TISSUE EXPANSION IN RECONSTRUCTIVE SURGERY: APPRAISAL OF EL-MINIA EXPERIENCE.

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The use of tissue expanders in reconstructive surgery has become well established and found wide applicability, but their use has been associated with multiple complications. Recent advances in the technical aspects of tissue expanders and developed experience led to an overall reduction in the high rate of these complications.
Over about 5 years, a total of 90 tissue expanders were inserted for the reconstruction of different lesions in 51 patients using the same surgical protocol. These cases were done in the Plastic Surgery Unit at El-Minia University Hospital. In 29 cases (56.9%), more than one expander were used in the same patient simultaneously. Of the 90 expansions there were 78 complete successes (86.6%), 2 failures (2.2%), and 10 expanders had to be removed prematurely (11.1%). Seventy-one expanders (78.8%) were new and 19 (21.1%) were re-used for the same patients after being cleansed and autoclaved. Sixty-one injection ports (67.7%) were inserted internally and 29 (32.2%) were exteriorized. Overall outcome in most cases (86.6%) was excellent; however, complications were common.
This study summarizes the experience in using tissue expansion in reconstructive surgery in the Plastic Surgery Unit. It came to the conclusion that tissue expansion is a good and safe technique that allows the surgeon to overcome many qualitative and quantitative tissue deficiencies in selected cases. The re-use of the expanders for the same patient does not increase the rate of infection or extrusion, while exteriorization of the valve, specially in the scalp, increases rate of infection. The outcomes from tissue expansion procedures done in this series are similar to most of those reported in the literature.

Keywords: Tissue expansion; Reconstructive surgery.

INTRODUCTION

Tissue expansion is one of the most important contributions in plastic and reconstructive surgery in recent decades. Human tissue readily adapts to physiologic expansion without thinning of the overlying skin. The living integumentary tissue in vivo responds to gradual stress stimuli by increasing mitotic activity to maintain its thickness and protective integrity [1].

The technique of stepwise skin expansion was first described by Wilson 1948, who documented that serial excision could be used for surgery[2]. The first published clinical report of tissue expansion was by Neumann using a rubber balloon in 1957. In early 1970s, Radovan re-introduced the technique and started using silicone balloons with self-sealing valves. This work went largely unheeded until the first soft tissue expansion seminar, that was held in Ann Arbor, Michigan in 1982, which led to the wide spread acceptance and use of the technique in reconstructive surgery [3].

Tissue expansion was developed for a specific indication; however, within a very short time, this concept has found wide applicability. It has gained increased acceptance in post-burn reconstruction of scalp alopecia and burn scars [4,5]. With adequate planning, this procedure results in minimal or no donor scar, a characteristic unique to this technique [6] .

As expected, this technique has resulted in various complications during its development. The novice surgeon may experience complication rates as high as 40%, primarily because of improper patient selection, limited

experience, and evolving techniques. As surgeons become more acquainted with the technique, the rates of major complications should decrease to 3-5%. Recent advances in the technical aspects of tissue expanders have led to an overall reduction in the high rate of complications typically associated with their usage [7-12].

AIM of this study was to evaluate the role of tissue expanders in reconstructive surgery. Also, to find out the rate of complications after its use and the cost of treatment in terms of use of hospital resources and length of hospital stay.

PATIENTS AND METHODS

From January 1998 to December 2002, ninety tissue expanders have been utilized in 51 patients at the Unit of Plastic Surgery, El-Minia University Hospital. Tissue expansion was indicated when adjacent skin was insufficient to provide primary closure for optimal functional and aesthetic results after removal of different lesions. The exclusion criteria or the non-candidates included those who could not comply with the protracted course and psychological embarrassment of expansion, lacked enough available donor skin, or exhibited unstable or infected donor tissue. Children less than 4 years of age, especially with scalp lesions were not included.

