Tissue Expansion in Pediatric Head and Neck Reconstruction

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ABSTRACT

Tissue expansion has proved successful in reconstruction of large defects. The purpose of this study is to present the results of tissue expansion in reconstruction of pediatric head and neck defects. This clinical series includes 46 patients with an average age of 6.7 years, who underwent tissue expansion reconstruction of large head and neck defects at Cairo University Hospitals between January 2004 and June 2007. A total of 50 expanders were used. Expanded flaps were designed as advancement (N=34), rotational (N=14) and transposition (N=2). The average follow up period was 18.3 months. Complete coverage of the defect was achieved in 91.3% (N=42) with excellent tissue match. The complication rate was 14% (N=7). Complications included exposure (N=3), infection (N=3) and expander failure (N=1). The overall outcome was rated to be good in 52.2% (N=24), satisfactory in 34.8% (N=16) and fair in 13% (N=6). Tissue expansion can be successfully used in reconstruction of large head and neck defects in children, however not without the risk of complications.

Key words: expanders – children –congenital anomalies –thermal injuries

INTRODUCTION

Tissue expansion offers a new frontier in head and neck reconstruction. It provides the capability of creating new additional skin with identical properties. Early attempts addressed scalp reconstruction. This was then followed by the use of expanded flaps in reconstruction of various facial defects.1

The expanded skin offers an ideal quality to cover head and neck defects. Expanded flaps can offer skin of the same exact quality. This perfectly applies to the scalp and some facial defects, where the expanded skin belongs to the same exact subunit. Even when different subunits are used, a perfect match in color and texture is obtained.2

When first applied in the field of head and neck reconstruction, tissue expansion was associated with significantly high rate of complications. Despite the relatively high rate of complications, successful completion of expansion can be achieved in almost 80% of patients.3

We present the experience of the authors at Cairo University Hospitals with pediatric tissue expansion in reconstruction of head and neck defects. Different aspects are discussed including the final outcome and complication rate of this challenging reconstructive modality.

MATERIAL & METHODS

Forty six pediatric patients with major head and neck defects were included in this study. Age ranged from 2 to 12 years with an average of 6.7 years. 32 were females while 14 were males. All defects were covered using local flaps after tissue expansion of the donor sites as secondary reconstructive procedures. Management of these patients was done at Cairo University Hospitals during the period from January 2004 to June 2007.

Defects were located at the head and neck region. These included scalp (24), forehead (4), nose (4), cheek (6) and neck (8). Causes of the defect were thermal trauma in 31 cases, physical insult in 5 cases, pigmented lesions in 6 cases,
vascular malformation in 2 cases and congenital facial cleft in 2 cases. (Table 1)

Maximal dimensions of the defects ranged from 4.2 to 12.5 cm with an average of 6.8 cm. All defects were not amenable to coverage by conventional ways. Informed consents were obtained from family members before the procedures of expansion.

A total of 50 expanders were used in this series. Single implant was used in 42 patients, while double expanders were used in 4 patients. Among these 4 patients, two patients with scalp defects had simultaneous expanders, while the other two (facial cleft and neck burn) had serial expansion. (Figure 1)

Expanders used were of the Radovan type with a single self-sealing filling port. Among these expanders, only six had external ports, while the remainder had remotely-placed internal ports. The implants used were all rectangular in shape.

Expanders were all inserted under healthy skin of adjacent areas. The plane of implant placement was sub-galeal in the scalp, sub-frontalis in the forehead, sub-cutaneous in the face and sub-platysmal in the neck. All patients received peri-operative parenteral antibiotics.

Expansion was started three weeks after placement of the expander. The rate of expansion was on weekly basis. Saline was injected into the port using a 22G needle. The volume of saline inflation never exceeded 10% of the maximal implant capacity. This was guided by the condition of the expanded skin as well as patient’s discomfort. All expanders were over-inflated to about double their maximal capacity and were left for a period of two weeks after full inflation before coverage procedures were performed.

