Original Article
The feasibility of tissue expansion in reconstruction of congenital and acquired deformities of pediatric patients

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Abstract: Skin expansion is one of the major developments in reconstructive surgery. The use of tissue expansion has been popularized among plastic surgeons and has become the treatment method of choice for many congenital and acquired defects in a wide variety of diseases in adults and then later in children. The authors analyze their clinical experience in the treatment of burn scars and complex defects by tissue expansion in pediatric patients. The study included thirty five expansion procedures performed in 25 patients. Smooth surface expanders with a remote valve were used in the scalp (22), face (2), neck (3), hand (2), thorax (2), breast (1), palate (2), abdomen (1). Self-inflating osmotic tissue expanders were used in four patients, one of them had cleft palate and the other two of them had congenital hand anomalies and the last one had frontal scar and alopecia in the frontal hairline. In 19 out of 25 cases (76%) tissue expansion was achieved without complications. At the same time, in 1 cases minor complications and in 5 cases major complications occurred. The number of expanders per patient was only one in 16 cases. More than one expander was used to remove parts of the same injury in 9 cases. Our study may help to draw attention again on different aspects in tissue expansion and critically focus on each step of the tissue expansion both using self-filling tissue expanders and smooth surface tissue expanders with a remote valve.

Keywords: Pediatric patients, self-inflating expander, smooth surface tissue expander

Introduction
Skin expansion is one of the major developments in reconstructive surgery in recent years. The concept of tissue expansion in surgical practice was first reported by Neumann in 1957 for the reconstruction of a partially avulsed ear, while skin expansion was pioneered independently by Radovan, Austad, and Lapin [1, 2]. By implanting a silicon sac subcutaneously and regularly injecting sodium chloride into it, new skin forms under the mechanical stretch, providing a supply of tissue similar in color, structure, and adnexal distribution to the lost tissues for defect repair [3-5]. Skin expansion has gained spectacular success, especially in the field of breast reconstruction and in the treatment of scalp defects [6, 7]. However the use of tissue expansion has been popularized among plastic surgeons and has become the treatment method of choice for many congenital and acquired defects in a wide variety of diseases in adults and then later in children [8].

The authors analyze their clinical experience in the treatment of burn scars and complex defects by tissue expansion in pediatric patients. Tissue expansion has become the method of choice for reconstruction of congenital and acquired defects in every site capable of expansion in our clinic. We retrospectively analyzed the success, failure and complication rates of all our pediatric cases of tissue expansion and compared the results with those in the literature.

Materials and methods
The data were retrieved in the form of a retrospective case note study spanning a 12 year period. The study included thirty five expansion...
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procedures performed in 25 patients. The study protocol has been approved by Ethic Committee of Sisli Etfal Training and Research Hospital.

Age, gender, indications for skin expansion, site of scars or defects to be reconstructed shape and volume of expander inserted, expander volume reached after expansion, time reached to maximum volume expansion and complications, either major complications and minor complications were reviewed. Major complications of expansion were defined as infection (clinical redness associated with pain, pyrexia, and solution of symptoms with antibiotic treatment), dislocation, leakage, exposure, wound dehiscence, extrusion, and necrosis. Minor complications included hematoma, seroma, delayed wound healing longer than 14 days [9]. If active treatment of complications led to completion of expansion this was termed “salvage”; if the treatment had to be abandoned it was termed “failure”.

Smooth surface tissue expanders with a remote valve and self-inflating osmotic tissue expanders were used. The prosthesis was generally placed through an incision that was included in the scar to be removed and put under the skin and the fascial layer, except for the scalp where it is placed under the galea. In all patients, one or two closed negative suction bulb 22-French round drains were placed at the time of expander placement. Also, intraoperative saline filling were done for preventing hematoma and a mean fill volume of 10 percent were infused without adversely affecting blood supply to the skin flaps. Proper inflations generally began 2 week after the first operation and continued at 7 days intervals: inflation phase was on average 3 months long, according to the location and nature of the defect to reconstruct [10, 11]. The filling volume was each time suggested from the patient discomfort and blanching of the skin overlying the implant [10, 11]. Overfilling followed by limited deflation has been proposed as a method of increasing inflation volume at each session. Despite instrumental monitoring methods, objective inspection and patient response were usually our first reliable indicators of adequate implant inflation [10]. When removing the expander, we never removed the whole capsule because it carries blood supply to the flap, but we only incised it in order to enhance flap movement.