Materials:

Expanders were available in multiple sizes and shapes from various manufacturers. All expanders were made of silicone, with remote self-sealed valve and connecting tubing. The connectors of the valve and tubing were either metal or plastic. No custom-made prosthesis was used. The shape and size of the expanders were chosen by the surgeon according to the shape of the defect and type of flap to be raised. One up to three expanders were used for the treatment of each defect simultaneously.

Surgical Procedure:

After careful evaluation and planning, the flap to be used for the reconstruction is selected and marked adjacent to the defect. The number, size, and shape of the expanders to be used varied according to the location and size of the defect. Incisions were made at the edge of the defect or away in a healthy tissue. A subcutaneous or sub-muscular pocket was dissected under the defect. The balloon and connecting tubing were implanted in this pocket and the valves were either located internally or exteriorized (Fig. 1). Wounds were closed in layers and all expander sites were drained with closed suction drainage system. The balloon was filled with enough saline to minimize its folds and to occlude the pocket cavity. Prophylactic antibiotics were administered to all patients. As soon as the wounds have completely healed, gradual expansion started with serial, usually weekly, injections of normal saline

through the valve on an outpatient basis. Pain, palpable tenseness, and blanching of the overlying skin dictated the amount of expander inflation for each patient per session. When the estimated expansion has been achieved (usually double the width of the defect), the expander was removed after at least 2 weeks from the last inflation. The lesion was excised, and a flap was created from the expanded tissue and was advanced into the defect and sutured to the adjacent healthy tissues without tension. Two operations at least were required with intervals ranging from few weeks to months, depending on the location and the size of the defect(s).

The results were evaluated in terms of objective criteria (the final reconstructive and esthetic outcomes, as well as complications related to the expansion), and subjective criteria (patient satisfaction about the results whether they are excellent, good, acceptable, or unsatisfactory). These results will be compared to other results of similar studies done elsewhere. Patients will be followed up on an outpatient basis for at least 6 months.

RESULTS

Over about five years, 90 expansion prostheses were inserted in 51 patients on different anatomical areas using the same surgical protocol. There were 37 women and 14 men, with a mean age of 22.23 ±11.03 (range 6 – 65 years). Of them, there were 7 children in the age range of 6 – 14 years (Table 1). Different lesions treated were; 21 scars (post-burn--n = 18, post-trauma -- n = 2, and post-surgery -- n = 1); 11 with alopecia (post-burn cicatricial -- n = 10, and areata -- n = 1); 7 nevi (hairy mole -- n = 6, nevus sebaceous_ n = 1); breast that required reconstruction (n = 4) or augmentation (n = 2); keloid (post-burn -- n = 3); syndactyly (congenital -- n = 2); and lymphedema (scrotum -- n = 1).

In 29 cases (56.9%), more than one expander were used in the same patient simultaneously (table 2). Seventy-one expanders (78.8%) were new and 19 (21.1%) were re-used for the same patient after being cleansed and autoclaved. In sixty-one expanders (67.7%), the injection ports were inserted internally and in the other 29 (32.2%), the ports were exteriorized (table 1). Of the 90 expansions, there were 78 complete successes (86.6%), 2 failures (2.2%) due to necrosis and early extrusion of the implants. The other 10 expanders (11.1%) had to be removed prematurely because of closed infection or extrusion, but reconstruction could be achieved.

Five patients had more than one period of treatment (range 2-4). The median (range) in-patient hospital stay was 8 days (2-69); number of visits to the outpatient clinic for filling were 7 times (5-27); and total treatment period/patient was 76 days (21-189). Follow up ranged

from 6 month to 2 years. Statistical analysis was not valid due to small number of cases in each anatomical site.

The major complications included skin penetration with extrusion of the prosthesis (17.6%, n = 9), closed septic complications or cellulitis (15.7%, n = 8), induced skin ischemia or necrosis after expansion with exposure of the expander system (13.7%, n = 7), breakdown of the surgical wound (5.9%, n = 3), and bad function of the expander or implant failure (5.9%, n = 3). No damage due to undermining was recorded (Table 3).