Coverage procedures after tissue expansion (total of 50) included advancement flaps in 34 cases, rotational flaps in 14 cases and transposition flaps in 2 cases. Advancement and rotational flaps were all designed as random-pattern flaps. (Figure 2) Regarding transposition flaps, both were axially designed. The first was an expanded forehead flap based on the angular vessels, used for covering a nasal defect. The second flap was an expanded forehead flap which was laterally based on the superficial temporal vessels to cover a cheek defect. (Table 2)

Patients were followed up for a period ranging from 12 months to 2.5 years, with an average follow up period of 18.3 months. Assessment of the results was based on several criteria. These included:
1. Percentage of coverage of the defect (calculated from the total size of the defect before coverage)
2. Properties of the expanded skin including color match and hair bearing.
3. The quality of scars.
4. The occurrence of complications

After assessment of the individual parameters in outcome, the overall outcome is calculated. The overall outcome was qualified accordingly as satisfactory, fair and poor. The incidence of complications and its impact on the final outcome was as well documented.

RESULTS

Percentage of Defect Coverage:
Complete coverage of the defect was achieved in 42 patients (42/46; 91.3%).(Figure 3) In one case (1/46; 2.1%), early exposure of the expander dictated its premature removal and consequently the expanded skin was insufficient for complete coverage. The estimated residual defect was 40%. In 3 cases (3/46; 6.5%) mild residual defects (<20%) were encountered and were left to heal by secondary intention.

Properties of skin (color/hair):
Regarding the properties of the expanded skin, it showed perfect color match in all cases. In two cases of scalp reconstruction, visible alopecia was noted. On the other hand, hair growth in potentially non-hair-bearing areas was noted in two cases. These two cases had had forehead flaps reconstruction of facial defects (cheek and nose). (Figure 4)

Scars:
Scars after completion of the reconstructive procedures were hardly noticeable. The best scars were noted on the scalp, nose and cheek. The widest scars were noted on the neck. It has to be mentioned that in all neck cases, closure was documented as being done under some tension.

Complications: Complications were reported in 7 out of 50 (14%) expansion procedures, constituting a rate of 14% (Table 3).
Expander Failure (1/50; 2%): There were no cases of actual leakage from the expander. However in a single case with an external port, the port was avulsed by the patient. The expander was removed and replaced. This was documented as expander failure.

Exposure of the Expander (3/50; 6%): Two cases showed exposure of the main reservoir of the expander without evidence of infection. In these two cases, termination of the procedure and premature coverage procedures were performed with residual defects. A third case had the internal port exposed. This was exteriorized without interrupting the expansion plan.

Infection (3/50; 6%): Among the three cases of infection, two cases showed early postoperative infection (within the first 4 weeks). The implant was removed and the procedure was abandoned for three months. Re-placement of the implant was done thereafter, and expansion was resumed. In one case, infection developed late in the course of management (two weeks before reaching the target volume). A decision was taken to remove the expander and proceed to flap advancement under strict antibiotic cover.

All flaps survived after expansion. There was no flap necrosis reported. There was no donor compromise in this series. Skull bones were carefully examined after expansion for any deformity. No clinical or radiological deformities were noted. Regarding neck expanders, there was no clinical evidence of any vascular compromise.

Therefore, among all complicated cases, three patients had what can be described as complications that actually affected their final outcome [expander exposure (2), late infection (1)]. In these 3 cases, termination of the procedure and premature coverage was coupled with residual defects. Fifty seven percent (4/7) of complicated cases did not affect the final outcome, however added more time to the total time consumption needed to obtain the desired coverage.

Based on the aforementioned individual parameters, the overall outcome was found to be good in 24/46 cases (52.2%), satisfactory in 16/46 cases (34.8%) and fair in 6/46 cases (13%). The scalp showed the highest scores regarding percent coverage, quality of tissue transferred and incidence of complications, while the neck showed the lowest scores. (Table 4)

Table (1): Causes of head and neck defects (total 46).

<table>
<thead>
<tr>
<th>Cause</th>
<th>Scalp</th>
<th>Forehead</th>
<th>Nose</th>
<th>Cheek</th>
<th>Neck</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal</td>
<td>21</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>8</td>
<td>31</td>
</tr>
<tr>
<td>Physical</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>Pigmented</td>
<td>-</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td>Vascular</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Cleft</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>46</td>
</tr>
</tbody>
</table>

Table (2): Design of expanded flaps (total 50).

