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ORIGINAL ARTICLE

Tissue expanders for soft tissue reconstruction in the head and neck area—requirements and limitations

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Abstract
Objectives The repair of skin defects in the head and neck region still poses a significant problem for many clinicians. Tissue expansion is described as a treatment option providing good color, texture, and thickness match of the expanded skin. Unfortunately, the complication rates for tissue expansion range from 0 to 48 %. Therefore, the purpose of this study was to investigate risk factors for the use of tissue expanders in head and neck reconstructions.
Materials and methods Forty-nine patients with skin deficits in the head and neck area underwent tissue expansion. Sixty-two implanted expanders were analyzed regarding the various complications and the success rate.
Results The success rate of treated patients was 37 (75.5 %) of all 49 included patients. The most frequent cause for the skin deficit was a tumor resection near the tip of the nose followed by skin deficits resulting after craniectomy. Interestingly, a higher number of expanders and a larger volume were significantly associated with a worse outcome. There was a trend of association between larger defect size and failure, too.
Conclusions The internal tissue expansion is a suitable technique for skin reconstruction in the head and face area. Compared to distant or free flaps, it often offers a better cosmetic outcome. In very large defects (>100 cm^2) or when more than two expanders are needed, the failure rate increases. In these cases, other treatment options are recommended.
Clinical relevance The internal tissue expansion is a suitable technique for skin reconstruction in the head and face area.

Keywords Tissue expansion · Soft tissue defects · Head and neck · Complications

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Introduction

The reconstruction of damaged or lost skin is a clinical challenge in modern reconstructive surgery. Local, regional or distant, pedicled or free flaps all produce additional scars and often substantial donor site morbidity. Since Neumann introduced the concept of tissue expansion for reconstructive surgery in 1957 [1], it has found wide applicability. The technique of tissue expansion enables the surgeon to create a new local supply of skin and subcutaneous tissue [2, 3]. Traditional expanders are silicone envelopes that have a self-sealing injection port, where saline is injected to enlarge the expander [4]. Nevertheless, tissue expansion is only one option to accomplish skin reconstruction in the head and neck. Skin grafting and local, distant or free flaps are another option to close these defects [5–8]. In order to choose the most promising treatment modality beside other factors

like absent donor site morbidity, the complication rate is important. Unfortunately, the reported complication rates for tissue expansion range from 0 to 48 % [3, 9–12]. Therefore, the purpose of this prospective study was to investigate risk factors for the use of tissue expanders in head and neck reconstructions.

Material and methods

Between 2004 and 2010, fourty-nine patients with a deficit of skin in the head and neck area underwent skin reconstruction with local tissue expansion. Sixty-two CUI™ saline fill rectangular shaped standard tissue expanders of 140, 250 and 340 cm^3, respectively, with remote subcutaneous injection ports, were used (Allergan™, Santa Barbara, CA, USA). Unfortunately, four expanders had to be excluded from further analysis because of cessation of treatment due to dead or removal of the expanders. Depending on the localization of the defect, an incision was made rectangular to the intended direction of the expansion and an adequate supragaleal pocket for the expander was created. Then a smaller pocket was created for the port as far away from the expander as technically possible, and the incision was closed in two layers after injecting 10 ml of saline into the expander through the port. Sixteen days upon expander implantation, the filling period started using saline. Injections were performed three times a week and the filling quantity was adjusted to individual signs of pain and/or loss of capillary refill of the overlying skin. The expander was removed due to major local complications or when enough skin was expanded to close the skin deficit. All surgical procedures were performed under general anesthesia. All patients were treated with perioperative antibiotics, usually consisting of ampicilline and sulbactam (Unacid®, Pfizer, Berlin, Germany; 3×3 g i.v. per day)

For the evaluation of risk factors, the age of the patients, the number and size as well as the position of the expanders and the localization of the defect, concurrent osseous defects, all complications, the cause of the defect, radiotherapy, and the filling were measured and recorded. The success of the expander treatment was defined as the closure of the initial skin deficit.

For statistical analysis, the software SPSS® 18.0 was used. To detect any statistical differences, the Kruskal–Wallis test, the Mann–Whitney *U* test as well as the Chi-square test were performed. A *p* value below 0.05 was considered as statistically significant.

Results

Fifty-eight expanders were implanted and analyzed (36 in male, 22 in female patients). Five expanders were placed in patients who had undergone radiotherapy. The age of the patients was 58 (±16) years and the defect size was 40 (±43) cm^2. On average, 1.4 (±0.8) expanders were used in each patient. The mean size of the used expanders was 269 (±182) cm^3. The overall success rate for the expander treatment was 70.7 %, whereas 17 (29.3 %) expanders did not result in a sufficient defect closure. Taking into account, that some patients received more than one expander, the success rate of treated patients was 37 (75.5 %) of all 49 included patients.