Skin penetration or extrusion of the implant occurred 9 times in 90 inserted expanders (10.0%). This complication was most frequently observed in the ear & neck (33.3%), lower limb (25%), and scalp & breast (16.6%). Three implants were extruded through adjacent incision sites located within the lesions or at their borders due to breakdown of the suture line. The other 6 implants were extruded through penetration of the necrotic skin due to ischemia. Closed infections occurred in 8 prosthetic insertions (8.8%). This complication was most frequently observed in the neck (33.3%), ear (33.3%), lower limb (25%), and breast (16.6%). No closed infections occurred in the face, lateral forehead or in the mid-forehead with a glabellar flap for nasal reconstruction. Expander produced flap ischemia or necrosis with balloon exposure occurred in 7 out of the 90 expansions (7.7%). The highest rate of exposure occurred in reconstruction of the ear (66.6%), the lower extremity (50%), and scalp (16.6%). Implant failures or deflation occurred in 3 out of the 90 expanders (3.3%). They were recorded in the scalp (16.6%) and upper extremity (12.5%) (Tables 1&3).

The minor complications included; minor sepsis (21.6%), inadequate tissue expansion (17.6%), improper valve location or valve turnover (5.9%), and valve and tubing exposure (5.9%) (Table 3). Minor sepsis occurred in 11 prosthetic insertions (12.2%). This was most common in trunk (43%), post auricular (33.3%), and scalp & lower limb (25%). To a less extent, it was observed in the breast, neck, and upper extremity. Inadequate expansion occurred in 9 out of 90 expansions (10.0%). It was more frequent in the forehead & ear (33.3%), extremities (25%), and scalp & breast (16.6%). Improper valve placement or turnover, or tubing and valve exposure occurred in 6 of the 90 expansions (6.6%). It happened more in the upper limb. Also, it was observed in the scalp, breast, and trunk (Table 1). Evaluation of the results on subjective criteria are presented on (Table 4).

Fig. (1). (Case # 12). Two implants were utilized in the scalp of a boy, 12 years old with post-burn alopecia. The valves were exteriorized for easier injection without pain.

Fig. (2). (Case # 50). A 17-year-old female with giant hairy mole occupying almost the whole right cheek, reaching lateral side of the nose and lateral upper lip. Reconstruction was excellent although necrosis and extrusion had occurred.
A&B-Pre-operative front and lateral views.
C&D-Skin necrosis with exposure of the implant that occurred during expansion of the balloon.
E&F- Post-operative front and lateral views at 2 months.

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Table (1): Demographic and clinical data of 51 patients treated with 90 expanders.

Site	No. of Cases	Sex M/F	No. of Expanders	New Expanders	Re-used Expanders	Int. Valves	Ext. Valves	Minor complications				Major complications					
								Minor Sepsis	Valve turnover	Tubing Exposure	Inadequate expansion	Cellulitis or closed infection	Damage from undermining	Ischemia, exposure of implant	Surgical wound breakdown	Bad function or deflation	Skin penetration or extrusion.
SCALP	12	7/5	22	16(72.7%)	6(27.3%)	12(54.5%)	10(45.5%)	3	1	-	2	1	-	2	1	2	2
BREAST	6	0/6	11	9(81.8%)	2(18.2%)	8(72.7%)	3(27.3%)	1	-	1	1	1	-	-	-	-	1
UPPER EXTREMITY	8	1/7	15	12(80%)	3(20%)	10(66.6%)	5(33.3%)	1	1	2	2	1	-	1	-	1	1
TRUNK	7	1/6	18	14(77.7%)	4(22.2%)	11(61.1%)	7(38.8%)	3	1	-	1	1	-	-	-	-	1
Abdomen	3	0/3	9	7	2	5	4	1	1	-	1	1	-	-	-	-	1
Chest	2	0/2	4	3	1	3	1	1	-	-	-	-	-	-	-	-	-
Back	1	1/0	3	2	1	1	1	1	-	-	-	-	-	-	-	-	-
Genitalia	1	0/1	2	2	-	2	2	1	-	-	-	-	-	-	-	-	-
NECK	6	1/5	10	7(70%)	3(30%)	8(80%)	2(20%)	1	-	-	-	2	-	-	-	-	2
LOWER LIMB	4	2/2	5	4(80%)	1(20%)	3(60%)	2(40%)	1	-	-	1	1	-	2	1	-	1
FOREHEAD	3	0/3	3	3(100%)	-	3(100%)	-	-	-	-	1	-	-	-	-	-	-
EAR	3	2/1	4	4(100%)	-	4(100%)	-	1	-	-	1	1	-	2	1	-	1
FACE	2	0/2	2	2(100%)	-	2(100%)	-	-	-	-	-	-	-	-	-	-	-
TOTAL	51	14/37	90	71(78.8%)	19(21.1%)	61(67.7%)	29(32.2%)	11	3	3	9	8	-	7	3	3	9

