Objective: To describe the novel use of an external tissue expander in the reconstruction of scalp and forehead defects.

Methods: A prospective review was performed on 7 patients who underwent extirpation of head and neck malignant neoplasms resulting in scalp and forehead defects. Reconstruction was performed using an external tissue expander device. Patient clinical factors, defect size, and photographs were collected.

Results: Seven patients had large scalp and forehead defects ranging in greatest dimension from 5.0 x 4.0 to 8.0 x 7.0 cm. The external tissue expander was in place for 6 to 14 days, reducing the defect sizes by 50% to 99%. At the time of device removal, primary closure was achieved in 5 patients. One patient required bilateral advancement rotation flaps, and 1 patient healed by second intention. One patient with a history of scalp irradiation and diabetes had partial skin loss after device removal and required reconstruction with a latissimus dorsi myocutaneous free flap. There were no other postoperative complications, wound breakdown, or device failures.

Conclusion: External tissue expansion is a safe and effective technique for closing large scalp and forehead defects that would otherwise require skin grafting or free flap reconstruction.


The scalp and forehead are challenging areas in which to achieve optimal closure, both technically and cosmetically. The poor flexibility and limited appropriate donor tissue make even small defects difficult to close. As in all areas of the head and neck, it is ideal for repairing tissue defects with tissue that is similar in color, thickness, and texture. The hair-bearing nature of the scalp makes this goal challenging to achieve.

Several options exist for closure of medium and large scalp and forehead defects, ranging from skin grafts and granulation via second intention to more extensive advancement flaps and microvascular free tissue transfers. Many of these options fail to achieve the goal of replacing the defects with like tissue, often resulting in poor cosmesis. Tissue expansion has previously been a reliable method for achieving closure of scalp defects but has the disadvantages of delaying definitive treatment and preplanning. We suggest exploring the use of a novel external tissue expander for closure of scalp and forehead defects. We report 7 cases of scalp and forehead reconstruction using a novel external tissue expander (DermaClose RC; Wound Care Technologies).

METHODS

Our prospective case series includes patients who were treated for head and neck cancer at Mayo Clinic, Rochester, Minnesota, from August 2010 to October 2011. Each patient underwent wound closure with the novel external tissue expansion device. After institutional review board approval, data were gathered using the institutional electronic records. Data regarding patient clinical factors, defect size, and photographs were collected. After the malignant neoplasm was removed and negative margins were confirmed, an external tissue expansion device was applied. The patients were seen in the clinic every 48 to 72 hours for wound examination and advancement of the tension device when required.

The external tissue expander is a device that accelerates wound closure by applying a continuous tension to wound edges until the skin has sufficiently stretched to allow primary closure or to result in a much smaller wound (Figure 1). Application of the external device involves placement of 316L surgical stainless steel anchors approximately 1 to 3 cm from the defect margins.
from the wound edge and 2 to 3 cm apart from each other. Anchors are stabilized with 2 standard wide (6-7 mm) skin staples. The USP 2 monofilament nylon line housed in the device’s tension controller is then attached around each anchor in a shoelace or radial fashion. Finally, tension is applied around the skin anchors by turning the knob of the tension device until the controller is fully tightened, indicated by an audible clutch mechanism (Figure 2). For wounds longer than 10 cm or wider than 5 cm, multiple devices may be used in series.

RESULTS

The mean patient age for this 7-patient case series was 70 years (age range, 57-87 years). After excision of the malignant neoplasms with the patient under general or local anesthesia, the defects ranged from 5.0 × 4.0 to 8.0 × 7.0 cm in greatest dimension. The device was placed intraoperatively and remained in place for 6 to 14 days. The patients required tightening of the device 1 to 3 times between device placement and removal. The tightening was performed during outpatient office visits. After removal of the device, the defects decreased in size by 50% to 99% (Table). Five patients were able to achieve primary closure at the time of device removal. One patient required bilateral advancement rotation flaps, and 1 patient healed by second intention once the device was removed. Defects before and after device placement, with resultant closure for 4 patients, are shown in Figure 3.

The patients tolerated the device being in place. Tightening of the device caused moderate pain, which was controlled with a combination of oral analgesics and a local anesthetic. There were no cases of wound breakdown at the sites of the skin anchors. One patient had partial skin loss after device application and bilateral advancement rotation flaps. He had poorly controlled diabetes and a 6.0 × 7.5-cm vertex scalp defect that had been previously irradiated. A latissimus dorsi myocutaneous free flap was required to reconstruct the defect and was performed without complication. Two patients had dehiscence of their wounds after primary closure. After device removal, these patients had their wounds closed in a 1-layer fashion with staples. Both wounds dehisced 1 to 2 weeks after staple removal. The remaining patients underwent a 2-layer closure with a polydioxanone suture followed by a polypropylene suture (Prolene; Ethicon Inc). There were no incidences of wound breakdown with this method of closure.

Defects of the scalp and forehead create substantial reconstructive challenges. The skin in these areas has limited elasticity, and the hair-bearing nature of the scalp makes adequate cosmesis difficult to achieve. Several options exist for closure of medium and large scalp and forehead defects. Primary closure is optimal but is seldom achieved for defects that are larger than 3 cm in diameter. Wide undermining of the scalp in a subgaleal plane will usually be required and provides only limited additional closure. Healing by second intention offers an additional option for defects with periosteum present. It allows optimal tumor surveillance and avoids complex reconstruction procedures. Disadvantages include the time and compliance that are required for proper wound care as well as a poor cosmetic result. The prolonged wound care may interfere with timely postoperative radiation therapy, and irradiation may compromise the final result, leaving the patient with exposed bone. The area will not contain hair, and the scar may be atrophic and have prominent telangiectasis that may be unsightly.

