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Original Article

The effect of tissue expanders on the growing craniofacial skeleton

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ABSTRACT

Background: Tissue expansion can safely be considered one of the major advances in reconstructive plastic surgery. Reported complication rates for tissue expansion have been as low as zero and as high as 48% when expanding the head and neck region in pediatric patients.[1] Our study is to discuss the osseous effects during and after tissue expansion in children.

Materials and Methods: Thirty four expanders were implanted, 30 in scalp and 4 in face. In 4 patients, 2 expanders were used. The mean age of the patients was 3.8 years. All CT examinations (pre-expansion, post-expansion and after reconstruction) were done correspondingly with each other to be able to compare the following parameters: bone thickness and bone density under the expander; certain intracranial dimensions under the center and the edge of the expander and observing the contour of the skull in the 3D reconstruction.

Results: Variable bony changes were observed in the 30 patients, apposition at the edge of expander (Periosteal reaction) being the most frequent change, which was observed in, all except 3 patients. Bone resorption and thinning occurred in 9 patients. Inward bone displacement varied from 1 to 3 mm in two patients.

Conclusions: In spite of the reported complications like thinning and deformation of underlying bone, expansion in infants and children is safe if done with a proper preoperative planning and we prefer to delay the expansion after two years as possible.

KEY WORDS

Tissue expansion, cranium, pediatric, growing skeleton-scalp

INTRODUCTION

Tissue expansion allows adjacent soft tissue to be incorporated into the reconstruction of a large defect that cannot be closed primarily without undue tension. Since the donated tissue is from the same region as the defect site, appropriate color match and texture of the donor tissues are maintained. Additionally, tissue expansion can circumvent the need for more extensive surgeries including distant pedicled or free tissue flaps.[1] Tissue expansion can safely be considered one of the major advances in reconstructive plastic surgery. The merits of the technique are supplying skin adjacent to the defect of similar color and texture with minimal donor site morbidity. However, in order to achieve the best possible result, the expanded flap must be mobilized maximally. Inability to perform this may impair the final result.[2]

Currently, a host of shapes and sizes of silicone

expanders is available and custom-made expanders can be manufactured when unique situations are encountered. The single self-sealing filling port may be incorporated into the body of the expander or it may be connected to the body of the expander by silicone tubing. This remote port may be placed subcutaneously away from the body of the expander or it may be passed externally. These ports allow injection of isotonic sodium chloride solution and removal of it if overexpansion occurs.[3] The aim of this study is to demonstrate the effect of expander on the bony aspect in infants.

MATERIALS AND METHODS

Scalp and facial expansions for 30 pediatric patients (14 males and 16 females) were performed during the period from May 2003 to 2005 at Plastic department of Zagazig University Hospital. The mean age of the patients studied was 3,8 years, with a range from 2 to 10 years. Thirty four expanders were implanted, 30 in the scalp and 4 in the face. In four patients, 2 expanders were used [Table 1]. Our patients were classified as burn scars (n=20), post-traumatic scars (n=4), haemangioma (n=3), large congenital nevi (n=2) and congenital aplasia cutis (n=1) [Table 2], All patients underwent routine clinical and laboratory assessments; two staged operation (expander insertion, regular intermittent (conventional) inflation and reconstruction). Computed tomography (CT) was done on three occasions: pre-expansion; post-expansion and 3 to12 months after reconstruction.

Table 1: Age of patients involved in the study and the types of expanders used

Age	***No. of patient***
2-5	13
5-8	7
>8 to 10	10
Type of expander	***No. of expanders***
Round	23
Rectangular	7
Crescent	4
Semisolid base	14
Hard base	8
Soft base	12

Table 2: Indications for expanders in our patients [N=30]

Preoperative patients characters	***No. of patient***
Burn scar	20
Traumatic scar	4
Congenital *Aplasia cutis*	1
Haemangioma	3
Congenital nevi	2

Surgical technique

Preoperative planning; The expanders which were chosen were larger than the length of the defect. These were inserted in the appropriate adjacent sites. Some sites were smaller than the defects, so we used 2 expanders. We used round expanders (n=23), rectangular expanders (n=8) and crescentic expanders (n=4). Their bases were semisolid (n=18), soft (n=10) and hard (n-6). All expanders had remote filling ports. In 4 patients, 2 expanders were used [Table 3].