Table (2): *Number of implants inserted in the same patient simultaneously.*

No. of expanders/case	No. of Patients	Total No. of expanders
ONE	22 (43.1%)	22 (24.4%)
TWO	19 (37.3%)	38 (42.2%)
THREE	10 (19.6%)	30 (33.3%)
TOTAL	51 (100%)	90 (100%)

Table (3): *Complications in 51 patients treated with 90 expanders.*

COMPLICATIONS		% from No. of expanders	% from No. of cases
Minor sepsis.	11	12.2 %	21.6 %
Improper placement of the valve (turnover).	3	3.3 %	5.9 %
Tubing and valve exposure.	3	3.3 %	5.9 %
Inadequate expansion or premature removal of the implant	9	10.0 %	17.6 %
Cellulitis or closed infection.	8	8.8.%	15.7 %
Damage due to undermining.	-	--	--
Skin ischemia, necrosis, exposure of the implant	7	7.7.%	13.7 %
Surgical wound breakdown.	3	3..3 %	5..9 %
Bad function of the implant, deflation.	3	3..3 %	5..9 %
Skin penetration and extrusion.	9	10.0 %	17.6 %

Table (4): *Results in 51 patients treated with tissue expansion.*

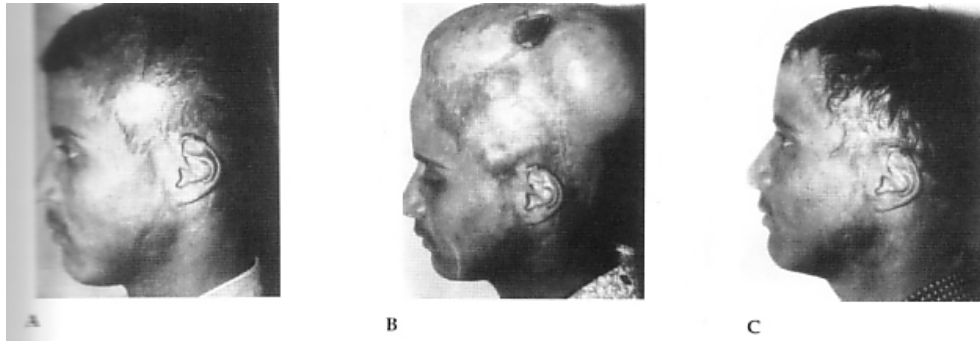| Site	Excellent	Good	Acceptable	Bad	Total
SCALP	4	5	2	1	12
Breast	3	2	1	-	6
Upper Limb	1	4	3	-	8
Trunk	2	4	1	-	7
Abdomen	1	1	1	-	3
Chest	1	1	-	-	2
Back	-	1	-	-	1
Genitalia	-	1	-	-	1
NECK	1	4	1	-	6
Lower Limb	-	2	1	1	4
Forehead	2	1	-	-	3
Ear	-	1	1	1	3
Face	1	1	-	-	2
Total	14	24	10	3	51
	27.4 %	47.1 %	19.6 %	5.9 %	100 %

