TISSUE EXPANSION USED AS A METHOD OF RECONSTRUCTIVE SURGERY IN CHILDHOOD

Tzolova N., Hadjiiski O.

N.I. Pirogov Hospital of Emergency Medicine, Burns and Plastic Surgery Centre, Sofia, Bulgaria

SUMMARY. Tissue expansion has developed as an important routine procedure in plastic and reconstructive surgery in the past two decades. It is used progressively in cases of reconstruction treatment for children and adults who do not have enough adjacent tissue for reconstruction of the skin surface that is defective as a result of a trauma, burns, or congenital deformation. When applied to children, the method of tissue expansion enabled us to achieve aesthetic and functional results that had not been obtained before with traditional procedures of reconstructive surgery. This paper presents the results of tissue expansion in 62 children in the period 2000-2006 treated in the Burns and Plastic Surgery Centre in Sofia, Bulgaria. Seventy expanders with different forms and different volumes varying from 50-1000 ml were used as treatment according to the specific goals for reconstruction. The indications for using tissue expanders for children were the following: skin and soft-tissue defects after deep burns and injuries, traumatic defects, and pigmented stains. The children in this study of tissue expansion were 39 boys and 23 girls. The higher percentage (64%) of injured boys was due to the higher occurrence of traumatism among boys. The anatomical areas subjected to tissue expansion in relation to the reconstruction of the primary tissue defects were as follows: scalp, face, neck, mental area, breast area, sacral area, back, and upper and lower extremity. More than one tissue expander was placed in the same area in five children during a single operational phase. We observed functional recovery and excellent aesthetic results in 85% of the patients who underwent the tissue expansion treatment. The lowest percentage of complications was reported in the group of children aged 4-7 yr, i.e. 3.22%.

Introduction

Tissue expansion for medical purposes was first reported in 1905 by Codvilla (as described by Barroso M. Da Luz Ferreira), who attempted to lengthen tissue in the hip area. In 1957 Neumann was the first to expand skin by using an inflatable balloon. He reconstructed a subtotally avulsed auricle by using expanded skin from above the ear to cover a cartilage graft. It was not until 1976 that another study concerning tissue expansion surfaced, when Radovan’ successfully expanded the tissue of the chest of a woman who had undergone a mastectomy. The positive results for tissue expansion were achieved through the positioning of a silicone implant. Radovan later refined and popularized this technique for post-mastectomy breast reconstruction. More recent reports have described the use of tissue expansion for a variety of congenital and acquired deformities among children and adults.

Material and methodology

This study presents a retrospective analysis of the treatment of 62 children - suffering from burns, traumas, or congenital pigmented stains - with the application of tissue expanders in the period 2000-2006 in the Hem N.I. Pirogov Children’s Burns and Plastic Surgery Clinic. We used the method of tissue expansion of healthy tissue as a means of curing and correcting defects of various kinds. This was achieved with the help of a silicone reservoir, which was inflated gradually through a self-sealing injection port until the overlying and adjacent tissues increased in volume, thus contributing additional skin. Apart from the mechanical aspect of tissue expansion, Agris also believes that the expanded skin undergoes some biological changes, such as mitosis (we not only expanded the skin but also created new tissues). The choice of this operational technique was deliberate - we selected patients with indications for tissue expansion and we also analysed the medical and operative reports of all patients in order to create an anamnesis for diseases that might potentially serve as contraindications for this operational technique, e.g. unstable physical condition, concomitant oncological disease, diabetes, and severe hypertonia. The patient should be convinced before such an operation that this is the desired method of reconstruction. Table I presents the indications for tissue expander reconstruction in the observed group of 62 children.

