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Maximizing the Gain from Tissue Expanders in Extremities Reconstruction

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ABSTRACT

Tissue expansion in extremities had a bad reputation due to high rate of complications. But not every complication is a failure. Improvement in expanders quality and advances in the techniques that allow management of complications without aborting the procedures, improved the results. Another point of concern is how the expanded flaps can be used to reconstruct the deformity and at the same time with no flap necrosis. It is very disappointing to have any loss of the flaps after long course of expansion and hope. The aim of this article was to present the authors experience with tissue expansion in extremities and to present the different options of how to use the expanded flaps in the extremities to maximize gain. Of 57 expanders used, 43 flaps were directly advanced with no back cuts. Back cuts on one side of the expanded flap were used in 11 flaps. Five expanded flaps were included in "5-flaps design" or "Z-plasty design". There was failure of expansion in Two cases with no advancement at all. Direct advancement was very safe with no complications. Back-cut (transposition flaps) helped maximal gain but there was partial flap necrosis in two cases which were managed conservatively by dressings. Inclusion of the expanded flaps in "5-flaps design" or "Z-plasty design" helped release of associated contractures. Conclusion is that in difficult deformities in the extremities when direct advancement cannot solve the deformity back-cut on only one side of the expanded flaps can reconstruct the deformity safely. Expansion provides skin that can help release of contractures.

INTRODUCTION

Tissue expansion provides donor skin that is optimal match in terms of skin color, texture and sensation. Literature showed that the tissue expansion technique has been used in almost all areas of the body. But tissue expansion in the extremities has been reported to have high complication rate **[1-13]**. The main causes of these complications were infection and exposure. Using soft based expanders and using multiple small expanders lowered the rate of exposure. Techniques that were devised to manage infected expanders allowed salvage of expanders and completion of expansion **[14-18]**. A recent study done by the author found statistically non-significant difference between tissue expansion in limb and non-limb sites **[19]**.

Different techniques in literature were described to maximize the gain from tissue expanded flaps **[8,20-24]**. They achieved maximal gain by advancement of the flap and adding back-cut to the sides of the advanced flaps. Whereas double back-cut flap advance very nicely and open the flap effectively, the single back-cut design appear as Zide and Karp state to be well suited to filling triangular defects **[25]**.

The advantages of the expanded transposition flaps over the pure advancement include the ability of the transposition flaps to dissipate tension away from the flap apex and distribute it more proximally. This prevents distortion in the reconstructed region. In addition flap design prevents webbing and tenting across concavities which can happens with pure advancement of the expanded flaps **[23]**.

On the other hands the disadvantages of the expanded transposition flaps includes addition of scars in a patient whose target is cosmetic management of a deformity **[25]** and the risk of compromising the vascularity of the transposition flap if the back-cut was not designed properly.

The aim of this article was to present the author's experience with tissue expansion in extremities and to present the different options of how to use the expanded flaps in the extremities to maximize gain.

PATIENTS AND METHODS

The study included 41 patients, 29 were females and 12 were males. The youngest patient was 4 year old and the oldest was 32 year old. More than, one expander were used to manage single deformity in 9 patients. Three patients had expanders applied

at different limb locations in the same patient (shoulder and arm in one patient, leg and upper thigh in one patient and leg and foot in one patient). Expanders in bilateral extremities were used in three cases (both thighs in one patient and both buttocks in two patients). The deformities were post burn in 25 patients, post traumatic in 14 patients, giant hairy mole in one patient and post surgical (15 years after separation of conjoint twins from buttock) in one patient. Table (1) shows data of the patients according to the site of the expander application, the number of the expanders applied, the flap design options.

Preoperatively, history taking was the routine, followed by examination and preoperative investigation. The idea of the procedure and the risk of complications were explained to the patient. Consent forms for the surgery and for photography were signed by all patients. Photos were taken to all patients before insertion of the expander, after full expansion before removal and after removal and insetting the flaps. The patients were followed-up for at least three months.

At the time of the application surgery the plan for application of expanders was studied well. The decision to use one or more expanders and the size of the expander and the site of application were all planned before surgery. All expanders used were rectangular in shape. All expanders had soft bases and remote injection ports. All ports were buried subcutaneously except in three cases the ports were left external because there was no space to bury the ports.