Fig. 3.   (Case # 11).   Post-burn cicatricial alopecia of the scalp in a male 18 years old. Two expanders, 300 cc each, were utilized for reconstruction.
   A- Pre-operative lateral view.
   B- During expansion.
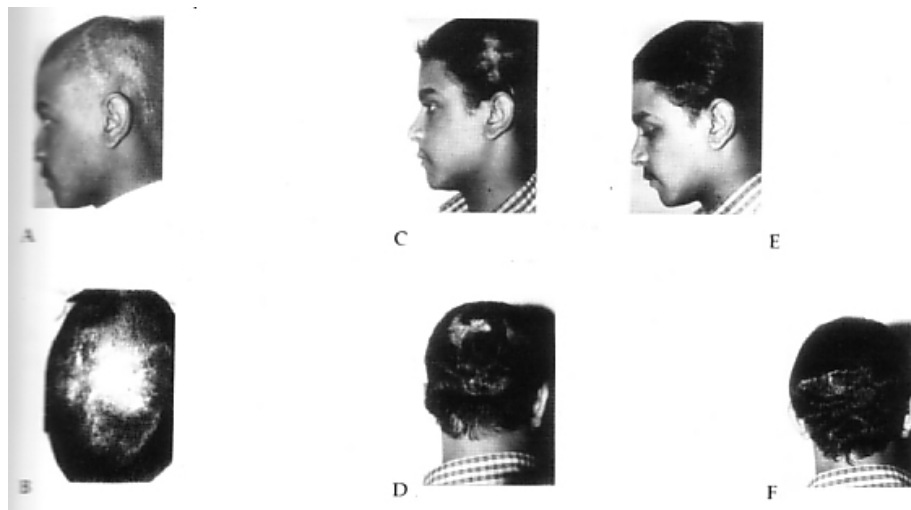   *C- Post-operative lateral view.*

Fig. (4).   (Case # 1).   Post-burn cicatricial alopecia of the scalp in a 17 years old male.
   A&B- Pre-operative lateral and top views.
   C&D- Post-operative lateral and back views after the first stage operations.
   E&F- Post-operative lateral and back views after the second stage operations.

Fig. (5).   (Case # 27).
   A- Post-burn multiple keloid of the anterior abdominal wall in a female child, 11 years old.
   B- Three expanders have been inserted in the anterior abdominal wall. One of the valves was exteriorized.
   C- Early post-operative view.
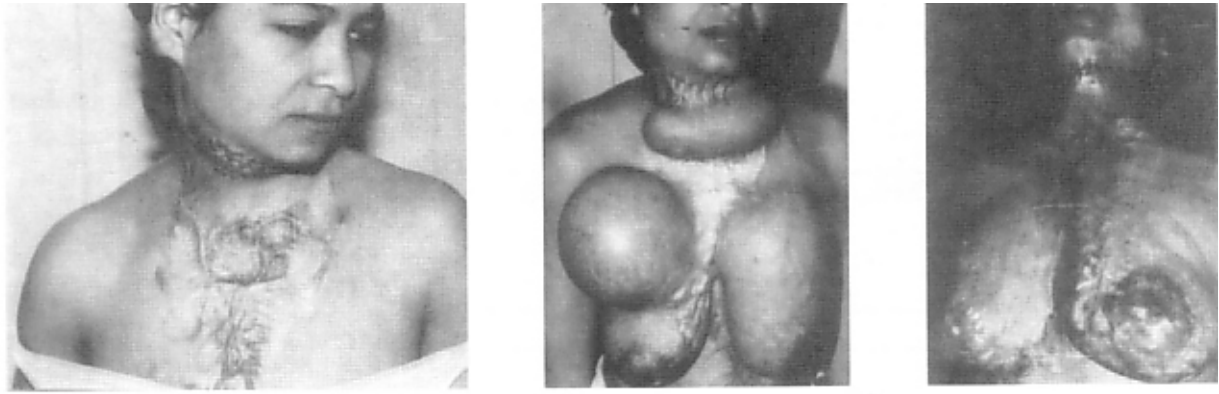
Fig. (6).   (Case # 31).
     A-   A 20-year-old female with post-burn scarring of the anterior neck and chest wall.
     B-   Three implants have been inserted with internal valves.
     C-   Early post-operative view.

