A Retrospective Analysis on the Proper Size of Tissue Expanders to Treat Scalp Lesions

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**Background:** Tissue expanders have become established instruments for scalp reconstruction. However, selection of the size of the expander has not been investigated systematically, and it generally depends on the experience of the surgeon.

**Methods:** We retrospectively analyzed 21 patients who had undergone treatment for scalp lesions using tissue expanders without any complications and measured 2 variables: the volume of the expanders per area of the excised lesions and the hypothetical stretched functional skin width relative to the width of the excised lesions. We also sought to evaluate the relationship between these 2 variables and the need for revision surgery during the postoperative course.

**Results:** The need for revision surgery was statistically higher in patients with a volume of 7 ml/cm² lesion or less and width of functional skin of less than 2.5 cm/cm lesion (P < 0.05). For scar repairs, the required size and volume of the expanders tended to be larger than those required for any other lesions.

**Conclusions:** Expanders that generate functional skin at least more than 2.5 times the width of the lesion and have a volume more than 7 ml/cm² lesion are necessary to cover scalp lesions without complications. (Plast Reconstr Surg Glob Open 2014;2:e118; doi: 10.1097/GOX.0000000000000070; Published online 14 March 2014.)

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ers and discuss the proper size of expanders to treat scalp lesions without complications.

**PATIENTS AND METHODS**

We retrospectively investigated the clinical records of 36 patients with scalp lesions in whom tissue expanders had been inserted from January 2000 to December 2009 at the Department of Plastic and Reconstructive Surgery, Kyoto University Hospital. For further analysis, we selected those patients who had achieved complete filling of the expanders without complications and then undergone reconstruction of the defects using a simple advancement technique after resection of the whole lesion. Based on the clinical records and photographs, we examined the gender and age of each patient, the kind and size of the lesions, the number of expanders used in each patient, the size, volume and shape of the tissue expanders, and the postoperative course.

Based on these data, we calculated 2 variables: 1) the volume of the tissue expanders relative to the area of the excised lesions and 2) the skin width after stretching by tissue expanders, which matches the direction of flap advancement, relative to the width of the excised lesions. In the analysis of the volumes, all tissue expanders that were inserted into each patient were added and compared with the area of the lesion that was measured in the clinical photographs taken before insertion of the expanders. In the analysis of the width, we targeted only those patients in whom the expanders were inserted in the same direction and excluded those in whom 3 or more expanders were inserted, to improve the accuracy of the analysis. The width of the hypothetical functional skin that could be used to cover the defect was defined as the width of the bottom of expanders subtracted from the width of the surface of the expanders (Fig. 1). This width of the hypothetical functional skin was compared with the width of the lesion that was measured in the clinical photographs taken before insertion of the expanders (Fig. 2). We then sought to evaluate the relationship between these 2 variables and the need for revision surgery during the postoperative course.

**Statistical Analyses**

The receiver operating characteristic (ROC) curve was used to assess the ability of the analysis to discriminate between patients who needed revision surgery and those who did not. The area under the curve (AUC), which reflects how good the analysis is at distinguishing between these 2 groups, is interpreted such that an AUC greater than 0.9 has high accuracy, while 0.7–0.9 indicates moderate accuracy. To determine the cutoff points for the optimal sensitivity and specificity, the Youden index was used. Patients were dichotomized at the cutoff points and analyzed using Fisher’s exact probability test. \( P < 0.05 \) was considered statistically significant.

**RESULTS**

Fifteen patients were excluded from the study: 8 patients experienced complications during insertion...
of the expanders, 5 patients did not achieve complete filling of the expanders, and in 2 patients the whole lesion could not be resected during the surgery. There were 21 patients who fulfilled the requirements for this study, including 11 men and 10 women, aged 1 to 61 years (Tables 1 and 2). The number of tissue expanders inserted into each patient ranged from 1 to 3 and the total number was 38. For the width measurement, there were 13 patients who fulfilled the inclusion criteria, including 8 men and 5 women.

All tissue expanders were placed beneath the galea. In most cases, rectangular expanders were used because they provided the most efficient expansion. However, other types were sometimes used based on the donor conditions. The first injection of saline solution was administered after an undisturbed healing period of 14 days and added once or twice weekly, thereafter, based on specific clinical signs, that is, skin tension, color, and pain. Removal of the tissue expanders was performed 2–4 weeks after full expansion to prevent retraction of the expanded skin after reconstruction.