The most frequent cause for the skin deficit was a tumor resection near the tip of the nose followed by skin deficits resulting after partial craniectomy by neurosurgeons (Table 1). There were statistically significant differences regarding the success rate. The most promising indications were skin reconstruction after skin tumor resection, skin defects of the tip of the nose, and alopecia (Table 1). The localization of the skin defect influenced the success as well. The predominant defect site was the parietal region characterized as the supply zone of the a. temporalis superficialis followed by the tip region of the nose and the forehead. These three regions account for about two third of all defects (Table 2). The success rates of the various defect localizations were statistically different too. Whereas defects of the nose, the cheek/upper lip, and unilateral defects of the parietal and occipital region could successfully be treated in the very most cases; defects of the forehead and large defects including the supply zone of all temporal and occipital arteries were more prone to generate serious complications (Table 2). When the expander was in situ, 15 of 22 complications occurred during the filling phase. However, only 17 complications finally resulted in a failure (Table 3).

Interestingly, a higher number of expanders per patient and a larger volume were significantly associated with a worse outcome. There was a trend of association between larger defect size and failure, too. However, the *p* value for this statistical association was slightly above the limit of 0.05 (Table 4). The time interval between the implantation of the expander and the first filling played no crucial role regarding overall success and failure.

Defects of the nose represented the largest group of defects. Therefore, the reconstructions are described more in detail. The very most of these nose defects were localized at the tip area. For reconstruction, the expander was implanted at the opposite forehead and the injection ports were placed subcutaneous over the os mastoideus (behind the ear). In these group, only two expander failed because of infections of the expander (the overlying skin, respectively) during the filling phase.

Discussion

Reconstruction of skin deficits in the head and neck area still presents a unique challenge to the surgeons. The technique

Table 1 The common causes of the skin deficit

Cause of the skin deficit	Total Number (%)	Success Number (%) *
Skin tumor of the nose (predominantly in the tip area)	15 (25.9)	13 (86.7)
Osseus calvarium defect with skin deficit	13 (22.4)	9 (69.2)
After skin tumor resection of the calvarium	11 (19.0)	10 (90.9)
After resection of meningeoma	9 (15.5)	3 (33.3)
Other causes	5 (8.6)	3 (60.0)
Alopecia	4 (6.9)	3 (75.0)
Skin deficit after radiotherapy	1 (1.7)	0 (0.0)

*$p<0.046$, statistically significant difference analyzed by Chi-Square test

of tissue expansion offers excellent advantages to solve these problems in many cases. Regarding the numbers in our study, the number of patients and expanders included in this analysis is far above of many other reports in the literature [3, 13–20]. Thus, our data might have some relevance. Of all used expanders and treated patients, 70.7 and 75.5 %, respectively, resulted in a successful treatment outcome. That means that the skin deficit could be compensated without any additional treatment. As mentioned above, the reported complication rates range from 0 to 48 % [3, 10, 12]. Manders and co-workers reported a 24 % major complication rate which is in line with our results [12]. Chun and colleagues [3] described a 12 % major complication rate when 25 patients with burn injuries were treated with tissue expansion and a comparable expander volume of 290 cm^3. However, these patients were much younger (average age: 24 years) than our group (average age: 58 years). Interestingly, the number of used expanders per patient and the expander volume was significantly associated with a worse outcome. Usually, these parameters correlate with the defect size. That means that skin deficits or defects of about 55 cm^2 are good candidates for expander treatment, whereas larger defects (105 cm^2) have to face more complications. Defects of the nose often require smaller expanders. That explains the high success rate for this defect localization. In a very recently published report, Kheradmand and colleagues describe the advantages of nasal reconstruction using tissue expanders implanted on the forehead. Although they described in six (30 %) out of 20 patients (presenting full thickness defects of the nose) major or multiple minor revisions, they reported an overall high satisfaction rate of their patients [21].

Compared to other treatment options like distant or free flaps, the tissue expansion offers some unique advantages. With tissue expansion, esthetic subunits can be replaced with skin of identical or similar quality and thickness, and distant donor sites can be avoided. Sensate and hair-bearing skin can be expanded and used for head and face reconstruction. Usually, there is an excellent color and texture match [3]. In addition, long-term expansion profoundly enhances the vascularity of the tissue allowing more extensive flaps [22]. Moreover, a redistribution of the hair follicles in the expanded scalp can be observed although no new follicles are created [13].