Table I - Indications for tissue expansion

<table>
<thead>
<tr>
<th>Indications</th>
<th>Number</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>Burns</td>
<td>56</td>
<td>90.0</td>
</tr>
<tr>
<td>Traumatic defects</td>
<td>4</td>
<td>6.4</td>
</tr>
<tr>
<td>Pigmented stains</td>
<td>2</td>
<td>3.6</td>
</tr>
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</table>
Table II - Age and percentage

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-7</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>8-11</td>
<td>20</td>
<td>32</td>
</tr>
<tr>
<td>12-18</td>
<td>37</td>
<td>60</td>
</tr>
<tr>
<td>-</td>
<td>62</td>
<td>100</td>
</tr>
</tbody>
</table>

The patients’ age ranged from 4 to 18 yr. Table II indicates the children with tissue expansion in relation to their respective age.

The sex distribution of the children selected as suitable for tissue expansion was as follows: 39 boys, representing 64% of the observed group, and 23 girls, representing 36% (the higher percentage of injured boys was related to the higher occurrence of traumatism among boys).

Tissue expansion is achieved with the help of silastic balloons in their respective different shapes: rectangular, round or crescent-shaped. The shape of the expander depends primarily on the site of expansion and on reconstruction needs. The rectangular expander provides the most effective surface area gained, compared to the round or crescent-shaped one. Rectangular expanders gain 38% in tissue area of the calculated surface increase of the expander, whereas round expanders gain 25% and crescent-shaped expanders gain 32% of the calculated surface increase. The tissue expanders used in this study had different volumes varying from 50 to 1000 ml.

In the head, face, and neck area, the expander was usually placed beneath the subcutaneous fat, while in the scalp the expander was placed underneath the galea. The expander should not be placed under previously irradiated skin, and by making several incisions we seek to reduce the pressure over the balloon. A large enough pocket needs to be dissected so that the expander fits without any folding.

After careful selection of the tissue expander, we chose the location - the donor area - to place it. The most important condition is to have more healthy skin and tissues in close proximity to the defect or deformity. The skin incision for implanting the expander was made in a site that was well hidden and/or incorporated into the incisions planned for reconstruction and, if possible, perpendicular to the expander’s long axis.

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After the incision and the placement of the expander system, we instilled intra-operationally through the valve 50 ml saline in order to check if the system (expander, drain, and valve) was closed and therefore that the dead space was obliterated and aiding homeostasis. Expansion was begun two weeks post-operatively by instilling saline into the reservoir with a 23 gauge or smaller needle. During the first seven days and even the following four or five days, we instilled enough saline for the patient not to complain of significant discomfort, such as skin pressure, significant pain, change of colour of neighbouring skin, etc.

Injections were continued on a weekly basis until the desired amount of skin needed for the reconstruction was obtained (usually 6-8 weeks). The anatomical regions subjected to tissue expansion in relation to the reconstruction of the primary tissue defect or deformity are presented in Table III. In the 62 children with indications for tissue expansion to exposure of the implant.

Two types of tissue expansion are known and currently used. We prefer to use prolonged tissue expansion from 1 to 8 weeks, which guarantees gradual expansion of the volume of the expander and the corresponding gradual expansion of the specific skin area. Some authors recommend fast filling of the silastic balloon, with maximum filling during the time of its placement, mainly in adult patients.

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Table III - Anatomical location of placement of expanders

<table>
<thead>
<tr>
<th>Location</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scalp</td>
<td>16</td>
<td>22.80</td>
</tr>
<tr>
<td>Face, neck, and mental area</td>
<td>22</td>
<td>31.50</td>
</tr>
<tr>
<td>Breast area</td>
<td>12</td>
<td>17.14</td>
</tr>
<tr>
<td>Back</td>
<td>8</td>
<td>11.42</td>
</tr>
<tr>
<td>Sacral area</td>
<td>4</td>
<td>5.72</td>
</tr>
<tr>
<td>Upper extremity</td>
<td>6</td>
<td>8.57</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>2</td>
<td>2.85</td>
</tr>
<tr>
<td>All</td>
<td>70</td>
<td>100</td>
</tr>
</tbody>
</table>
pansion, we placed 70 expanders in the anatomical regions as now indicated.

