Microvascular Free Tissue Transfer in the Reconstruction of Scalp and Lateral Temporal Bone Defects

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ABSTRACT

Defects of the scalp and lateral temporal bone (LTB) represent a unique challenge to the reconstructive surgeon. Simple reconstructive methods such as skin grafts, locoregional flaps, or tissue expanders are often not feasible due to a myriad of reasons. Vascularized free tissue transfer coverage offers distinct advantages in managing these defects. A retrospective case series was performed on all patients at the University of Washington Medical Center who had scalp or LTB defects reconstructed with free tissue transfer from May 1996 to July 2009. Cases were analyzed for defect characteristics, flap type, vessel selection, radiation status, dural exposure, complications, and outcomes. Sixty-eight free flaps were performed in 65 patients with scalp or LTB defects. Twenty-two resections included craniotomy, and 48 patients had pre- or postoperative radiation. Defects ranged from 6 to 836 cm². All flaps (46 latissimus, 11 rectus, 4 radial forearm, 6 anterolateral thigh, and 1 omental) were transferred successfully. Vein grafts were required in five cases. Complications included delayed flap failure requiring secondary reconstruction, neck hematoma, venous thrombosis, skull base infection, large wound dehiscence, small wound dehiscence, donor site hematoma and seroma, and cerebrospinal fluid leak. Cosmetic results were consistent and durable. Microvascular free tissue transfer is a safe, reliable method of reconstructing scalp and LTB defects and offers favorable cosmetic results. We favor the use of latissimus muscle-only flap with skin graft coverage for large scalp defects and rectus or anterolateral thigh free flaps for lateral temporal bone defects.

KEYWORDS: Scalp reconstruction, lateral temporal bone reconstruction, scalp neoplasms, scalp defects, microvascular reconstruction, free tissue transfer

Scalp and lateral temporal bone defects may result from tumor resection, chronic infection, osteoradionecrosis, trauma, burns, or congenital lesions.^{1,2} Reconstruction of these areas presents several unique

challenges including the need for coverage of sizable composite defects with inelastic surrounding tissue, as well as the required protection of nearby intracranial contents. Reconstructive procedures are often further

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complicated by previous surgery and/or radiation or require planned postoperative radiation. Chronic soft tissue infection or osteomyelitis of the calvarium may also be an issue in these already complex cases. These factors negatively impact on the viability of surrounding tissue and severely limit the use of locoregional flaps for reconstruction. Furthermore, aggressive disease requiring resection of calvarial bone precludes the use of local flaps or staged reconstructive procedures, such as tissue expanders.²⁻⁴ Finally, even after committing to reconstruct these areas with free tissue transfer, it is often challenging to reach donor vessels in the neck from scalp sites near the vertex.

The specific goals of reconstructing scalp and lateral temporal bone defects include (1) restoration of the bony contour, (2) restoration of soft tissue thickness, (3) epithelial coverage to the defect area, and (4) seal intracranial contents from the nasal cavity or outside air. From an overall reconstructive standpoint, it is important to create a durable tissue that withstands trauma or radiation and heals relatively quickly to allow for any necessary adjuvant therapies to be administered in a timely fashion.⁴ Because of these considerations, and the anatomic challenges facing locoregional reconstruction of this region of the body, free tissue transfer is particularly useful, and commonly necessary, in scalp and lateral temporal bone reconstruction.

This study reviews our institutional experience in scalp and lateral temporal bone reconstruction over a 13-year period. Based on our results from 68 free flaps in 65 patients, we provide recommendations for the use of microsurgical free tissue transfer in the reconstruction of this challenging area.

MATERIALS AND METHODS

A retrospective chart review was performed on consecutive patients undergoing free flap reconstructions for scalp and lateral temporal bone defects at the University of Washington Medical Center between May 1, 1996, and July 30, 2009. Information was obtained regarding the patients' age, sex, pathological diagnosis, and previous treatment. The location, size, and type of defects, as well as the type of reconstruction, donor vessels, perioperative complications, and clinical outcomes, were then analyzed.

