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A Retrospective Comparative Analysis between Tissue Expansion in Limb and Non Limb Sites: A Single Author Experience

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ABSTRACT

Tissue expansion technique is considered an important tool in the armamentarium of reconstructive surgery. It provides donor skin that is optimal match in terms of skin color, texture, sensation and hair-bearing characteristics. Literature shows its applications from head to feet. But tissue expansion in the extremities carries high rate of complications. Fortunately, not every complication in tissue expansion means failure.

Objective: A retrospective comparative analysis between tissue expansion in limb and non limb sites.

Material and Methods: Ninety-four expanders in 84 patients were included. These constitute a single author experience. Sixty five expanders (69%) were applied to non-limb sites and 29 expanders (31%) to limb sites. Indications were mainly post burn and post traumatic scarring. Complications and failure were recorded.

Results: Non-limb expanders showed 18.46% complications and 4.6% failure. Limb expanders showed 31% complications and 10.34% failure. Among limb expanders, upper limb showed 13.33% complications and 6.66% failure. Lower limb expanders showed 50% complications and 14.28% failure.

Conclusion: Although there was high complication rate in expanders applied to extremities, 10.34% failure rate does not justify forbidding the use of such great technique in extremities reconstruction. Close follow-up of patients will prevent many complicated expanders from failure.

INTRODUCTION

Neumann **[1]** was the first to describe the use of a subcutaneous implant to reconstruct an external ear deformity. But Radovan **[2]** was the first to gain extensive clinical experience with the tissue expansion techniques. The technique was rapidly and widely applied to create new dimensions in reconstructive surgery **[3-9]**.

Tissue expansion is based on the observation that all living tissues respond in a dynamic fashion to mechanical stresses placed on them **[10]**. The increase in skin surface area over the expander includes normal skin brought in from adjacent areas as well as new skin generated by increased mitosis **[11]**. Agris **[12]** wrote "we are not just expanding, but creating new tissue".

Tissue expansion provides donor skin that is optimal match in terms of skin color, texture, sensation and hair-bearing characteristics. Literature showed that the tissue expansion technique was used in almost all areas of the body from scalp to feet. It has achieved its most notable successes in the areas of breast and scalp reconstruction **[2,4,5,13]**.

Tissue expansion in the extremities is associated with a high rate of complications **[6,14-25]**.

The aim of this study is to demonstrate a retrospective comparative analysis between tissue expansion in limb and non limb sites through a single surgeon experience.

PATIENTS AND METHODS

This retrospective study included the author experience with 94 expanders in 84 patients. Thirty were male (35.7%) and 54 were female (64.3%). The youngest patient was 3 year old while the oldest was 45 year old. Twenty percent of patients (17 patients) were between 3 and 12 years and 41.6% were equal to or less than 18 years. Sites for application of tissue expanders are shown in Table (1). Indications for tissue expansions are shown in Table (2).

All patients were operated upon under general endo-tracheal anesthesia. The surgical procedures differ according to the site of application. For the scalp, remote incision perpendicular to the long axis of pocket of expander was used. Incision should not interfere with the vascularity of the planned flap after delivery. The scar will be hidden within the hair bearing area. The subgaleal plane is used. For the reconstruction of breast after

mastectomy, the expander will be applied in submascular plane. For the remaining areas in the body the subcutaneous or subfascial planes were used. Incisions in non hair bearing sites should be put at areas that will be discarded with the scar tissue after advancement of the flaps or at inconspicuous areas. The valves (ports) in all cases were buried. Suction drains were left in all cases until the suctioned fluid turned serous fluid. Ten percent of the expander volume was injected intraoperatively. After two weeks lag period, inflation of the expanders using normal saline fluids began. The frequency of injection was once a week. The amount to be injected depends on the tightening of the skin, the blanching, the pain and the presence of sharp edge of expander pushing on the overlying skin. Whenever there was sharp edge of expander pushing on the skin the expansion was very slow till smoothening of the sharp edge. Afterwards, expansion was fast. Every time before injection of normal saline, adequate disinfection of the site of injection was performed. While removing the injecting needle, any turbid fluid coming out of the puncture site at skin was observed. This indicated the presence of infection. In all cases with infection exteriorization of the buried ports was done to drain infection from the pocket connecting the port to the expander **[26]**. Over-inflation of the expanders was the routine except if the expanded amount was enough or late exposure developed necessitated immediate delivery. After full expansion, the expander was left two weeks without further inflation before delivery. In cases of post mastectomy reconstruction the expander remained three months before it was replaced with permanent implant. Figs. (1a, 2a, 3a, 4a, 5a, 6a, 7a, 8a) show applied tissue expanders in scalp, forehead, face, neck, breast and upper abdomen, arm, hand and leg respectively.