Procedure

Prophylactic *anti-staphylococcal* antibiotic was administered intravenously at the start of the procedure and then a small marginal incision was made enough to introduce the expander and its valve. The same incision was used to remove the expander and advance the expanded flap. The pocket for the tissue expander was dissected 2 cm larger than the dimensions of the expander in the subgaleal plane in the scalp (facilitated by the use of a urethral dilator) and in the subcutaneous plane in the face, superficial to the superficial muscloaponeurotic system with great care to avoid injury of facial nerve. The pocket was copiously irrigated with an isotonic saline solution, prior to insertion of the expander. Expansion was done till the expander was tense without pain or skin blanching. All patients were expanded twice weekly. Overexpansion by nearly twice normal was done in all cases which complete the procedure. Expansion proceeded uneventfully in 6 cases however, reconstruction were performed immediately in 2 cases.

Reconstruction: The expander and its valve were removed through the original incision. All flaps were designed as random flaps except in 2 patients where axial flaps based on the superficial temporal artery were used to reconstruct the right ear and the left eye brow. All CT examinations (pre-expansion, post-expansion and after reconstruction) were done correspondingly with each other to be able to compare: bone thickness and bone density under the expander; certain intracranial

Table 3: Relation between the type of expander base and bony changes

Type of the expander	***No. of the immediate CT changes***	***Changes/type***
Baseless	29	29/12 (2.42)
Semi hard base	23	23/14 (1.64)
Hard base	10	10/8 (1.25)

dimensions under the center and the edge of the expander and to observe the contour of the skull in the 3D reconstruction.

RESULT

Thirty four expanders were implanted, 30 in the scalp and 4 in the face. In 4 patients, 2 expanders were used [Table 4]. There were 62 instances of bony changes which occurred in 30 patients. Apposition at the edge of expander (Periosteal reaction) was the most frequent change and occurred in all except 3 patients [Table 5]. Inward bone displacement [Figure 1] about 1 to 3 mm in longitudinal axis was noticed in 15 patients which was seen more in the group of patients aged from 2 to 5 years as proved by CT. Also bone apposition and resorption either under the expander [n=7] patients or away from it [n=2] was noticed and the most serious effect of suture widening in patients between 2 and 5 years [Figures 2-4] respectively. Skin necrosis and plugging of the expander occurred more in patients aged from 2 to 5 years [Table 6]. Regarding the type of the expanders we used several types of expanders rounded type in [n=23] patients with a good postoperative results [Figures 5, 6] and a rectangular type in [n=7] patients.

DISCUSSION

Tissue expansion plays an integral role in pediatric plastic surgery. Surgeons have been using this technique for years in the treatment of large congenital nevi, haemangioma, burn and post-traumatic scars, meningomyelocoeles, congenital aplasia cutis and other congenital deformities. We used the expanders for different causes mainly burn scar in [n=20]. When applying tissue expansion to the pediatric population, there are certain unique variables, which differ from adults making this type of surgery even more complex. These include body size, tissue tensile strength and thickness and patient cooperatively.[1] Expansion in infants and children is controversial. Possible complications include thinning and deformation of underlying bone and subsequent scar widening with growth.[4]

Johnson *et al*[5] stated that tissue expansion may cause temporary thinning in outer skull in children and is contraindicated in children less than 3 years because of open cranial suture.