<table>
<thead>
<tr>
<th>Type</th>
<th>Scalp</th>
<th>Forehead</th>
<th>Nose</th>
<th>Cheek</th>
<th>Neck</th>
<th>Total</th>
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</thead>
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<tr>
<td>Advancement</td>
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<td>4</td>
<td>-</td>
<td>7</td>
<td>8</td>
<td>34</td>
</tr>
<tr>
<td>Rotational</td>
<td>11</td>
<td>-</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>14</td>
</tr>
<tr>
<td>Transposition</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>4</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>50</td>
</tr>
</tbody>
</table>
Table (3): Complications. (*: double expansion done in 2 cases of scalp and cheek defects.)

<table>
<thead>
<tr>
<th>Complication</th>
<th>Scalp (26)*</th>
<th>Forehead (4)</th>
<th>Nose (4)</th>
<th>Cheek (8)*</th>
<th>Neck (8)</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Failure</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Exposure</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Infection</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Donor Morbidity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Flap Necrosis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>3</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td>3</td>
<td>7</td>
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Table (4): Overall outcome

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Scalp</th>
<th>Forehead</th>
<th>Nose</th>
<th>Cheek</th>
<th>Neck</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td>Good</td>
<td>16</td>
<td>1</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>24</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>7</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>16</td>
</tr>
<tr>
<td>Fair</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>24</td>
<td>4</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>46</td>
</tr>
</tbody>
</table>

Figure 1: A large post-burn scalp defect necessitating double simultaneous expanders.

Figure 2: 2a: Neck expansion for reconstruction of cervicofacial burn; 2b: The subplatysmal flap elevated prior to advancement into the cheek; 2c: Final result
Fig. 3: 3a: Scalp defect measuring 11cm x 7cm; 3b: intraoperative photograph showing the expanded advancement scalp flap; 3c: Intraoperative appearance after flap inset obtaining complete coverage of the scalp defect

Fig. 4: 4a: Craniofacial Cleft connecting the left oral commissure to the left lower eye lid; 4b: Expansion of the forehead 4c: Postoperative appearance after expanded forehead transposition flap reconstruction of the left mid facial cleft. Eye closure can be obtained after reconstruction; 4d: expansion of the cheek; 4e: final appearance one year after advancement of the expanded cheek flap

DISCUSSION

While small defects in the area of the head and neck can be effectively managed by simple conventional techniques, larger defects constitute a real challenge to reconstructive surgeons. Tissue expansion offers an ideal reconstructive modality to deal with large defects. Sufficient tissue can be generated for complete coverage in almost 80% of patients. Incomplete coverage can be caused by underestimation of the size of the defect and consequent under-expansion of the adjacent tissues. The other cause is the occurrence of a complication late in the process of expansion that necessitates abortion of the process and premature flap coverage.3

In the present series, the average defect size was 6.8cm. Complete coverage of the defect was
obtained in 91.3% of patients. Most residual defects in this series were in the range of 20%, yet affected to some extent the final outcome of the reconstructive process. Figure 1 shows a mild residual scalp defect after double simultaneous expansion. With smaller defects, like shown in figure 3, single expander can yield a flap capable of complete coverage. Tissue expansion provides head and neck defects with tissue of perfect match. Scalp defects, for example, can not be reconstructed except with dense hair-bearing thick skin.

Facial defects need perfect color match, and require in some areas (the nose for example) no hair follicles. Forehead expansion provides perfect tissue for nasal defects. However, for a short distance off the hair-line, scanty hair follicles exist. Transfer of tissue in that incidence may end with unsightly hair growth on the nose or any other area with no hair growth. We noted this incidence in two of our patients who had forehead transposition flap reconstruction for nasal and cheek defects. Both flaps carried some hair bearing skin distally and constituted an aesthetic problem.

Tissue expansion offers adequate skin to allow for hiding the scars into natural lines and obtaining tension-free closure. The amount of expanded skin has to be enough to achieve these two goals. In addition, the design of the expanded skin flap has a significant role in the final scar outcome. Bauer and Margulis (2004) presented their experience with a large series of 995 expanded flaps performed in 430 pediatric patients. They concluded that there is significant advantages in the use of transposition flaps over pure advancement. They emphasized the ability of transposition flaps to dissipate tension with less likelihood of anatomic distortion in the reconstructed area.

In this series, we noted that the widest scars were encountered in the neck. This may be explained by insufficient expansion of the neck skin due to lack of a hard base. Expanded neck skin in our series did not provide tension-free closure in all cases. This consequently resulted in wide noticeable scars. In addition all neck flaps were advancement or rotational flaps. No transposition flaps were used in the neck.