RESULTS

During the study period, 68 free flaps were performed in 65 patients with scalp or lateral temporal bone defects (Table 1). Sixty-one of these reconstructions were primary, three flaps were secondary due to complications of earlier reconstructions, four were required due to scalp breakdown following craniotomy/craniectomy without free tissue reconstruction.

Table 1 Patient and Reconstruction Characteristics

Characteristic	Finding
No. of patients	65
Age (y)	10–87 (mean, 67.5)
Sex	48 male, 17 female
No. of free flaps	68
No. of primary reconstructions	65
No. of secondary reconstructions	3
Follow-up (mo)	2–119

Indications for free flap surgery were diverse: squamous cell carcinoma (24), chronic wound/osteoradionecrosis (ORN)/osteomyelitis (18), basal cell carcinoma (8), angiosarcoma (5), melanoma (4), dermatosarcoma (1), gliosarcoma (1), Merkel cell carcinoma (1), adenoid cystic carcinoma (1), adenocarcinoma (1), angiomatosis (1), spindle cell carcinoma (1) recurrent meningioma with calvarium involvement (1), and nerve sheath tumor (1).

Fifty defects were located on the scalp, and 18 on the lateral temporal bone. Twenty-one resections included craniectomy; all calvarial reconstructions were via calvarial bone grafts, titanium mesh, or porous polyethylene implant (Porex Surgical Inc., Newnan, GA). Thirty cases were performed on a previously radiated field, and another 20 patients were planned for postoperative radiation. Defect size ranged from 6 to 836 cm², with a mean of 160.4 cm².

All free tissue transfers were performed successfully; one case did have a venous thrombosis following a neck hematoma requiring anastomotic revision, which was subsequently successful. Another free flap failed 15 months following initial microvascular surgery secondary to pedicle compromise during a flap recontouring procedure. Reconstructions were performed with a variety of free flaps: latissimus dorsi (46; see Fig. 1), rectus abdominis (11; see Fig. 2), anterolateral thigh (6; see Fig. 3), radial forearm (4), and omental (1). Size range of defects based on reconstruction type were as follows: latissimus dorsi: 110 to 836 cm² (mean 225.5 cm²); anterolateral thigh: 8 to 156 cm² (mean 122.7 cm²); radial forearm: 12 to 66 cm² (mean 44.5 cm²); rectus abdominis: 6 to 140 cm² (mean 74.5 cm²); omental: 320 cm². For microvascular anastomosis, the donor arteries utilized were superior thyroid (32), transverse cervical (14), facial (18), lingual (2), and occipital (1). Donor veins were comprised of external jugular (39), superior thyroid (4), internal jugular (9), facial (10), retromandibular (2), and transverse cervical (3). All anastomoses were performed end-to-end save for nine end-to-side anastomosis to the internal jugular vein. Five cases required the use of vein grafts from the saphenous vein.

Overall, 10 major complications and 13 minor complications occurred, representing a 14.7% major and 19.1% minor complication rate (Table 2). Of the major

complications, three patients had to return to the operating room. One patient had a significant wound dehiscence at the inferior border of the free flap, necessitating coverage with a pectoralis major myocutaneous flap; another patient developed a large dehiscence requiring secondary free tissue transfer for closure. One patient developed a neck hematoma leading to venous pedicle thrombosis requiring surgical evacuation and venous anastomosis revision. Another patient developed an abdominal wound hematoma from the rectus abdominis donor site, which was managed by surgical evacuation. The third patient had persistent osteomyelitis with dural exposure, eventually requiring a second free flap to adequately cover the scalp. Finally, one patient devel-

oped cerebritis with seizures postoperatively, requiring anticonvulsants and extended intravenous antibiotic treatment for *Serratia*-positive cerebrospinal fluid (CSF) cultures, but ultimately recovered without sequelae. The minor complications consisted of four minor wound dehiscences, which healed with conservative management; seven seromas and a single small hematoma in latissimus dorsi donor site wounds; and a single case of postoperative delirium. These complications represented 19.4% of the latissimus flaps in the series.