RESULTS

Despite there was complications in 21 out of the 94 expanders used, failure occurred in 6 expanders (Table 3). The remaining complications were managed by either immediate delivery whenever expansion approached full size or salvage of expander by exteriorizing the buried port in case of infection. Percentages of complications and failure per site are shown in Table (4). Table (5) shows the complications and failure in limb and non-limb sites, while Table (6) compares the percentage of complications and failure in limb and non-limb sites. Table (7) compares the percentage of complications and failure in upper and lower limbs.

Results showed that post burn scarring, contracture and alopecia accounted for 53 indications out of the 84 (63%). Non-limb expanders accounted for 65 of the 94 expanders (69%). Limb expanders accounted for 29 of the 94 expanders (31%). Whereas complication rates in non-limb sites accounted for 18.46%, complication rate in limb sites accounted for 31%. Failure rate in non-limb sites was 4.6% and in limb sites was 10.34%. Complication rate in upper limb was 13.33% and in lower limb was 50%. Failure rate in upper limb was 6.66% and in lower limb was 14.28%. Figs. (1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b) show advancement of expanded flaps, after delivery of tissue expanders and excision of skin grafts and scars.

Table (1): Sites for application of expanders.

Site	Number of patient	Number of expanders
Scalp	23	25
Face	5	6
Neck	11	13
Back	6	6
Abdomen	9	9
Breast	5	6
Thigh	9	11
Leg	2	3
Arm	9	10
Forearm	3	3
Hand	2	2
Total sites	84	94

Table (2): Indications for tissue expansion.

Indication	Number of patients
Post burn scarring and contracture	38
Post burn alopecia	15
Post traumatic scarring and skin grafts need ablation	11
Post inflammatory scarring and alopecia	7
Post mastectomy reconstruction of breast	4
Before excision of giant hairy mole	3
To provide expanded full-thickness skin graft	3
Before excision of cirsoid aneurysm	1
Before elevation of median forehead flap	1
Before augmentation cranioplasty	1

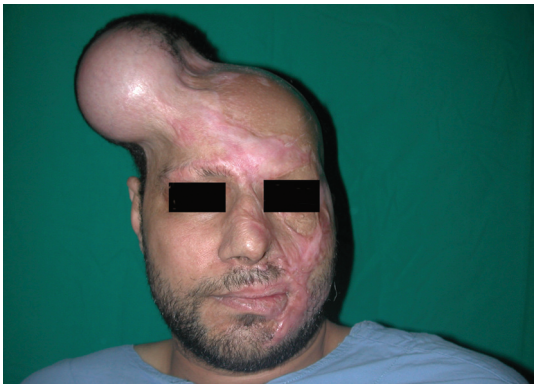

Fig. (1-A): Tissue expander in the scalp and forehead to ablate the skin graft applied after chemical burn.

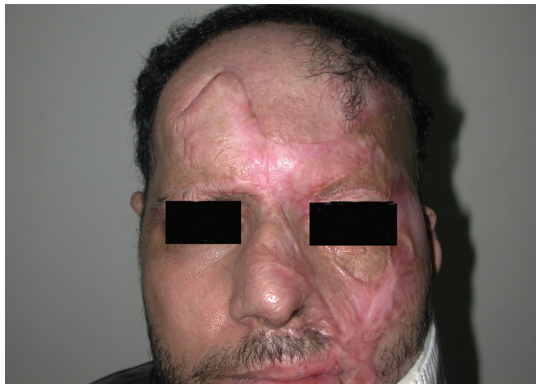

Fig. (1-B): Advancement of the expanded scalp and forehead flap after excision of most of the skin graft of scalp and forehead.