We placed more than one expander during one operational phase in a single anatomical location in five patients, i.e. two expanders in the scalp area in four children during one operation, and also in the face and neck area in two patients, and in the breast area in two other cases.

The predominant tissue expansion location was the lower region of the face, the mental area, and the neck: 31.5%. We performed most tissue expansions in the areas of the face, neck, and breast because of the higher percentage of burns in small children in these areas.

The reconstruction of the tissue defect or deformity went through two basic operational phases: placement of the expander system with a drain and valve in the first operational stage, during which stage the patient underwent intensive and diverse antibiotic prophylactics. After filling the expander until it reached the desired volume during the second operational phase, we performed reconstruction of the defect or the deformation with the newly created expanded tissue from the previous operation.

**Results**

We analyse the operational treatment with tissue expansion of 62 children distinguished on the basis of various indications. Ninety per cent of the children operated on had suffered deep dermal burns and were in the process of developing hypertrophic scarring and keloids, and 6.4% presented acquired traumatic deformations. Two children presented congenital pigmented stains.

Sixty-four per cent of the group were boys, who have a higher risk of traumatism and burns. In relation to age groups, the highest percentage of children operated on (60%) was in the 12-18 yr age group.

In the youngest age group (4-7 yr), the placing of an expander was recorded in only 8% of cases. We relate this finding to the consideration that the parents of such small children with burns or deformations did not seek medical help and to the long duration of the reconstructive procedure and its effect on the children’s psychological development.

The choice of the area of placement of the expander in the different anatomical locations is related to the various specifications of the tissue structures and their capacity for expansion. The physiology of the process of prolonged tissue expansion is not just a matter of stretching skin but involves the actual formation of additional new skin that has all the attributes of the original tissue.

When placing an expander in the scalp, expanders should be placed beneath the galea. Expansion is relatively difficult and the process proceeds slowly, probably because of the resistance of the galea. However, adequate expansion can usually be accomplished in 6 to 8 weeks. This expansion can be quickened by performing galeotomies when the expander is implanted. We did not observe any negative changes, such as a reduction of hair-bearing follicles in the newly expanded skin. The largest expander used had a volume up to 250 ml.

During reconstruction of the lower facial and mental areas we had no complications and reconstruction was completed in accordance with pre-operational expectations. The expanders used ranged from 50 to 250 ml.

In the neck we placed the expander above the platysma. Reconstruction was in accordance with the planned results. In two cases we observed complications of the newly created flap.

In the other anatomical areas we placed the expanders hypodermically and in volumes of up to 1000 ml (Figs. 1-10).

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**Fig. 1** - Clinical case 1. Fifteen-year-old boy after flame burns in the face.

1A. Implanted rectangular expander.
1B. Expander filling stage.
1C. One month post-op.
Complications

The complications rate reported in the literature and in statistics ranges from 5 to 60% and can be reduced by appropriate patient selection and surgical experience. The most serious complications are overlying skin necrosis, implant exposure, and extrusion, which may be secondary to infection, trauma, erosion of the flap owing to folds in the expander, overaggressive expansion, or placement of the valve over a bony prominence.

No significant complications were observed in the selected group of children (Table IV). We observed the flap on a daily basis, and when there was a change in its colour we partially reduced the amount of saline instilled and thus succeeded in decreasing pressure over the extended skin and in preventing the occurrence of skin necrosis. When

<table>
<thead>
<tr>
<th>Anatomical area</th>
<th>Number</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Skull</td>
<td>5</td>
<td>55.6</td>
</tr>
<tr>
<td>Lower extremity</td>
<td>1</td>
<td>11.1</td>
</tr>
<tr>
<td>Neck</td>
<td>2</td>
<td>22.2</td>
</tr>
<tr>
<td>Breast area</td>
<td>1</td>
<td>11.1</td>
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</table>

Table IV - Complications in relation to anatomical area

<table>
<thead>
<tr>
<th>Age</th>
<th>Number</th>
<th>Percentage</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>4-7</td>
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</tr>
<tr>
<td></td>
<td>62</td>
<td>100</td>
<td>9</td>
</tr>
</tbody>
</table>
the colour and viability of the flap recovered we instilled small amounts of saline at two-day intervals until we achieved the desired expansion.