Our study was done for patients aged between 2 and 10 years. Osseous changes in the age group below 5 years were more than in those above 5, with more risk of bone thinning and inward bone displacement. Suture

Table 5: Changes occurring in 30 patients. with apposition at the edge of expander periosteal reaction was the most frequent change and occurred in, all except 3 patients

Immediate CT changes	*No. of changes*
Inward bone displacement	15/62 (24.11)
Apposition (at edge of expander)	23/62 (37.64)
Resorption under the expander	7 /62 (11.58)
Resorption away from the expander	2 /62 (3.4)
Bone thinning under the expander	11/62 (17.35)
Suture widening under the expander	4/62 (6.76)
Osteonecrosis	0
Increase I.C.T.	0
Total changes	62

Figures in parentheses are percentage

Table 6: Bone changes and skin changes in relation to the age of the patients

Age of the patients (yrs)			*Bone changes*
2-5	5-8	8-10	
11	3	1	*Inward bone displacement
8	7	8	*Apposition (at edge of expander
1	0	1	Resorption away from the expander
0	4	3	Resorption under the expander
4	0	0	*Suture widening under the expander
60	30	20	Bone thinning under the expander osteonecrosis
0	0	0	Increased I.C.T
30	17	15	Total changes
2-5	5-8	8-10	Skin changes
2	0	1	Infection
11	4	8	Haematoma
2	1	0	Seroma
4	2	1	Skin necrosis and plugging of the expander
2	1	0	Wound dehiscence
11	2	6	Pain relived by analgesia
2	0	1	Pain necessitate removal of the expander

Table 4: Site of the defect and site of expansion with the main bone(s) under the expander. Four cases had two expanders (3 bitemproparietal and 1 with occipital and parietal expanders).

Site expanded		*Main underlying bone*	*Site of defect*	*Patient no.*
Scalp	Bilateral tempro-parietal	Parietal and temporal	Vertex	8
	temple	Temporal	Vertex	7
	parietal	Parietal	Temple	6
	Occipital	Occipital	Temple	6
Face	Cheek	Mandible and zygomatic arch	Infraorbital	1
	Cheek	Mandible	Infraorbital	2

widening that occurred in this group may necessitate delay of the procedure until above five years; but with no significant differences between patients below five years from those above with respect to the CT changes after and before expansion

A few studies have investigated the effect of tissue expansion on the craniofacial bone. They demonstrated bone growth inhibition under the expander with apposition zone at the periphery. It can not be determined whether the bony changes are caused by pressure related erosive changes or whether they are due to complex growth changes Also, it can not be determined whether rapid expansion may lead to fewer bony changes,[6] Penoff,[7] reported a case of outer table as well as a portion of inner table erosion during scalp expansion in a child. In our study of the effect of tissue expander on skull bones, the bone appeared thinner and had a reduced convexity. At 9 months post-operatively, in most cases, a complete normalization was confirmed by computed tomography.[8]

We report in this work two cases with erosion of the outer and inner table of the skull away from the sites of pressure, of unknown aetiology that may be due to growth inhibition or traction on a nutrient vessel of the skull. All these effects were relieved after six months as a complete normalization confirmed by CT.

Inward bone displacement had occurred in 15 [44%] patients. Suture widening had occurred in 4 patients [11.5%] and no effects were noticed on the superior sagittal sinuses for patients who had expanders inserted over the anterior fontanel, unlike the study done by Keith *et al*.[1] who reported laceration of superior sagittal sinus in infants with expander inserted on anterior fontanel. In this study, after scalp expansion, bone resorption was observed in 7 patients under the expansion [Figure 2] and in two patients the resorption had occurred away from sites of expansions [Figure 3]. Bone resorption during scalp expansion was observed on occasion and consisted of thinning of outer table of the calvarium according to CT examination post operatively. Apposition at the edge of the expanders also occurred in 23 patients, rapid inflation and expansion had occurred in 7 patients with no differences between those with rapid and those with slow expansion. Prolonged expansion with large volume expanders did not lead to significant CT changes. Full thickness erosion of the skull secondary to tissue expansion has been recorded with prolonged expansion using large volume expanders.[9] Tissue expansion involves at least 3 stages: insertion, expansion and reconstruction. The ultimate success or failure of the reconstructive effort is largely based on the preoperative planning, selection of appropriate expander(s) and the placement of the expander(s) at the initial operation.[10] If the defect is large and cannot be completely excised after the initial expansion, the defect is only partially excised and the expander is deflated but left in place. After the wound has healed, expansion is initiated again. A third operation is then necessary to remove the expander and accomplish the final reconstruction. This process is termed sequential expansion.[10] We did not prefer the sequential expansion, as it is time consuming and preferred only if the donor area is so small so as to insert only one expander. We inserted two expanders in four patients to reconstruct a big defect, with good results but it was more painful and one of them necessitated removal of the expander before over filling.