The operation was performed under general endotracheal intubation. All patients received intravenous single dose of antibiotics administered after endotracheal intubation. The incisions to insert the expanders were as small as possible and in normal non affected skin to avoid delayed healing. The site of incision was planned to be excised with the lesion during delivery of the expander. Dissection of the pockets was done subcutaneously to avoid increase compartmental pressure in extremities during inflation in case it was placed subfascial. Ten percent of the expanders volume was injected intra-operatively.

All patients were followed very closely post operatively and injection of the expanders with normal saline solution repeated once weekly. Seven patients presented during the course of expander inflation with signs of infections. Patients presented with early signs (five patients) were salvaged whereas the patients presented lately (two patients) after the infection was spontaneously drained from the skin covering the expanders were non-salvageable and the expanders were removed by evacuation of the saline and removal of the expanders under local anaesthesia. The first sign of infection in my experience was the collection of sero-purulent fluid over the ports. This fluid reached there through the tunnel containing the tube connecting the expander to the port. Salvaging was through incising the skin over the port and exteriorizing the port. The collected sero-purulent fluid was then drained and the pocket was washed through the connecting tunnel using Gentamycin.

After completion of expansion (usually within three to four months) the patients were re-operated upon for delivery of expanders under general endotracheal entubation. Excision of the deformed tissues was done and the expanded flaps were advanced. There were three options for the use of the expanded flap. The first option which was used in 43 expanded flaps was the pure advancement with no back-cut. The second option was the back-cut technique on one side of the expanded flaps. In this second option incision was placed along the advancing edge of the flap and then continued halfway along the side of the expander. From this point back-cuts were made to the height of the expander on one side. This was applied to 11 expanded flaps. This option is tricky because any extension in the back-cut may compromise the vascularity of the flaps. The third option which was used in five flaps was the inclusion of part of the expanded flaps in "5-flaps design" or "Z-plasty design" to help release of contracture at the same time of excising the deformed tissues.

Flaps were inset in place and sutured in two layers and suction drains were left. No compression was applied to the flaps to avoid affecting their vascularity. The patients were followed-up for vascularity in cases of transposition flaps and the drains were removed when the bloody discharge changed into serous discharge and oral antibiotics was recommended for all patients and continued till the removal of the drain.

RESULTS

After performing the tissue expanders application surgery the patient recovered from the anaesthesia and the early post operative period was uneventful. Follow-up revealed infection in seven expanders. Five were salvaged and two were non-salvageable and removed. Late exposure occurred near the end of the course of expansion in two expanders one applied at the leg and the other at the foot.

After delivery of tissue expanders the patients recovered from the anaesthesia and the early post operative period was uneventful. All flaps survived completely except two transposition flaps showed partial tip necrosis. This was managed conservatively using dressings and healed with secondary intension. This did not affect the final results and there was no contracture resulted from healing by secondary intension because the areas affected did not cross joints. Table (1) shows the complications of expanders and the complications of the flaps.

Although the percentage of the infected expanders was 12.3% and the percentage of total complications affecting expanders (including the late exposure) was 15.8% the failure was only 3.5%. The percentage of complications (partial necrosis in two flaps) among the transposition flaps was 18.2% while among the total expanded flaps was 3.5%.

Figures (1A,B,C, 2A,B,C, 3A,B) show the results after completion of expansion and after the delivery and advancement of the flaps.

Table (1): Data of the patients according to the site of the expander application, the number of the expanders applied, the flap option and complications.