When saline leakage from the incision was observed, we lightly aspirated it within 24 h of the expander placement and applied compressive bandages, without expanding the balloon during this period of time.

Another possible complication, i.e. massive haemorrhage from the expander pocket immediately after the operation (observed in one patient), required re-incision of the wound, stoppage of bleeding, and careful and meticulous homeostasis in the initial procedure. In the group of children operated on using this technique, we observed complications in nine children, i.e. 15% of all patients observed.

The complications observed were relatively minor. Five children experienced ridge necroses of the extended flaps in the skull. The width of the necrosis was from approximately 1 to 1.5 cm. In one case, the lower extremity developed a dehiscence of the incision in the final stage of expander extension, which, however, did not affect the final results of the reconstruction. We also observed a local infection with a microbiological result of *Staphylococcus aureus* in tissue expansion in the neck, which we treated with antiseptic solutions, thus successfully completing the reconstruction.

We evacuated seromas within 24 h in ten of the patients with tissue expansion. We artificially perforated a crescent expander in the breast area and the operation concluded with a change of expander.

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**Fig. 4 - Clinical case 4. Child with post-burn severe contracture and hypertrophic scarring.**
Treatment was not interrupted in any patient and there was no consecutive replacement of the expander. We do not consider the high percentage of complications in the skull area to be significant since the complications all fell under the “minor complications” definition. There was therefore no direct connection between the anatomical area and any specific complication.

We analysed the children’s age and the frequency of complications. The results are presented in Table V. The highest percentage of complications was in the age group 12-18 yr. The fewest complications (3.22%) were observed in children aged 4-7 yr, which means that the tissue expansion method is recommended for reconstruction in this age group.

**Discussion**

Tissue expansion is used successfully in reconstructive surgery for the treatment of acquired defects and congenital deformations in children and adults. The expander technique offers opportunities for reconstruction with minimal loss of tissue and minimal donor site scar, while the skin colour, texture, and contour achieved are superior to those obtained with other reconstruction techniques.

However, despite these advantages, tissue expansion is not a perfect technique without its problems, disadvantages, and limitations; the technique’s disadvantages include the need for two stages, the multiple visits for serial injections, the objectionable temporary appearance, and the interference with everyday activities and clothing habits.

In the period 2000-2006 we applied tissue expansion to 62 patients and placed 72 expanders. This operational technique was applied in the Hem N.I. Pirogov Children’s Burns and Plastic Surgery Clinic even before 2000, but the cases were not analysed.

The indications for tissue expansion indicate that 90% of the patients presented hypertrophic scars and keloids after deep burns.

The patients’ ages ranged from 4 to 18 yr, with the age group 12-18 yr presenting the highest percentage of traumatism, i.e. 60%. In most cases, the reason for reconstruction was burns, traumatic defects, and a marked desire for functionality and a better aesthetic condition. These factors were partially responsible for the higher frequency of operations needed for the complete reconstruction.

Regarding our criteria for successful reconstruction, we mean operations completed with the desired aesthetic and functional results - 85% of the children who underwent tissue expansion treatment presented an excellent appearance and restored functionality.

We observed complications in nine children in the observed group. These complications were considered to be minor as they did not terminate the reconstructive treatment in any children with post-operational complications and we completed the reconstruction successfully. The low percentage of complications was due to the careful and correct selection of the patients, as also to the experience gained in a large number of operations.

The complications we observed were the following:

- ridge necroses in the rotated flaps of width 1-1.5 cm
- development of dehiscence of the incision in the lower extremity, which we believe was due to over-inflation of the expander
- limited local infection, expressed by inflammation of the implant incisions at the end of tissue expansion; this was treated with antiseptic solutions
- seroma developing in ten children operated on; these were removed within 24 h, after which we...
applied a compressive bandage and continued increasing the volume of the expander.