Fig.(7).   (Case # 35).
     A-   A female patient, 18 years old with post-burn hypertrophic scarring of the lateral side of the neck.
     B-   An oblong expander, 450 cc have been inserted.
     C-   Post-operative view.

Fig. (8). (Case # 14). A female, 56 years old with post-mastectomy reconstruction of the left breast with DIEP-flap. An expander, 250 cc was utilized for augmentation. A reduction mammaplasty was done to the right breast for symmetry
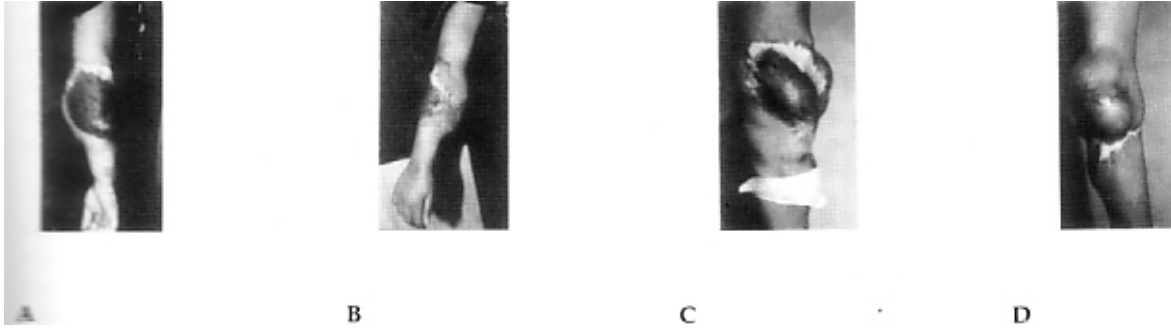
Fig. (9):. (Case # 19).
   A-Giant hairy nevus in most of the circumference of the right forearm in a girl, 18 years old.
   B&C- During expansion with sequential excision of the lesion.
   D-Final stage to remove the hypopigmented scar resulting from insertion of the expander after removal of more than
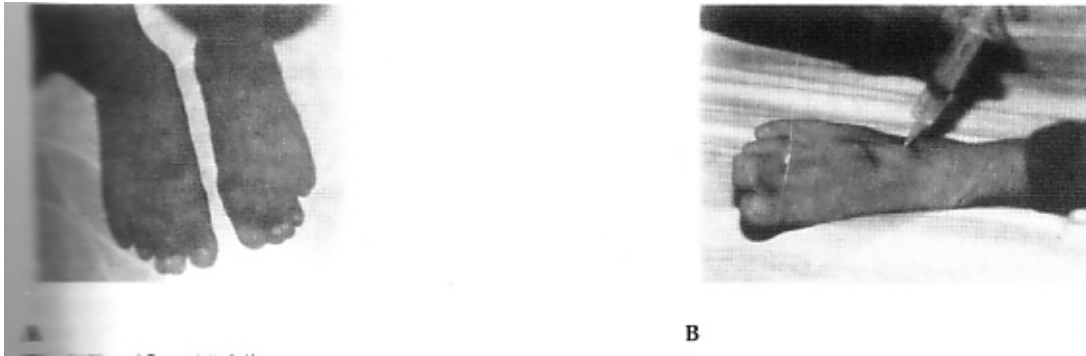   90% of the lesion.

Fig. (10). (Case4 # 24).
   A-   A child, 6 years old with syndactyly in his feet.
   B-   During injection of an expander, 2 cc that was implanted on the dorsal aspect between toes.