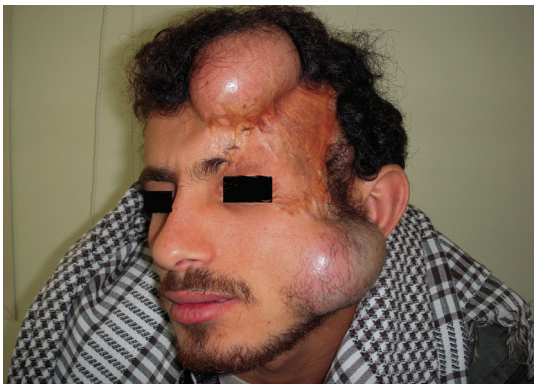

Fig. (2-A): Two tissue expanders applied in the forehead and left cheek to manage post inflammatory scarring of the left upper and midface.

Fig. (2-B): Advancement of the expanded flaps after excision of the scarred left upper and midface.

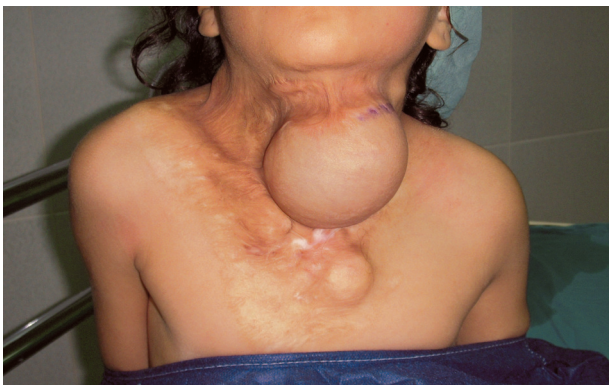

Fig. (3-A): Tissue expander applied to the left side of the neck to manage post burn scarring of the right side of neck.

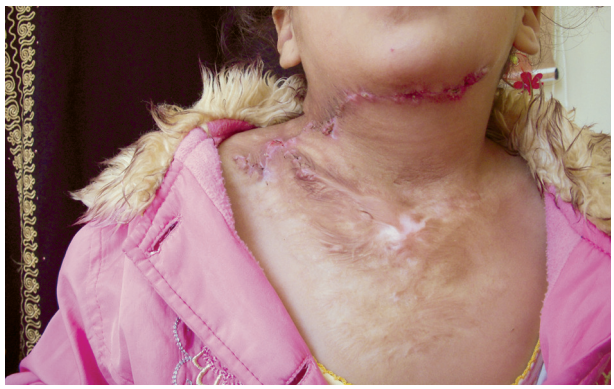

Fig. (3-B): Advancement of the flap after excision of the post burn scarring of the right neck.

Fig. (4-A): Tissue expander applied to the upper abdomen to manage post burn scarring of the right inframammary fold and the right upper abdomen.

Fig. (4-B): Advancement of the flap after excision of scarred tissues of the right inframammary fold and the right upper abdomen.

Fig. (5-A): Iatrogenic absence of the right breast after surgical intervention to the right breast in early childhood.

Fig. (5-B): Reconstruction of the right breast in two stages. The first stage was by rounded subpectoral tissue expander. The second stage was by replacement of the tissue expander by silicon filled breast implant. The nipple was reconstructed in the 2nd stage.

Fig. (6-A): Tissue expander applied to the left arm to ablate meshed skin graft in the upper left arm.