The anatomical area with most complications was that of the skull, with complications after five surgical operations, corresponding to 55% of all the complications observed.

Our analyses, like those of other researchers such as Cunha and Barroso, the percentage complications is lowest in the youngest age group. In children aged 4-7 yr we reported complications in 3.22%. We conclude that as a child’s age increases, so do complications. Our explanation is that children’s skin possesses a high concentration of water, good turgor, good vascularity, high elasticity, and availability of collagen, as well as good chances of rapid tissue repair, as a biological characteristic of the specific age.

### Conclusion

Tissue expansion is an affordable, successful, and reliable method for the reconstruction of congenital and acquired defects on the skin surface. It provides reconstructed tissue that is almost identical to the tissue lost as regards texture, colour, and contour, which makes tissue expansion a recommended surgical technique. When tissue expansion is used for the reconstruction of defects on the skull, the rotational flaps spread hair follicles, which do not differ from the healthy hairy part of the skull. In cases of reconstruction of the lower part of the face with an expander in adolescent boys, the technique restores the beard in this area. With regard to the new rotated flap, we report complete physical recovery, with new tissue possessing the same characteristics as the defective old skin.

The advantage of this technique is the minimal scarring in the donor site. This and other successful post-operative results mean that this method of tissue expansion is aesthetically most efficient and capable of successfully restoring the functionality of the injured anatomical area.

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RÉSUMÉ. L’expansion tissulaire est devenue depuis vingt ans une importante procédure routinière de la chirurgie plastique et reconstructrice, utilisée progressivement dans les cas de reconstruction comme traitement des enfants et des adultes qui ne présentent pas une quantité suffisante de tissus adjacents pour la reconstruction de la surface cutanée atteinte de traumatisme, brûlures ou déformation congénitale. Appliquée aux enfants, la méthode de l’expansion tissulaire a permis aux Auteurs de cet article d’obtenir des résultats esthétiques et fonctionnels qui n’avaient pas été obtenus jusqu’alors avec les procédures traditionnelles de la chirurgie reconstructrice. Les Auteurs présentent les résultats de l’expansion tissulaire appliquée à 62 enfants dans la période 2000-2006 traités au Centre des Brûlures et de Chirurgie Plastique à Sofia, Bulgarie. Ils ont employé 70 extenseurs de diverse forme et volume (de 50 jusqu’à 1000 ml) dans le traitement selon les buts spécifiques de la reconstruction. Les indications pour utiliser les extenseurs tissulaires chez les enfants sont les suivants : défauts cutanés et des tissus mous après les brûlures profondes et les lésions, les défauts traumatiques et les taches de pigmentation. Les enfants inclus dans cette étude de l’expansion tissulaire étaient 39 du sexe masculin et 23 du sexe féminin. Le pourcentage supérieur (64%) des enfants mâles est dû à la fréquence plus élevée de traumatismes chez les garçons. Les zones anatomiques traitées avec l’expansion tissulaire par rapport à la reconstruction des défauts tissulaires primaires étaient les suivantes : cuir chevelu, visage, cou, zone du menton, zone du sein, zone sacrée, dos, extrémité supérieure et inférieure. Plus d’un extenseur tissulaire a été mis en place dans la même zone chez cinq enfants pendant une seule phase opérative. Les Auteurs ont observé le rétablissement fonctionnel et des résultats esthétiques excellents dans 85% des patients qui ont reçu le traitement de l’expansion tissulaire. Le pourcentage le plus bas des complications, c’est-à-dire 3.22%, a été observé dans le groupe des enfants âgés de 4 à 7 ans.

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**BIBLIOGRAPHY**


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Address correspondence to: Dr Nikolina Tzolova, Ovcha Kupel, 9 Lublqna Str., Ap. 7, Sofia 1618, Bulgaria.
E-mail: niki.tzolova@yahoo.com