Skin grafts may be used over any size of defect. Healing is facilitated by an intact periosteum; however, exposing the diploic space of bone or galeal rotation flaps will allow healing of skin grafts over exposed bone. Similar to healing by second intention, split-thickness skin grafts will often be compromised after irradiation. Also, poor cosmesis and lack of hair-bearing skin are the main disadvantages of using skin grafts. Various local and advancement flaps are commonly used for medium to large scalp defects. Because of the scalp’s inelasticity, they will typically need to be proportionally larger than other facial flaps.

Distant pedicled flaps, including the latissimus dorsi and lower trapezius flaps, have also been used for occipital and lateral scalp defects. They have limited reach and cannot extend above the temporal line. Microvascular tissue transfer is often required for reconstruction of large defects, particularly in cases with cranial defects. Microvascular skin flaps are reliable options that allow coverage of large defects with vascular tissue in a single-stage procedure. The main disadvantages are the poor tissue match and lack of hair-bearing skin, length of the procedure, and morbidity to donor sites.

The use of tissue expanders for scalp reconstruction has become increasingly popular over the last 2 decades. Two main types have been described in the scalp: long-term tissue expansion using Silastic balloons under the galea and intraoperative sustained external tissue expansion. Both techniques allow reconstruction of scalp

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**COMMENT**
<table>
<thead>
<tr>
<th>Patient No./Sex/Age, y</th>
<th>Pathologic Findings</th>
<th>Initial Defect Size, cm</th>
<th>Length of Device Application, d</th>
<th>Final Defect Size, cm</th>
<th>% Wound Closure</th>
<th>Final Closure Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/M/77</td>
<td>Scalp vertex defect: failed STSG for leiomyosarcoma</td>
<td>6.0 × 7.5</td>
<td>8</td>
<td>2.5 × 9.0</td>
<td>50.0</td>
<td>Bilateral advancement rotation flaps</td>
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<tr>
<td>2/F/83</td>
<td>Scalp vertex defect: melanoma</td>
<td>7.5 × 7.5</td>
<td>6</td>
<td>1.3 × 2.0</td>
<td>96.0</td>
<td>Primary closure</td>
</tr>
<tr>
<td>3/M/66</td>
<td>Scalp vertex defect: leiomyosarcoma</td>
<td>9.5 × 5.0</td>
<td>8</td>
<td>0.2 × 2.0</td>
<td>99.2</td>
<td>Primary closure</td>
</tr>
<tr>
<td>4/M/86</td>
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<td>14</td>
<td>3.5 × 2.5</td>
<td>82.0</td>
<td>Second intention</td>
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<tr>
<td>5/F/57</td>
<td>Scalp vertex defect: recurrent basal cell carcinoma</td>
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<td>99.9</td>
<td>Primary closure</td>
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<tr>
<td>6/M/57</td>
<td>Paramedian forehead defect: reconstruction for nasal basal cell carcinoma</td>
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<td>1.4 × 1.5</td>
<td>95.4</td>
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<td>Scalp vertex: melanoma</td>
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<td>6</td>
<td>1.0 × 1.0</td>
<td>95.0</td>
<td>Primary closure</td>
</tr>
</tbody>
</table>

Abbreviation: STSG, split-thickness skin graft.

**Table. Characteristics of Scalp and Forehead Defects Reconstructed With an External Tissue Expander**

**Figure 3.** Defects before and after external tissue expander placement with resultant closure for 4 patients.
defects with matched tissue—in color, thickness, and texture. However, the process of tissue expansion using silastic balloons is typically prolonged and requires the expansion process to be planned and executed before the wound is created. It prohibits the use of tissue expansion in acute wounds due to trauma or in cases of malignant transformation requiring timely resection.

The scalp is an ideal location for external tissue expansion. Cox et al. described a case in which both skin expansion with inflatable expanders and an external tissue expander were used to close a scalp defect due to trauma. Two inflatable expanders were inserted under each side of the defect, and the external tissue expander was then applied to the skin edges. Over the course of 30 days, the prosthesis was inflated and the external tissue expander was tightened to bring the wound edges closer. The defect was ultimately closed with a local rotation flap.

External tissue expansion uses the principles of mechanical creep and stress relaxation to reduce the size of large defects. Mechanical creep is the stretching of a material, in this situation skin, under a constant load over time. When skin is stretched, its convoluted collagen fibers straighten and realign parallel to each other. Elongation of these fibers beyond the inherent extensibility of skin results in mechanical creep. Displacement of water from the collagen network and microfragmentation of elastic fibers makes the skin more viscous, allowing it to stretch. Stress relaxation is defined as the decrease in retractive forces exhibited by a material when it is held at a given stretch over time. Tissue expansion, presuturing, undermining, and skin retraction rely on these principles to assist with wound closure.

In conclusion, we describe a novel external tissue expansion device that can be applied intraoperatively at the time of the defect is created and achieves closure in a relatively short time. After device removal, wounds should be closed in a 2-layer fashion to prevent delayed wound dehiscence. This device appears to be appropriate for most patient populations. We had one instance of a device-induced tissue loss in a patient with diabetes who had received previous external beam irradiation. Caution should be exercised in patients in whom local tissue vascularity may be compromised. Although the device applies a constant tension, in our experience this required advancement every 48 to 72 hours, resulting in frequent office visits. Other disadvantages are that there is some discomfort for patients during and after the device tightening and that the application requires closure of the defect at a later time. The advantages include the ability to apply the device with the patient under local anesthesia in cases in which the patient would not tolerate a general anesthetic, the lack of prolonged inpatient hospitalization, and the absence of donor site morbidity that occurs with free flap reconstruction. This device offers an alternative option for large scalp and forehead defects that would not be amenable to primary closure and would otherwise require skin grafting or free flap reconstruction.

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REFERENCES