Results

A total of 35 expanders were placed, in 25 pediatric patients between January 1999 and April 2011; this series comprised 14 females and 11 males with a mean age of 9.26 years (range: 11 months-14 years old). Skin expansion was performed for a variety of indications; however, it was not used for open wounds. Smooth surface expanders with a remote valve were used in the scalp (22), face (2), neck (3), hand (2), thorax (2), breast (1), palate (2), abdomen (1). Self-inflating osmotic tissue expanders were used in four patients, one of them had cleft palate and the other two of them had congenital hand anomalies and the last one had frontal scar and alopecia in the frontal hairline. The number of expanders per patient was only one in 16 cases. More than one expander was used to remove parts of the same injury in 9 cases. Advancement scalp flaps were made to remove alopecia sites in 23 cases, and to repair the hairline in one.

Rectangular expanders were used in 25 cases, rounded ones in 5 cases, crescent one in 1 case, all with internal remote valves. Anatomically, 4 expanders were placed in trunk and limbs in the subfascial plane through an incision that was included in the scar to be removed. 5 expanders were placed in the face and neck in the subcutaneous. In the scalp, 22 expanders were placed in the subgaleal plane. The volume of expanders used ranged between 0.7 ml and 600 ml (mean: 308.4 ml), while the fully expanded volumes ranged between 0.7 and 650 ml (mean: 329.5 ml). Time of treatment (time from expander placement to expander removal at the time of reconstruction ranged between 2 and 3 months with a mean of 2.8 months.

In 19 out of 25 cases (76%) tissue expansion was achieved without complications. At the same time, in 1 cases minor complications and in 5 cases major complications occurred. Four expanders were exposed at the end of the procedure; in two cases. Expansion was interrupted by withdrawal of the expander and advancement of the flap. Since this occurred during the final stages of expansion the outcome was not compromised and this cases were termed “salvage”. Only in one case that was used self-inflating osmotic expander, implant was withdrawn in the early period and it was termed “failure”.
Case 1

A four year old girl was presented with an unstable and aesthetically unpleasant scar on the frontotemporal region because of traffic accident. In the first session, 200 cc (crescentic) subgaleal tissue expander was inserted to occipital region and 250 cc (rectangular) subgaleal tissue expander was inserted to parietal region. The overexpanded flap allowed excision of the whole wide scar on the temporal region. In the second session, 60 cc self filling osmotic tissue expander were used to reconstruct the frontal hairline one year later. Small ulceration has occurred on the middle of the planned flap on the frontal region due to rapid expansion. Expansion was successfully continued and completed for 7 weeks.
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A galeal tissue expander was inserted to parietal region. Intraoperative tissue expander saline fill volume was made according to the manufacturer’s suggested fill volume. Expansion was uneventful and continued for 10 weeks. The saline volume instilled was 10% more than manufacturer’s stated volume (Figure 1A). The overexpanded flap allowed excision of the whole wide scar on the temporal region. In the second session, 60 cc self filling osmotic tissue expander were used to reconstruct the frontal hairline (Figure 1B) one year later. During the expansion, small ulceration has occurred on the middle of the planned flap on the frontal region due to rapid expansion. We managed this unwanted ulceration on the surface of the flap with close follow-up and hyperbaric oxygen therapy. Expansion was successfully continued and completed for 7 weeks (Figure 1).

Case 2

A 14 year old girl sustained a severe mastitis at the neonatal age and this infection was resulted with breast agenesia. Expansion was uneventful and continued for 9 weeks. The saline volume instilled was 300 cc. In the second session, 215 cc permanent breast implant were placed.

Figure 2. A severe mastitis at the neonatal age and this infection was resulted with breast agenesia. Expansion was uneventful and continued for 9 weeks. The saline volume instilled was 300 cc. In the second session, 215 cc permanent breast implant were placed.
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215 cc permanent breast implant were placed and nipple areola complex were reconstructed (Figure 2).

