects.[13]

In the present study of 92 patients the mean age was 21.95y±5.24 years and 71.17% were female. The statistics explain that majority of females seek consultation in the pre-marital period.

The proposal of expansion with good color match and minimal donor morbidity are readily accepted. In the study of 34 patients by Motamed et al, the mean age of the patients was 25.5±8.3 years and 70.59% were females.[5]

Figure 19: The expander removed by an incision on the superior part of tissue expander. The advancement flap was based on the lateral neck.

Figure 20: Suturing of the flap.

Figure 21: Photograph of the same patient after 6 months the final flap insetting.

The study also inferred that the most common cause of facial scars was flame burn (60.61%). He also reported that the scars were mostly located on the face (70.59%) and the neck (23.53%). Fochtmann et al, found the mean age to be 21 years in 63% females.[14]

On the end of the spectrum, Antonyshyn et al studied 33 patients in the age group 4 to 89 years with a mean age of 31 years.[15] In yet another work a reversal of patients' profile was found where 14 males and 11 females underwent treatment using expanders and the average age was 24 years (9 months to 46 years).[16] We, however, studied 92 patients only of facial scars of which 74% sustained facial burn.

Specifications of the expanders were vital for a successful operative outcome. Motamed et al, in his study inferred that use of rectangular expanders provide more flexibility in flap design.[5] Moreover, post expansion surface area is maximum with rectangular expanders, 38% to be precise.[11] In this study we used tissue expander of volumes 50 ml to 300 ml (mean 170.33±59.03 ml) as we reconstructed only facial scars where neck could accommodate only limited size and volumes of the tissue expanders. In the study of 33 patients by Ashab Yamin et al, the mean initial volume of the prosthesis was 321.55±182.52 ml that was brought to the final volume of 865±623.64 ml (minimum: 95 ml and maximum: 3000 ml).[17]

Predetermination of the amount and duration of expansion is vital and essential. In fact, they prepare the groundwork for the decision as to when to complete the expansion. This is important because early completion may result in inadequate tissue expansion and smaller than the calculated and required flap.[12] Delayed expansion procedure leaves the patient at higher risk for potential complications such as extrusion and infection.[12] In the present study only rectangular expanders were used, 71.74% with single and 28.26% with 2 expanders. Average volume of 118 expanders used were 170.33 cc. Post-expansion volume was 240.67±71.1 ml (80-380 ml) and the over expansion done was 40±13.41% of 118 expanders. Extreme overexpansion was necessary to advance unburned neck flaps over the mandibular border to avoid scar widening and lip ectropion.[18] Caudal advancement posed less risk of lip ectropion than cephalad advancement. Flap advancement or rotation should always be performed with the head extended or turned away to decrease the tension and scar widening. Even a modest improvement of facial burn scarring makes a tremendous psychological impact.[18]

Statistically 9 patients (7.62%) got complicated with expander exposure in 3(2.54 %), haematoma in 4(3.39%) and infection in 2(1.69%). Mohanty et al, in their study of 46 expanders, detected complications in 7 patients (17%), including prosthesis exposure in 3 patients (7.31%), blebs in one (2.43%), hematoma in one (2.43%), wound dehiscence in one (2.43%) and infection in one (2.43%).[19] Ashab Yamin et al, also found prosthesis related complications in 5 patients (13.89%) including prosthesis exposure in 2 patients.[17]

New applications of tissue expansion in head and neck reconstruction include self-expanding implants, developing use of growth factors and cytokines to improve the outcome of tissue expansion, and application of bone distraction to defects for the midface and mandible.[20]

Careful patient selection for tissue expansion, proper surgical planning, meticulous surgery with special attention to details lead to significant improvement in facial scars maintaining facial aesthetics.

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