Site	Number of sites	Number of expanders	Flap design options	Complications
Shoulder	3	3	Pure advancement in 3	None
Arm	11	11	Pure advancement in 8 Inclusion in 5 flap design in 2 No advancement in 1	Failure in 1 (early non-salvageable infection and exposure)
Around Elbow	3	6	Pure advancement in 3 Transposition flaps in 2 Inclusion in 5 flaps in 1	Salvaged infection in 1 Partial necrosis in the tip of a transposed flap in 1
Forearm	5	5	Pure advancement in 3 Transposition flap in 1 Inclusion in 5 flaps in 1 Inclusion in Z in 1	Salvaged infection in 1
Hand	3	3	Pure advancement in 3	None
Buttock	2	4	Pure advancement in 4	None
Buttock and Thigh	2	5	Pure advancement in 5	Salvaged infection in 1
Upper Thigh	6	8	Pure advancement in 4 Transposition flaps in 4	Salvaged infection in 2
Lower Thigh	2	2	Pure advancement in 1 No advancement in 1	Failure in 1 expander (non-salvageable infection and early exposure)
Around Knee	1	2	Pure advancement in 1 Transposition flap in 1	Partial necrosis of the tip of a transposed flap in 1
Leg	5	6	Pure advancement in 3 Transposition flaps in 2 No advancement in 1	Late exposure in 1 Salvaged infection in 1 Failure in 1 (non-salvageable infection and early exposure)
Foot	1	2	Pure advancement in 1 Transposition flaps in 1	Late exposure in 1
Total	44	57	58 options	

Total number of patients was 41 because expanders were applied at different limb locations in the same patient in three occasions (shoulder and arm in one patient, leg and upper thigh in one patient and leg and foot in one patient).

At the forearm one expanded flap had transposition flap at one end, and inclusion in Z-plasty at the other end that is why there were 58 flap's options for 57 expanders.

Seven infections occurred in this series but 5 were salvaged and 2 non-salvaged.

Two late exposures did not affect the outcomes.

Fig. (1-A): Photo of the upper limb of a 7 year old female patient shows post burn scaring and contracture. Two fully inflated expanders are shown.

Fig. (1-B): Photo for the same patient in Fig. (1A) shows the design of 5-flaps to release the contracture at the elbow. Parts of the expanded flaps are included in the design.

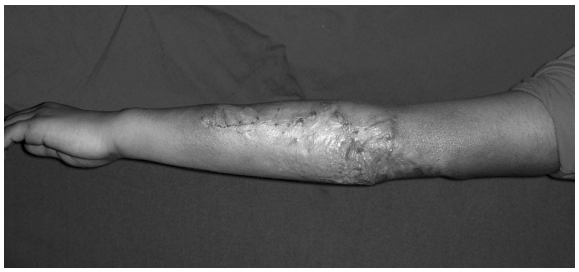

Fig. (1-C): Late post operative photo for the same patient in Fig. (1A).

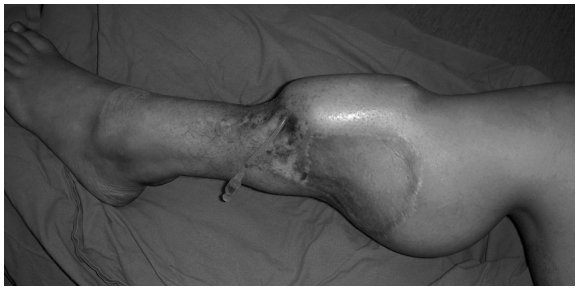

Fig. (2-A): Photo of the leg of a 20 year old female patient shows post traumatic grafted area. Two fully inflated expanders are shown. The port of the anterior expander is external because it was exteriorized to salvage the infected expander.

Fig. (2-B): Photo of the same patient in Fig. (2A) shows back-cut at one side of the anterior expander (the lower side) and the posterior expanded flap was advanced directly without back-cuts.

Fig. (2-C): Late post operative photo for the same patient in Fig. (2A).

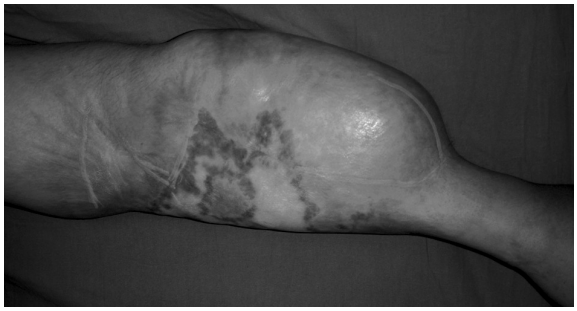

Fig. (3-A): Photo of the forearm of a 24 year old female patient shows post burn scaring in the forearm and contracture at the elbow. Fully inflated expander is shown. Drawing over the expander shows back-cut design at the distal side of the expanded flap and the proximal part is included in Z-plasty design to release contracture at the elbow.