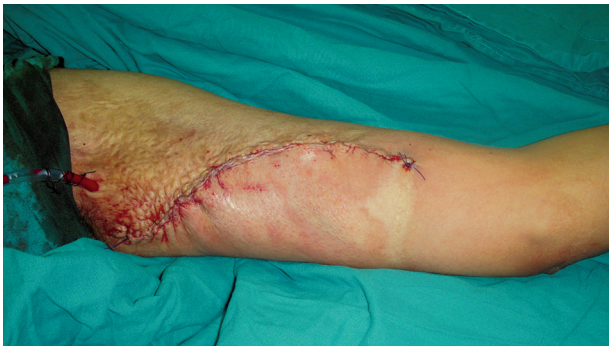

Fig. (6-B): Advancement of the flap after excision of most of the meshed skin graft at upper left arm.

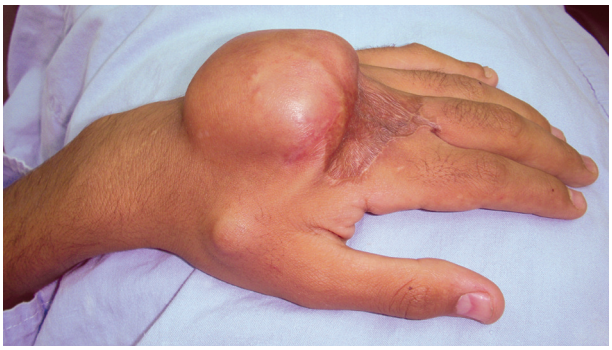

Fig. (7-A): Tissue expander applied at the dorsum of left hand to ablate skin graft at the dorsum of left hand.

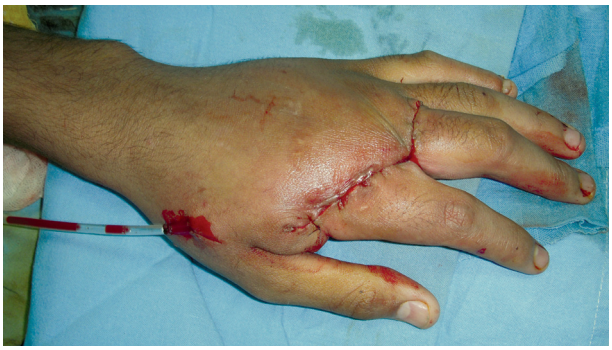

Fig. (7-B): Advancement of the flap at dorsum of left hand after excision of the skin graft.

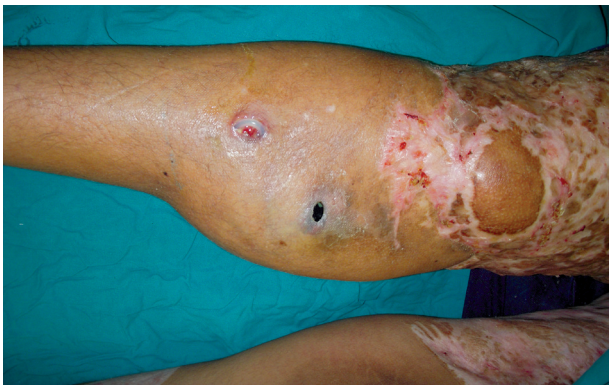

Fig. (8-A): Tissue expander applied to the right leg to reconstruct post traumatic scarring and contracture at the right knee. Late exposure of the expander is seen in the photo.

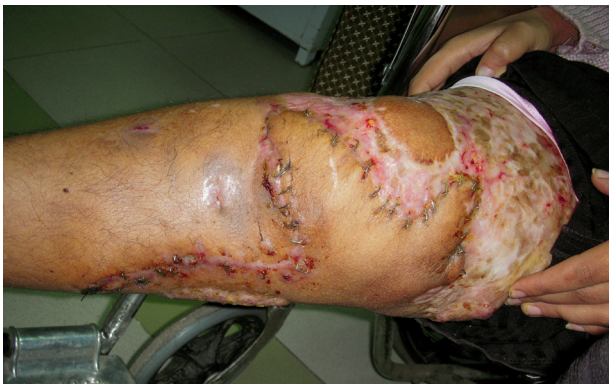

Fig. (8-B): Advancement of the flap to release scar and contracture at the right knee.

Table (3): Complications and failure per site.