Fig. (11). (Case # 26).
   A-   A case of syndactyly between the middle and ring fingers of the right hand of a female, 23 years old. An
        expander 3 cc was implanted between both fingers on the dorsal aspect.
   B- Post-operative view after correction without the use of STSG.

Fig. (12). (Case # 47). Complete extrusion of a 25 cc, horse-shoe expander in the post- auricular thin skin with post-burn scarring in a 28 years old male patient.

Fig. (13). (Case # 49). Post-traumatic cut of the lower third of the right auricle in a male 26 years old. Ischemia and necrosis in the skin overlying a 50 cc, kidney-shaped expander, occurred. Reconstruction still could be achieved, although it was sub-optimal (not shown).

DISCUSSION

Tissue expansion remains an exceptional reconstructive technique because of its ability to provide ideal tissue replacement and allows the surgeon to overcome many qualitative and quantitative tissue deficiencies in selected cases. It is of particular value in the repair of some difficult defects produced by Mohs micrographic surgery, especially, defects of the nose, forehead, temple and scalp,[13] as well as extensive defects in other areas, as closure of massive abdominal wall defects.[14] It also, allows safe extension of the usual techniques of flap surgery, free flaps, and skin grafts.[15] The great advantage of this technique is in using tissue re-expansion in reconstruction of extensive areas in the burned patient with limited donor sites, with the same color and texture of neighboring tissues; superior to skin obtained elsewhere, thereby surpassing conventional methods without the addition of new scars [5,6].

In virtually every patient, tissue expansion represents a distortion of body image, and some patients are simply unable to tolerate this procedure, either because of psychological instability or because of the distortion resulting during expansion may be unacceptable. Although most patients adapted to and tolerated the inconveniences of this procedure, the patients' psychological stability should be evaluated.[9]

One of the most worthwhile uses of tissue expansion is to help in correction of male-pattern baldness (MPB) and to achieve coverage of scalp defects with autogenous tissue that have unique hair-bearing qualities.[4] In this study, there were no cases of MPB, but the biggest group included repair of defects after post-burn scalp alopecia with the best esthetic results. Expansion of facial and scalp tissues proceeds quite rapidly after an initial phase of discomfort,

which is usually transitory and can be treated with mild analgesics.[9]

Attempt to exteriorize a valve (externalized valve) away from the expander balloon was used to avoid possible pain during percutaneous needle insertion into a buried valve, especially in children, accidental puncture of expander, and dislocation or rotation of the valve.[3] In this study, 67.7% of valves were used internally (mostly in the forehead, face and trunk). The external valves (32.2%) were more in scalp and extremities with higher rate of sepsis. The complete buried system is better as regard contamination, although it has higher rate of other complications as stated by Hamza et al [3].

The use of the expanders was recommended by different manufacturers to be utilized only once, and then to be disposed. But, due to the limited resources of the hospital, it was tried to re-use some of the expanders (21.1%) after being thoroughly cleansed and autoclaved. These were re-used in the same patient where they were used the first time (to guard against cross-infection)[16]. This worked well without any increase in the rate of sepsis or extrusion.

Tissue expanders in reconstructive surgery has been associated with multiple complications that ranged from minor side effects to life-threatening problems [7]. Major complications are those that alter the original surgical plan, require implant removal, or additional reparative procedures [9,12]. They include closed septic complications or cellulitis, damage due to undermining, induced skin ischemia that may lead to necrosis after expansion with exposure of the expander system, skin penetration with extrusion of the expander system, breakdown of the surgical wound, and bad function of the expander or implant failure with deflation [6,8,9,11,17]. The more frequent minor

complications include minor sepsis, improper valve placement, valve turnover, valve and tubing exposure, and inadequate tissue expansion. These usually reflect inexperience with the technique.[7,9,12] Patient must be advised pre-operatively of potential complications, which are not considered as disastrous.