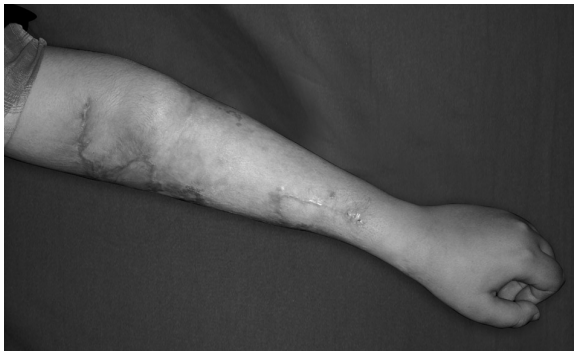

Fig. (3-B): Late postoperative photo for the same patient in Fig. (3A).

DISCUSSION

Tissue expansion is considered one of the best reconstructive techniques that can be applied everywhere in the body. Nothing can provide similar results without leaving a donor site morbidity. The disadvantages include complications especially in extremities and the cost.

The average complication rates in expanders applied to extremities from seven previous studies **[1,2,4,6,7,12,26]** were calculated by Pandya et al., **[13]** to be 38% and the average failure rate among six previous studies **[1,4,6,7,12,26]** were calculated by Pandya et al., **[13]** to be 16%. These averages werenlocated between the results of Pandya et al., **[13]** (42.8% complications and 16.6% failure) and my previous study **[19]** (30% complications and 15% failure).

In this current study the percentage of complications was 15.8% and the failure was 3.5%. This improvement in success rate of expansion in the extremities can be explained by gaining experience and by inclusion of non burn cases. Experience was in the form of using softer base expanders, multiple small expanders instead of single large ones, early detection of infection and early intervention. In deformities affecting the joints two expanders were used one proximal and one distal (Three cases around the elbow and one case around the knee). A deformity in the leg was managed by two expanders and another deformity in foot was managed by two small expanders. Burn that causes deformity and necessitates application of tissue expanders usually affects large area of the circumference of the limb. Therefore part of the expander might be covered by burned skin. This may explain the higher rate of complication and failure in the previous study when complications and failures were calculated on burned cases only.

Management of infected expanders using the technique of exteriorizing the buried port **[18]** was successful in five infected expanders and failed in two. Cause of failure was the late coming of the patients after the discharge became purulent and drained spontaneously through the skin covering the expanders resulted in exposure. Early exposure meant failure of the procedure.

Late exposure resulted from pressure necrosis over the expander and over the tube connecting the port to the expander. The cause was the bad skin quality and the poor blood supply in the leg and foot compared to other regions in the extremities. Hopefully this happened near the end of the course of expansion and did not endanger the procedure. The expanders were delivered and the flaps were advanced successfully.

Options for advancement of the flaps included first option which was pure advancement. This was proved to be very safe and easy and whenever possible this should be the target. Extra-expansion was the only thing needed in many expanders to allow pure advancement. Therefore overexpansion is considered one of the methods of maximizing gain from expanders in extremities.

The second option was the use of single back-cut on one side of the expanded flaps to create transposition flaps to cover triangular or V-shaped defects. The defects resulted from transposition of this flaps were either closed directly or interposing triangles of local tissues went into these back-cuts. Double back-cut is very risky in extremities based on the fact of poor blood supply and was not tried. Partial necrosis in two transposition flaps was caused by overenthusiastic extension of the back-cuts. As was mentioned in the patient and method section the back-cut should stop at the height of the expander.

The third option for maximizing gain from expanders in extremities was the inclusion of part of the expanded flap into a “5-flap design” or “Z-plasty design” to manage associated contracture. This was very effective in management of post-burn contractures associated with the post-burn scarings.

Conclusion:

Three options are available to maximizing gain from expanders in extremities. Pure advancement of the expanded flaps is the simplest and the safest. Overexpansion may be the only thing required to achieve this target. Expanded transposition flaps maximize the use of the expanded tissues in both vertical and horizontal direction with minimal distortion of the adjacent tissues. Inclusion of part of the expanded flaps in the geometric designs to release contractures is very sound idea to manage post-burn contracture associated with the post-burn scarring.

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