Expander failure is expected to occur more in pediatric population. Even though it occurs more in children, the reported rates are relatively low. Gibstein et al. (1997) reviewed the complication rate of 191 tissue expansions in children. They reported expander failure due to deflation in only 3%.

In this series, we had a single event of external port avulsion by the patient that necessitated expander replacement. No deflation accidents were noted in the main reservoir. This may be a factor to consider when planning tissue expansion in the pediatric patient. Internal ports may prove less likely to expander failure complication.

Expander exposure is another known complication in tissue expansion reconstruction procedures. Exposure may be caused by ischemic necrosis of the overlying skin. In the area of the head and neck with its relatively high vascularity, this complication is relatively less often. Expander exposure is reported to be in the range of 2-5% in pediatric tissue expansion. Its incidence in lower extremities is higher than in the head and neck.

We had this incidence in two of our patients representing a rate of 4%. Premature coverage of the defects without reaching maximal expansion yielded minimal residual defects with less than optimal final aesthetic outcome. While termination of the procedure is the answer to expander exposure, port exposure can be managed by exteriorization of the port and resuming expansion. This event was encountered only once in this series and expansion was completed uneventfully.

Infection may alter the expansion plan. Early in the course of expansion, the procedure has to be terminated. If it occurs late, flap reconstruction with antibiotic cover may save the procedure. The use of intraoperative antibiotic irrigation was found to be a non-influential factor on the complication rate.

In this series, two expanders were infected early, with the cost of extending the reconstructive plan for an extra of three months. In the single event of late infection, premature flap closure was done with impact on the final aesthetic outcome due to closure under tension. Accordingly we report an infection rate of 6%. This matches the rate reported at the Children’s Hospital at Harvard, where 11 patients out of 105 had had expander infections.

Flap necrosis after completion of the procedure is a rare complication. This is due to
the fact that the expanded tissue is characterized by high vascularity. Even the use of “super-thin flaps” which is sometimes called subdermal vascular network flaps proved to be absolutely safe in the region of the head and neck. Apart from the anterior aspect of the face and neck, expansion of the postauricular skin may be associated with some risk of partial flap necrosis. None of the cases included in this series suffered any degree of flap necrosis.

It has been reported that expansion of pediatric scalps can affect the underlying skull bones. Histological examination showed osteoclastic activity with consequent bone resorption and remodeling. Even with some degree of deformation, remodeling and complete normalization occur. Fontanellar and sagittal areas of the skull may be taken into consideration as a risk factor. Scalp expansion constituted the majority of cases in this series. No visible deformity could be detected after completion of the procedures.

Complication rates of tissue expansion in pediatric population have been reported to be ranging from 7.5% to 40%. While the range of complications reported is somehow wide, large series may be more accurate in reflecting the actual rate. Iconomou et al. (1993) studied 147 expansions on patients with a median age of 8 years. The rate of complication was 26%. Gibstein et al. (1997) reported a complication rate of 19% among 191 pediatric expansions, mostly in the head and neck region. They found no influence for the site of expander placement on the complication rate. Hurvitz et al. (2005) reported a complication rate of 30.8% in 182 pediatric cervico-facial expansions.

We report a complication rate of 14% in this series. This rate lies in the range reported in literature. The relative small number of patients as compared to large series reported in literature may reflect the inclination of our number to the lower figure of complication rates.

Building experience and consequent surgical modifications may improve the complication rate. Bilkay et al. underscored the importance of surgical experience and a systematic way of planning expander placement in minimizing complications. They reported a drop in their complication rate from 15.4% in their first cases to 5.7% consequently.

The overall results were good in more than half our patients (52%), satisfactory in 34%, while only fair results were obtained in 14%.

Regarding the final outcome and complication rates, the scalp got the highest scores. The neck was associated with less than perfect outcome in addition to the highest complication rate. Most of the data published on head and neck expansion in pediatric patients reported the neck to have the highest rate of complication as compared to other units as the face and scalp.

Finally, tissue expansion can provide the answer to large defects in the area of the head and neck. With perfect tissue match, it provides the ideal reconstructive option. Perfect functional and aesthetic results and low complication rates can be obtained in most cases.

REFERENCES