Case 3

A 11 months old boy was presented with congenital amniotic band anomaly. Initially, fourth web were reconstructed with local flaps and full thickness skin grafts. At the same session, 2.1 ml self-inflating osmotic tissue expander (cylindrical) was introduced the dorsal aspect of the planned first web area (Figure 3A). The expansion went uneventful and continued for 8 weeks. In the second session, the reconstruction of the first web was made with expanded local flaps and minimal full thickness skin grafts. It enabled defects to be covered with tissue similar in texture and color (Figure 3B).

Discussion

Tissue expansion has been described as a great advance in plastic surgery [1]. Cutaneous expansion is used increasingly in reconstructive surgery for the treatment of a variety of problems in children and adults. It enables defects to be covered with tissue similar in texture, color and type. Also donor site morbidity is generally minimal [12]. Donor site morbidity becomes extremely important in children due to their growth capacity and children add an extra challenge with their tendency to hypertrophic scarring along the reconstructive suturing lines [9]. Tissue expansion that preferred method allowed us to replace large scars in only two stages especially scalp and extremities reconstruction, where it is possible to leave minimal residual scars, located in less visible areas. However, initially it was associated with a relatively high complication rate similar in literature [12], with increasing experience, these complications become less common in the recent studies.

Female patients were predominant, in the studies of Almeida [13] and Nakamoto et al. [14], perhaps due to a stronger concern about aesthetics. The numbers of female and male patients are very close to each other because of our study group have consisted of children we have gave same attention to aesthetics both in male and female patients.

Areas most often involved were head and neck (76%), similar to others authors like Nakamoto et al. (70.6%), Pitanguy et al. (60.7%), and Marks (53.3%). Ranking second in our experience were torso (28%), similar to the literature, where the torso was more common [14-16]. Scalp alopecia is a common sequela to sustained burns of the head region, scalp reconstruction surgery after burns has become a common procedure [17]. The advent of tissue expansion started a new era of aesthetically reconstructed scalp alopecia by providing a major, hair-bearing scalp area with acceptable hair density [18, 19]. The major advantage of
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...this procedure is that the donor site morbidity. However, drawbacks are the long duration of the treatment with numerous clinical visits and a long period of disfigurement. Currently, it is believed that an alopecia area involving 50% or more of the total scalp surface can be repaired using tissue expansion (multistage or serial tissue expansion [20, 21].

Management of children poses great challenges to the treating surgeon. Tissue expander indications of acquired and congenital injuries must meet the criteria of healthy skin, the possibility of regular expansion, and psychologically stable patients. In contrary to known belief that children can not suit the proper inflation for smooth surface expanders with a remote valve, we did not need to end the tissue expansion in early period of the treatment due to non compliance to treatment. We have faced more problem with self-filling osmotic tissue expanders in our patients. Self filling expanders gain their 50% of final volume at the end of first week of postoperative time and they produced more discomfort and pain. In cleft palate patients that we placed implant to subperiosteal plane, implant exposition occurred in the first week and this treatment plan did not provide extra benefit. In the other patient who was placed to frontal area, rapid inflation caused ulceration in the middle of the flap although recommending patients to use moisturizer creams on expanding skin.

We suppose that self filling osmotic expanders did not easily replace to smooth surface expanders with a remote valve. In selecting patients consideration must be given to certain difficulties such as: limited donor site, involvement of several areas, patients who are emotionally distraught, the need for repeated surgical procedures or several expanders, and long term treatment or follow-up.

The overall complication rates reported with the use of tissue expander in the literature vary widely, ranging from 13% to 40%, [22] but the complication rates in pediatric patients range from 9% to 37% [23]. In 19 out of 25 cases (76%) tissue expansion was achieved without complications. At the same time, in 1 cases minor complications and in 5 cases major complications occurred.

Our complication rate came to 24%, the most frequent type were exposition. Similarly to the literature, we found most complications in the head and neck [16].

Methodologically, cutaneous overexpansion can be considered the other solution for avoiding a compromised result if surface area gain is insufficient [24]. Overexpansion appears safe without risk of implant failure by factors of 5–10 times the vendor stated maximum volume [25, 26]. Using this approach, we started to apply it also only to obtain wider and more pliable flaps. Using tissue overexpansion we have lived up the goal of replacing large scars in a one-stage procedure. A good example of this is described in scalp and extremities reconstruction, where it is possible to leave minimal residual scars, located in less visible areas.

Disclosure of conflict of interest

The authors have no conflict of interest to disclose for this study.

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