The volume of expanders/cm² area of excised lesions ranged from 5.3 to 27.0 ml, with an average of 11.9 ml (Fig. 3A). There were 8 patients who required revision surgery during the postoperative course, whereas the remaining patients did not require further treatment because their results were satisfactory (Fig. 4A). The methods of revision surgery were re-excision of the widening scar or hair grafting. The AUC of the ROC curve was 0.86, which indicated that the test had moderate accuracy, and the cutoff point determined by Youden index was

### Table 1. Patients with Scalp Lesions Where Tissue Expanders Had Been Inserted and Achieved Complete Filling of the Expanders without Complications

| Patient No. | Gender | Age     | Indication       | Type, Size, and No. Expanders | Width of Functional Skin (cm)/1 cm Lesion | Volume of Expanders (ml)/1 cm² Lesion |
|------------|--------|---------|------------------|-------------------------------|------------------------------------------|--------------------------------------|
| 1          | Male   | 1 y 2 mo | Congenital nevus | Rectangular (10×5×7) 1        |                                          |                                      |
| 2          | Male   | 1 y 5 mo | Congenital nevus | Rectangular (5×4×3) 2         |                                          |                                      |
| 3          | Male   | 1 y 8 mo | Congenital nevus | Rectangular (9×5×5) 1         |                                          |                                      |
| 4          | Female | 2 y 0 mo | Congenital nevus | Rectangular (9×5×5) 2         |                                          |                                      |
| 5          | Male   | 2 y 0 mo | Congenital nevus | Rectangular (10×5×7) 1        |                                          |                                      |
| 6          | Male   | 2 y 6 mo | Congenital nevus | Rectangular (12×8×4) 1        |                                          |                                      |
| 7          | Female | 18 y 11 mo | Congenital nevus | Rectangular (17×8×6) 1        |                                          |                                      |
| 8          | Male   | 23 y 3 mo | Congenital nevus | Rectangular (9×5×5) 2         |                                          |                                      |
| 9          | Male   | 26 y 9 mo | Congenital nevus | Rectangular (7×5×4) 1         |                                          |                                      |
| 10         | Male   | 4 y 0 mo | Scar             | Rectangular (12×8×4) 1        |                                          |                                      |
| 11         | Female | 23 y 6 mo | Scar             | Rectangular (8×4×5) 1         |                                          |                                      |
| 12         | Female | 25 y 1 mo | Scar             | Rectangular (10×5×7) 3        |                                          |                                      |
| 13         | Female | 45 y 2 mo | Scar             | Rectangular (9×5×5) 1         |                                          |                                      |
| 14         | Male   | 59 y 11 mo | Scar           | Rectangular (5×4×5) 1         |                                          |                                      |
| 15         | Female | 61 y 0 mo | Scar             | Rectangular (5×3×2) 1         |                                          |                                      |
| 16         | Female | 61 y 0 mo | Scar             | Rectangular (10×4×5) 2        |                                          |                                      |
| 17         | Male   | 1 y 6 mo | Sebaceous nevus  | Rectangular (5×3×3) 2         |                                          |                                      |
| 18         | Female | 6 y 0 mo | Sebaceous nevus  | Rectangular (9×5×5) 1         |                                          |                                      |
| 19         | Male   | 21 y 9 mo | Arteriovenous malformation | Rectangular (10×8×6) 1 |                                          |                                      |
| 20         | Female | 24 y 5 mo | Scleroderme en coup-de-sabre | Rectangular (9×5×5) 1 |                                          |                                      |
| 21         | Female | 29 y 10 mo | Neurofibroma     | Rectangular (10×5×7) 1        |                                          |                                      |

The defects were then reconstructed using simple advancement technique after resection of the whole lesions.

*Type, size, and number of expanders* are shown as “type (size) number.” The sizes are shown as follows: rectangular type (length × width × height) (cm), round type (diameter × height) (cm), and crescent type (length × width × height) (cm).

— indicates the patients who were excluded from the measurement because they underwent insertion of 3 or more expanders.
The sensitivity and specificity were 62.5% and 100%, respectively, at this cutoff point. On the other hand, the width of functional skin/cm excised lesion ranged from 1.1 to 5.6 cm, with an average of 3.1 cm (Fig. 3B). Five of 13 patients required revision surgery during the postoperative course (Fig. 4B). The AUC of the ROC curve was 0.98, which indicated that the test had high accuracy, and the cutoff points determined by Youden index was 3.4 cm, and the second recommendation was 2.4 cm. The sensitivity and specificity were 100% and 87.5%, respectively, at 3.4 cm, whereas the sensitivity and specificity were 80% and 100%, respectively, at 2.4 cm.

The need for revision surgery was statistically higher in patients in the range of less than 7 ml/cm² lesion and width of functional skin of less than 3.5 cm or 2.5 cm/cm lesion ($P < 0.05$).

The calculated values for the treatment of scars tended to be greater in both volume and width. As for the water volume of the expanders/cm² lesions, it was only in the scar cases that more than 21 ml was

| Lesion             | No. Patients |
|--------------------|--------------|
| Congenital nevi    | 9            |
| Scars              | 7            |
| Sebaceous nevi     | 2            |
| Others             | 3            |
| **Total**          | **21**       |

**Table 2. Types of Lesions**

![Fig. 3. A, Relationship between the water volume of the tissue expanders (ml)/cm² of the excised lesion and characteristics of the excised lesions. The volume of the expanders/cm² area of the excised lesions ranged from 5.3 to 27.0 ml, with an average of 11.9 ml. B, Relationship between the width of the functional skin (cm)/cm of the excised lesions and characteristics of the excised lesions. In the analysis of the width, we targeted only those patients in whom the expanders were inserted in the same direction and excluded those in whom 3 or more expanders were inserted; consequently, 13 patients fulfilled the inclusion criteria. The width of functional skin/cm excised lesion ranged from 1.1 to 5.6 cm, with an average of 3.1 cm.](image)
Aya et al. • Size of Expanders for Scalp Lesions

required, and the functional skin width of 4.5 cm or more/cm lesion was needed only in cases of scar and scleroderme en coup-de-sabre.