Site	Expanders	Complicated expanders	Intervention	Failed
Scalp	25	2 infected 1 late accidental puncture 2 late exposure	Salvaged Delivered Delivered	None
Face	6	1 exposure of port	Salvaged	None
Neck	13	1 early exposure	Removed	1
		1 late exposure and infection	Delivered	
Back	6	2 infections	1 Salvaged	1
Abdomen	9	1 infection	Salvaged	None
Breast	6	1 infection	Removed	1
Thigh	11	1 late accidental puncture 4 infection	Delivered 3 Salvaged	1
Leg	3	1 early exposure and infection 1 late exposure	Removed Delivered	1
Arm	10	1 early exposure	Removed	1
Forearm	3	1 infected	Salvaged	None
Hand	2	None	None	None
Total	94	13 infected 2 late accidental puncture 8 exposures	9 Salvaged Delivered 3 Removed	4 3
		21 complicated expanders*		6 failed expanders*

*There were combined exposure and infection in two cases, one of them ended up with failure. That is why complicated expanders were 21 instead of 23 and failed expanders were 6 instead of 7.
Delivered means successful delivery and flap advancement while removed means failed.

Table (4): Percentages of complications and failure per site.

Site	Complication	Percentage	Failure	Percentage
Scalp	5/25	20	0	0
Face	1/6	16.6	0	0
Neck	2/13	15.38	1/13	7.7
Back	2/6	33.33	1/6	16.66
Abdomen	1/9	11.11	0	0
Breast	1/6	16.66	1/6	16.66
Thigh	5/11	45.45	1/11	9
Leg	2/3	66.66	1/3	33.33
Arm	1/10	10	1/10	10
Forearm	1/3	33.33	0	0
Hand	0/2	0	0	0
Total	20/94	21.27	6/94	6.38

Table (5): Complications and failure in limb and non-limb sites.

Complication	Infection		Accidental puncture		Exposure	
	Salvaged	Non-salvaged	Salvaged	Non-salvaged	Salvaged	Non-salvaged
Non-limb sites	5/65	2/65	1/65	0/65	4/65	1/65
Limb sites	4/29	2/29	1/29	0/29	1/29	2/29

- Combined infection and exposure occurred in one expander in limb group that is why non salvaged expanders are 7 here instead of 6 and complicated expanders are 13 here instead of 12. Similarly combined infection and exposure occurred in one expander in non-limb group that is why complicated expanders are 10 here instead of 9.
-Non-salvaged means failed.

Table (6): Percentage of complications and failure in limb and non-limb sites.

	Complication No.	Complication %	Failure	Failure %
Non limb expanders	12/65	18.46%	3/65	4.6%
Limb expanders	9/29	31%	3/29	10.34%

Table (7): Percentage of complications and failure in upper and lower limbs.

	Complication No.	Complication %	Failure	Failure %
Upper limb expanders	2/15	13.33%	1/15	6.66%
Lower limb expanders	7/14	50%	2/14	14.28%

Table (8): Comparison between the results of this study and Pandya et al., study, regarding expanders' complication and failure in limb and non-limb sites.

	Complication non-limb group	Complication limb group	Failure non-limb group	Failure limb group
Pandya et al., study	27%	43%	14%	17%
This study	18.46%	31%	4.6%	10.34%

Table (9): Comparing rate of complication and failure between upper and lower limbs in this study and Pandya et al., study.

	Complication upper limb	Complication lower limb	Failure upper limb	Failure lower limb
Pandya et al., study	30%	47%	20%	16%
This study	13.33%	50%	6.66%	14.28%

DISCUSSION

Tissue expansion has become a well established method for soft tissue reconstruction. However, tissue expansion is not a panacea and carries a significant complication rate, even in the hand of experienced surgeons **[27]**. In this retrospective study, the number of females (64.3%) approaches to double the number of male patients (35.7%). This may be explained by that the female patients are more sensitive to any deformity than male patients. Therefore female patients accept tissue expansions more than male patients. About 40% of cases were equal to or less than 18 years which is the teenage when the person is maximally minded by his/her body shape. Friedman et al., recommended deferral of tissue expansion until at least the age of 7 years to maximize cooperation and minimize complications **[28]**. Only 7.14% of cases in this study were less than 7 years of age. Maclennan et al mentioned that scalp expansion is best deferred until at least the age of 2 years, to minimize molding of soft calverial bone **[27]**. In this study the youngest patient who has tissue expansion to scalp was 3 years of age and the expansion was very slow. Mild skeletal deformity occurred in this patient and spontaneous remodeling corrected this deformity within 6 months.