Regarding the surgical technique, some remarks are useful. In our study, all of the expanders were placed in the supragaleal layer. This is in agreement with Prakash and co-workers who compared sub- and supragaleal placement of

Table 2 Predominant defect site with respect to the regional vascularization

Localization of the skin deficit with respect to the regional vascularization	Total Number (%)	Success Number (%) *
Supply zone of a unilateral a. temporalis superf.	15 (25.9)	13 (86.7)
Nose (tip)	14 (24.1)	12 (85.7)
Forehead	7 (12.1)	3 (42.9)
Supply zone of all a. temporales superf. and a. occipitales	4 (6.9)	0 (0.0)
Cheek/upper lip (one including nose)	3 (5.2)	3 (100.0)
Supply zone of an unilateral a. occipitalis	3 (5.2)	2 (66.7)
Supply zone of both a. occipitales	3 (5.2)	3 (100.0)
Supply zone of both a. temporales superf.	3 (5.2)	2 (66.7)
Neck	2 (3.4)	0 (0.0)
Supply zone of a unilateral a. temporalis superf. and forehead	2 (3.4)	1 (50.0)
Supply zone of both a. temporales superf. and forehead	2 (3.4)	2 (100.0)

*$p<0.023$, statistically significant difference analyzed by Chi-Square test

Table 3 Complications

Complications	During filling number (%)	After defect closure number (%)	Total number (%)
No complications			36 (62.1)
Dehiscence over the expander	15(25.7)		5 (8.6)
Infection of the expander			3 (5.1)
Other complication while the expander was in situ			7 (12.0)
Dehiscence after expander explantation		7(12.0)	1 (1.7)
Other complication after the expander was removed			6 (10.3)

tissue expanders [13] and described a better outcome for the latter one. The positioning of the expanders is of utmost importance and challenging even for experienced surgeons. Not only the size and the position of the skin defect and the contingent need for cranioplasty have to be taken into account but the main factor to site the expander is the design of the prospective flap which in turn has to consider vascular territories of the expanded region. A disadvantage of the classical expander technique is that multiple office visits are required during the expansion period for painful external fillings. Other drawbacks of the technique are the inherent risk of infection by serial punctions of the port, rupture of the expander by percutaneous stabbing, and extrusion of the expander. External filling ports might by an appropriate alternative. Keskin and co-workers reported only about 10 % failure when they used external filling ports for tissue expansion [23]. However, they used on average smaller expanders than in our study.

In 1999, an osmotic active self-filling expander was developed in Germany by OSMED^{TM}. Although it is reported to overcome the above mentioned major drawbacks of the conventional expander technique and has been improved by covering it with a silicone shell to prevent uncontrolled expansion [24], its application has been reported mainly in several case reports [25–27] and has not yet gained widespread application. Nevertheless, three larger series have also been published recently: the work by Ronert et al. covers a 4-year period and 58 patients similar to our series and reports a successful explantation and defect closure in 81.5 % of cases before and in 91 % of cases after the introduction of the covering silicone membranes, even if most of the cases were patients for breast augmentation and only four cases were tumors in the head and neck region. Unfortunately, the outcome of these patients is not reported in detail in this study. [28]. The second series by Obdejin et al. gives their 3-year experience of nine patients whereas five of them had scalp deficits. In three of these five, the expanders had to be removed due to ischemia (two) or due to migration (one). This confers a success rate of 40 % in the head nad neck-patients of this series. [29] Chummun et al. reported their 5-year experience comprising ten patients (seven children and three adults), whereof five patients were treated in the head and neck region. In their series, two of the five patients had premature removal of the expanders due to infection or erythema, which accounts for a success rate of 60 %. [30] Absence of the repeated visits to the outpatient department for the painful external fillings make the self-filling expanders an interesting alternative especially in pediatric patients [31].

Another technique found in the literature is the “external” tissue expansion described by Lasheen and colleagues [17]. Negative pressure of −100 to −200 mbar forms a fold of skin and subcutaneous tissue. This tissue excess can be used for

Table 4 Correlation for the number and size of expanders per patient

Parameter	Values for successful treated patients/expanders	Values for not successful treated patients/expanders	p-value[a]	
Defect size	50.3 (± 53.3) cm^2	106.0 (±28.0) cm^2	0.051	Not significant
Number of expanders per patient	1.2 (± 0,4)	3.5 (±1.0)	0.005	Significant
Expander size per patient	224.0 (±189.8) cm^3	542 (±255.0) cm^3	0.013	Significant
Time from expander implantation until first filling	15.8 (±6.3) days	103.5 (±157.0) days	0.232	Not significant

[a] according to Mann-Whitney-U-test

plastic reconstruction. Unfortunately, the defect size was not reported. Therefore, it is unclear whether this technique is suitable for larger defects.

In conclusion, the internal tissue expansion is a suitable technique for skin reconstruction in the head and face area. Compared to distant or free flaps, they often offer a better cosmetic outcome. In very large defects (>100 cm^2), the failure rate increases. Therefore, other treatment options are recommended in those cases. Due to the promising initial results of the osmotically active self-filling expanders [27, 29, 30], a prospective randomized study to compare the outcome of the treatment with the conventional expanders to the osmotic expanders especially in the head and neck region will be performed at our institution. In the remote future, tissue engineering strategies might substitute these techniques at least for smaller defects [32].

Competing interests All authors declare that there are no competing interests regarding the interpretation or presentation of the above mentioned data or results. Especially, there are no commercial associations or financial obligations that might pose or create a conflict of interest.

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