**DISCUSSION**

No tissue in the human body adequately mimics the hair-bearing scalp. While a small defect of the scalp can be covered with a local skin flap composed of adjacent scalp, large defects are eventually treated by either skin grafts or free flaps. Unfortunately, the postoperative appearance following such treatments can be unattractive. Tissue expansion, especially in the scalp region, is an effective technique that enables tissue to be transferred from the adjacent hair-bearing areas. Furthermore, the scalp is also an ideal place for tissue expansion due to the rich blood circulation, thick overlying tissue, and the rigid support of the skull.

Although the concept of tissue expansion is simple, selection of the proper size implants for tissue repair is not. Insufficient expansion leads to inadequate covering of the lesion, the need for an additional skin graft, scar widening, or “stretch back.” Insufficient expansion leads to inadequate covering of the lesion, the need for an additional skin graft, scar widening, or “stretch back.”

Radvan and Morgan and Edgerton reported that the expander base should be the same size as the defect. On the other hand, Manders et al suggested placing as large an expander as possible. These recommendations were based on empirical observations. van Rappard et al studied the surface area gained by tissue expansion using 3 approaches: mathematical, in vitro, and in vivo (in pigs), and they concluded that the expander base should be roughly 2.5 times as large as the defect.

In our study, we considered the size of successfully expanded skin as it relates to the bulging of the expanders and the size of the base, and the skin available to cover the defect is obtained by subtracting the width of the bottom surface for covering the expander insertion portion from the width of all the expanded skin surface. In clinical practice, the width of the expander is constant and easier than consider-

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**Fig. 4.** A. Relationship between the number of patients requiring revision surgery and the volume of expanders (ml)/cm² of the excised lesion. There were 8 patients who required revision surgery during the postoperative course, whereas the remaining patients did not require further treatment. The cutoff point determined by Youden index was 6.9 ml; the sensitivity and specificity were 62.5% and 100%, respectively, at this cutoff point. B. Relationship between the number of patients requiring revision surgery and the width of functional skin (cm)/cm² of the excised lesion. Five of 13 patients required revision surgery during the postoperative course. The cutoff points determined by Youden index was 3.4 cm and the second recommendation was 2.4 cm. The sensitivity and specificity were 100% and 87.5%, respectively, at 3.4 cm, whereas the sensitivity and specificity were 80% and 100%, respectively, at 2.4 cm.
ing the real skin width. For these reasons, we defined the hypothetical functional skin based on the width of the expanders. We also predicted that there might be some relationship with the volume of the tissue expanders. Our study, therefore, analyzed the volume and the width of the stretched skin of the tissue expanders in the cases undergoing surgery.

Our results revealed that cases with a volume of less than 7 ml/cm² lesion and a width of functional skin less than 2.5 or 3.5 cm/cm lesion required revision surgery more frequently than cases with any other ranges. It was considered that the cases in these small ranges might experience scar widening or deformity caused by scar contracture, although the surgery had appeared to have been successful due to the total resection of the lesion after completion of the surgery. Based on the observation that the need for revision surgery was statistically higher in the patients with a width of functional skin below 2.5 and 3.5 cm/cm lesion, it can be said that those cases in which the functional width is between 2.5 and 3.5 cm/cm lesion may be considered borderline. On the other hand, there were no postoperative complications due to excess expansion, that is, hematoma, infection, and remarkable dog-ear.

Based on the above findings, tissue expanders that generate skin at least 2.5 times the width of the defect and have a volume more than 7 ml/cm² defect are necessary for successful scalp reconstruction without complications.

We also observed that a wider width of functional skin and a larger volume of tissue expanders were needed in some scars, which suggests that the amount of skin required for scars varies according to the degree of scar contracture, and are more than that required by any other type of lesions. Because the size of the skin defects created by removing the scar and by the release of the scar contracture are often much larger than the scar itself, successful repair of such defects sometimes requires 2-fold more or even greater skin width and volume of expanders compared with other lesions. Furthermore, in the cases of treatment for scars, it is necessary to plan in consideration of the primary diseases that caused the scars.

The present results suggest that the size of tissue expanders should be selected based on the width and area of the lesion. In applications involving scars, preoperative evaluation of the degree of the latent contracture should be performed before choosing the size and number of tissue expanders.

CONCLUSIONS

We analyzed 21 patients with scalp lesions in whom tissue expanders that generate skin at least more than 2.5 times the width of the defect and have volumes of more than 7 ml/cm² lesion are needed for successful scalp reconstruction without complications. For scar repairs, the size and volume of the expanders tended to be larger than those required for any other lesions.

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