The widely used type of tissue expanders is the Radovan prosthesis. It consists of a silicon bag and a self sealing inflation reservoir connected by a silicon tube. There are different volumes (from 25 ml up to 1000 ml) and different shapes (round, rectangular, elliptical and crescent). It may be baseless or have a woven dacron semi hard or hard base to direct the expansion force away from the base [Figures 7, 8]. The reservoir may be built-in or remote.[11] Conventional inflation is conducted on a weekly basis, however rapid expansion at 48 hours interval is developed. Usually within 8-10 weeks expansion becomes sufficient to allow reconstruction.

Don and Marion,[12] enumerated 10 simple rules to reduce the risk of complications occurring with tissue expansion and they preferred the use of the largest expander possible and use rectangular expanders-these "harvest" more tissue. We used rounded expanders [Figures 9, 5] for most of our patients [n=23], Crescent type in 4 and rectangular expanders in 7 patients. The rounded type was preferable as it easy to harvest and easy to plane the tissue flap for scalp reconstruction after its removal.

Some authors overfill the expander and allow the final volume to remain in the expander for several months to stabilize the expansion and counteract the tendency of the expanded flap to contract once the expander is

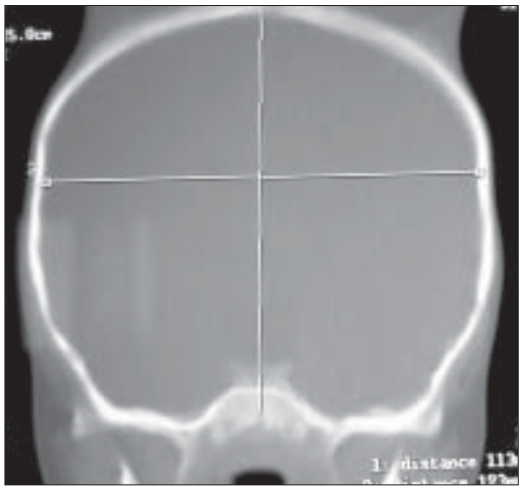

Figure 1: Inward bone displacment after prolonged expansion in a child 2.5 years

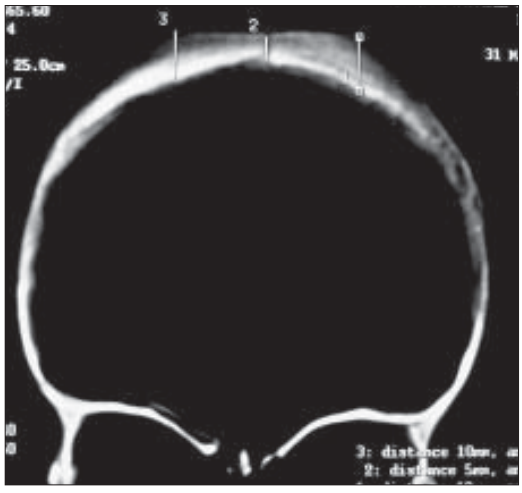

Figure 3: Bone resorption away from the site of expander and bone apposition around the expander