In this study, the most common causes of deflations were iatrogenically induced, related to misdirected needle sticks into the valve, tubing, or balloon. Other causes were disruption at implant joints or seals and slippage of the tubing off the in-line connector, especially the metal connector when the tubing is not secured to the connector with a suture. Pre-testing the implant with methylene blue-stained fluid at insertion is important. The causes of closed infections were peri-operative contamination, cellulitis, or valve contamination from probably a break in the sterile technique at surgery or during expansion. Parentral, local and intra-prosthetic antibiotics have helped to minimize bacterial growth.[18,19] The common cause of necrosis was compromised blood flow to the tissues by; creation of thin and unstable flaps due to traumatic skin dissection, diabetes mellitus, previous expansions, atrophic thin skin, and excessive expansion. Implant folds also produced resistant points leading to skin erosion. All these factors led to implant extrusion and were the main causes of failure of this method. The failure rate in this study was 2.2%, where in Steenfos et al series, it was 16%, and in Casanova et al, it was 4.9%.

An optimal approach to manage these complications is prevention, using a strict surgical protocol covering all stages of the procedure, attention to details, and sterile port-filling procedures [9,11,19]. Early implant failures may be managed by replacing the defective portion of the expander unit. Late failures may require surgery, at which time intra-operative expansion is beneficial to gain additional tissue. Flap ischemia may be best managed by surgical debridement and flap closure before implant contamination. Atraumatic undermining, remote valves, separate and remote approach for the prosthesis and suction drains in the cavities, are also of great help to minimize complications[12,20,21]. In this series, minor complications were salvaged when necessary by a secondary small procedures.

In this study, major complications less frequently involved the forehead and face; more frequently the scalp, breast, and upper extremity; and most often the ear, and lower extremity. The post-auricular thin skin can undergo necrosis during ear reconstruction with the expander.[20] In three cases of ear reconstruction, there was one early complete extrusion with failure of reconstruction (case# 47, fig. 12). The other case (post traumatic cut of the lower third) had necrosis with exposure of the implant and still reconstruction could be done, but needed another stage to augment the reconstructed part (case # 49, Fig. 13). The third case had a good result.

One of the most important factor involving expansion is the insertion of the expander and valves under the unstable scars, infected tissues, irradiated tissues, or skin grafts [5,19]. In one of the two failure cases of this series, the expander was done under an unstable post-burn scar in the thigh, which resulted in early extrusion of the implant (case # 43). It can be, in most cases, done only in well-healed injuries. There is insufficient experience, at this time, to recommend the use of it in subacute trauma [9].

The present study revealed an increased rate of minor complications in the group of 6 to 14 years of age where mostly the valves were exteriorized. There was an increased rate of major complications for scalp, neck, and extremity expansions compared to forehead, face, and trunk expansion in the other age groups. There were no increased complication rates for the concomitant expansion and type of expander used. These complication rates were not related to the gender, site of implantation, number of expanders, or the indication for expansion. A high rate of premature expander removal (11.1%) was noted because of complications such as skin penetration, infections, and wound breakdown. Most of these complications either occurred early in the series or when distant incision sites were not available.

Despite these complications, which in some cases required an additional operative intervention, the overall reconstructive results were successful and the pre-operative functional and esthetic goals were closely achieved in most cases (86.6%). Rate of complications in this series progressively decreased from 1999, which illustrates that a learning curve occurred in this seemingly simple but technically demanding procedure. This curve was necessary due to inadequate previous experience and new developments in tissue expanders. Others have admitted to an overall complication rates ranging from 22 to 48 percent, with total failure in 6 to 21 percent, which nearly parallels the results in this series [6,8,11,12,19].

CONCLUSION

Tissue expansion provides an excellent means for obtaining extra tissue and has become a widely used adjunct for cosmetic and reconstructive surgery. It is a good, safe and useful tool that has been used in selected cases with success. The outcomes from tissue expansion procedures done in this series are almost similar to those reported in the literature. There is room for improvement in reducing the rate of complications and the amount of time that patients spend being treated. But, even with complications, the majority of patients ultimately achieve successful reconstruction using tissue expansion.

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