Post burn scarring, contracture and alopecia in this study represents 63% of indications. This is because reconstruction of burn usually does not have many options. For post burn alopecia no other option to have hair bearing flaps. In addition burned patients have paucity of appropriate donor sites.

The most common sites for use of tissue expansion in this study were scalp and neck. They accounted for 47% of expanders. That is why the applications in non-limb sites were more common 69%.

Comparing the results of this study to similarly designed study of Pandya et al. **[25]** shows better results of this study regarding complication rate and failure rate in limb and non-limb groups. Both studies show low complication and failure rate in non-limb group. When comparing the results of complication and failure rate in upper limb and lower limb, the results of this study shows better results than Pandya et al. **[25]** study.

The average complication rates in limb expanders of 7 previous studies **[6,14,16,18,19,24,29]** was calculated by Pandya et al. **[25]** to be 38%. On the other hand the average failure rate in limb expanders among 6 previous studies **[6,16,18,19,24,29]** was calculated by Pandya et al. **[25]** to be 16%. These averages are located between the results of Pandya et al. **[25]** and that of this study.

*Pandya et al. **[25]** mentioned the causes that increase complication in extremities:*

1- Frequent motion, resulting in compressive and disruptive forces exerted by the regional musculature.

2- The difficulty to create a pocket from a distance, around a curve in a cylindrical extremity.

3- The limbs are poorly covered with muscle and/or soft tissue.

4- The presence of an incision in an area being expanded which predispose to incisional dehiscence.

To avoid these previous causes of complications and failure the following regimen was adopted in this study:

1- Dissection of a pocket wider than the expander and adoption of slow expansion to avoid disruptive forces.

2- Application of small expanders to avoid the difficulty of dissecting a large pocket around a cylindrical extremity.

3- Dissection should be subfascial or just suprafascial to increase soft tissue covering the expanders (if subfascial, care has to be taken to avoid compartmental syndrome).

4- Incisions in non scarred tissues better well away from the site of expansion are needed to avoid incisional dehiscence. All these precautions together with management of infection by exteriorizing the buried port improved the results of this study.

*Casanova et al. **[30]** mentioned other precautions to improve results in limb expansions:*

1- Carefull preoperative planning **[6,18,31,32]**.

2- the proper expander size should be chosen with care to prevent folds in the silastic envelope **[18,32]**.

3- Areas of scarring or previous irradiation should be avoided (Antonyshyn et al. **[18]** and Masser **[32]**).

4- The prostheses chosen for limb should be as neumerous as possible and shaped so that no skin is left unexpanded **[32]**.

5- they should be placed longitudinally, if possible, because it is more difficult to create adequate flaps for axial use than for transverse use in the leg **[16]**.

Casanova et al. **[30]** discussed the advantages of external valves. They stated that "they often use the external valves to avoid undermining extra skin and producing a hard point below skin when the fatty layer is thin" **[29]**. They used external valves in 61.5% of cases of skin expansion below the knee. External valves prevent port failures such as leakage, malposition and disconnection problem and avoid the complications associated with needle puncture. The possibility of infection via the connection-tube hole requires careful dressing.

In this study the buried port technique was used to avoid the infection and the need for dressing. However, when infection occurred the ports were exteriorized to provide access for drainage of infection **[26]**.

It is to be concluded that complications do not mean failure. Close follow up prevents many complicated expanders from failure. Failure rate 10.34% does not justify forbidding the use of expanders in extremities. A study including larger number of expanders has to be performed. Patients should be informed about the higher rate of complications and failure of expanders in extremities to weigh this risk against the benefit of using expansion technique.

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