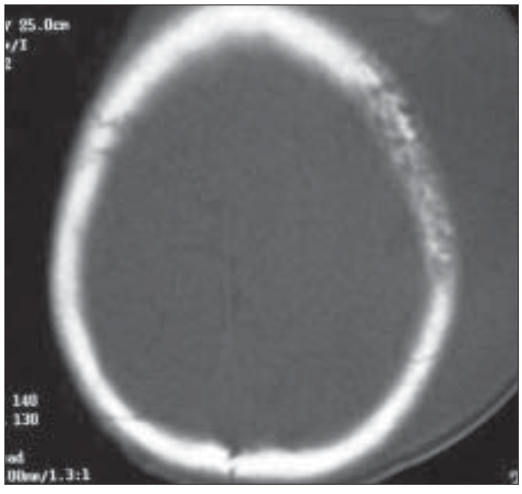

Figure 2: Bone resorption at site of expansion

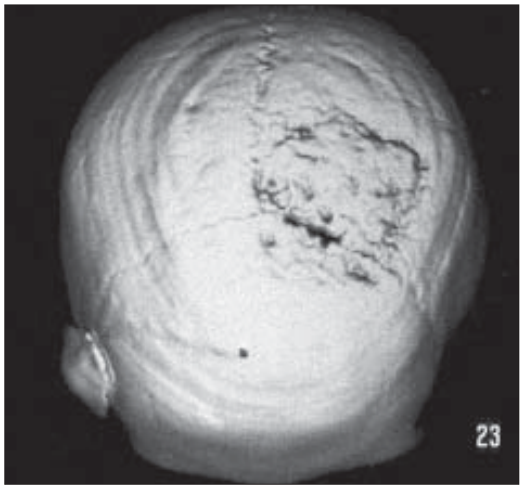

Figure 4: Widening sutures in a child 2 years old

removed. If expansion proceeds uneventfully, reconstruction may be performed immediately. The expander is removed through the original incision. If necessary, incisions may be made in the capsule surrounding the expander to gain additional flap length. This should be performed with extreme caution because of the delicate network of new blood vessels present just superficial to the capsule; these should be avoided if at all possible.[2] We did not need the incisions through the capsule for lengthening of the flaps due to overfilling of the expanders to gain tissue excess and utilized it.

Tissue expansion creates a three-dimensional structure. This tissue must be converted to a flat sheet or two-dimensional flap. Hence the 'excess' tissue present in the three dimensions must be maximally converted to a two-dimensional flap, so that all the additional tissue available is utilised rather than wasted.[2] Any type of rotation, advancement or transposition flap may be designed with the expanded tissue. All flaps in our study were designed as random flaps except in 2 patients where axial flaps based on the superficial temporal artery were used to reconstruct the right ear and the left eye brow [Figure 10]. Because of the increased vascularity of expanded tissue, much larger flaps may be designed while maintaining adequate blood flow. However, a word of caution is necessary regarding the use of epinephrine.

We had never used epinephrine during reconstruction in all patients. Evidence exists that the increased vascularity of expanded flaps may be exquisitely sensitive to the vasoconstrictive effects of epinephrine; therefore, it should not be used.[13]

Complications were divided into major and minor categories [Table 7]. Major complication was defined as

that resulting in premature loss of expander that required additional surgery or when preoperative plan was not completed, thus yielding a poor result. The minor complication were defined as those resulting in only partial accomplishment of the preoperative plan and thus defined as a fair result. Cunha *et al*[14] reported that complications rates for tissue expansion have been as low as zero and as high as 48% when expanding the head

Figure 5: Rounded expander baseless 11_13 cm

Figure 8: Post expansion of the rectanguler expander

Figure 6: Post reconstruction picture

Figure 9: Partial skin necrosis

Figure 7: Rectanguler expander with hard base

Figure 10: Post expanderwith reconstruction of the external ear

Table 7: Early postoperative soft tissue complications

Postoperative complications	*Expander no.*
Infection	3/34 (8.2)
Haematoma	23/34 (67.64)
Skin necrosis	7/34 (20.58)
Migration of the expander	2/34 (5.8)
Loss of hair	11/34 (32.35)
Wound dehiscence and exposure of the expander	4/34 (11.76%)
Seroma	3
Erosion of the underlying bone	0
Pain that necessitate removal of the expander	3
Neuropraxia relived by assurance	19

Figures in parentheses are percentage

and neck region in Pediatric patients (Keith *et al*. 2005). Tissue expansion is associated with a learning curve. Also, the use of multiple expanders is associated with a higher complication rate. With respect to the complications, we noticed that haematoma occurred in 23 patients as we avoid the use of epinephrine in all patients. However, this complication was avoided through application of tube drain for three days and application of a light pressure bandage. Skin tissue necrosis with plugging of the expanders was noticed in three cases due to rapid inflation. We proceeded with expansion in two of them after delaying the inflation rate; in one case the expander failed and we delayed the procedure. The pain and neuropraxia in all our patients were tolerable without analgesia except in two cases, where the pain continued in spite of analgesia that necessitated removal of the expander due to associated uncontrolled pus collection. No major complications were recorded in our patients.

REFERENCES

1. Keith AH, Heather R, John GM. Pediatric cervicofacial tissue expansion. Int J Pediat Otorhinolaryngol 2005;69:21-5.
2. Donald AH. Maximizing the use of tissue expanded flaps. Br J Plast Surg 2003;56:784-90.
3. Malata CM, Williams NW, Sharpe DT. Tissue expansion: An overview. J Wound Care 1995;4:37-44.
4. Lari AA. Tissue expansion. J R Coll Surg Edinb 1992;37:149-54.
5. Johnson TM, Lowe L, Brown MD, Sullivan MJ, Nelson BR. Histology and physiology of tissue expansion. J Dermatol Surg Oncol 1993;19:1074-8.
6. Schmelzeisen R, Schimming R, Schwipper V, Heydecke G. Influence of tissue expanders on the growing craniofacial skeleton. J Craniomaxillofac Surg 1999;27:153-9.
7. Penoff J. Skin expansion- A sword that “stretches” two ways: Scalp expansion and skin erosion. J Craniofac Surg 1990;1:103-5.
8. Collanna M, Cavalinin M, De Angelis A, Preis FW, Signorini M. The effect of tissue expansion on the cranial bone; A clinical, histological and instrumental study. Ann Plast Surg 1996;36:255-60 discussion 260-2.
9. Fudem GM, Orgel MG. Full thickness erosion of the skull secondary to tissue expansion for scalp reconstruction. Plast Reconstr Surg 1988;82:368-72.
10. Barret JP, Dziewulski P, Wolf SE, Desai MH, Herndon DN. Outcome of scalp donor sites in 450 consecutive pediatric burn patients. Plast Reconstr Surg 1999;103:1139-42.
11. Argenta L. Tissue expansion In Grabb and Smith’s Plastic Surgery. 5th ed. Lippincott-Raven publisher: Philadelphia; 1997.
12. Don AH, Marion G. Optimizing results with tissue expansion: 10 simple rules for successful tissue expander insertion. Burns 2005;31:1-4.
13. Sasaki GH, Berg JE. Tissue expansion of the head and neck. *In*: Otolaryngology Head & Neck Surgery 3rd ed. Edited by Cumming CW, Fredrickson JM, Harker LA, *et al*. Mosby: St. Louis; Boston New York Philadelphia London Tokyo Toronto; 1997. p. 573-98.
14. Cunha MS, Nakamoto HA, Herson MR, Faes JC, Gemperli R, Ferreira MC. Tissue expander complication in plastic surgery: A 10 year experience. Rev Hosp Clin Fac Med 2002;57:93-7.