Over the follow-up period of 2 to 119 months (mean 28.4 months; median 27 months), four late complications of surgery occurred. Ten of the 48 patients with malignancies were dead of disease, and three of

Figure 1 An 84-year-old man with basal cell carcinoma (BCC) of the scalp. (A) Vertex scalp BCC lesion with proposed resection margins marked out. (B) Preauricular incision marked out for passage of free flap vascular pedicle for later anastomosis in the neck region. (C) Vertex view of scalp following resection of lesion and margins. Note calvarial bone intact. (D) Right muscle-only latissimus dorsi free flap (LDFF) for reconstruction of scalp defect.

Figure 1 (Continued) (E) LDFF inset in scalp defect to reestablish soft tissue depth and contour of scalp region. Surrounding normal scalp sutured to LDFF muscle. (F) Meshed split-thickness skin graft (STSG) placed over LDFF to reconstruct epithelial lining of scalp. (G) Oblique view of scalp reconstruction with LDFF and STSG at 3-month postoperative follow-up. (H) Vertex view of scalp reconstruction with LDFF and STSG at 3-month postoperative follow-up.

those patients died of other causes. The remaining 38 patients with malignancies were alive and well with no evidence of disease, and along with the 16 patients with nonmalignant disease, had durable cosmetic results from free tissue reconstruction.

DISCUSSION

When considering reconstruction of scalp and lateral temporal bone defects, the usual ladder of options is limited; this concept has been detailed in numerous

other publications.²⁻⁵ First, the surrounding tissue is very inelastic compared with other parts of the body, so primary closure is only feasible for very small (usually <3 cm) defects. Simpler reconstructive methods are eliminated in large defects, or when bone has been resected, due to the obvious need for sealing the intracranial cavity. Because these defects frequently result from resection of malignant disease, the use of staged procedures, such as tissue expanders, is also restricted because of the need to expediently resect the primary tumor. Tissue expanders, however, can be utilized postoperatively to

restore hair-bearing tissue to areas of reconstructed scalp after healing has occurred.⁵ Finally, though well-designed local flaps can cover large areas, the surrounding tissues are often poorly vascularized due to previous surgery or radiation.

For all of these reasons, free tissue transfer should be considered for many cases of scalp and lateral temporal bone defects. Beasley et al proposed a staging system involving sizes of defects and some wound characteristics for forehead and scalp defects.² In our experience, it is difficult to define hard and fast criteria for the use of free flap reconstruction; rather, it is important to consider all factors, including but not limited to defect size, quality of surrounding tissue, and presence of exposed intracranial contents.

In this series, 43 of 50 scalp defects were reconstructed with latissimus dorsi muscle-only free flaps (Fig. 1); however, three radial forearm, two rectus (Fig. 2), one omental, and one anterolateral thigh flaps were also employed. The use of a combination of latissimus muscle-only flap with split-thickness skin graft for coverage of scalp defects allows maximum pliability of tissue, large surface area reconstruction, and creates a thickness that, after atrophy, closely approximates natural scalp⁶ (Fig. 1). The overlying skin graft typically heals very nicely, and the rate of wound complications is low. Our lateral temporal bone defects were reconstructed with nine rectus flaps (Fig. 2), five anterolateral thigh flaps (Fig. 3), and four latissimus flaps. Both the fasciocutaneous rectus free flap and

Figure 2 (A) A 72-year-old man with basal cell carcinoma of left external auditory canal and auricle with lateral temporal bone involvement. Left auricle and proposed resection margins marked. (B) Defect following resection of left auricle, left external auditory canal, left lateral temporal bone resection, left middle ear ablation, and left parotidectomy. (C) Muscle-only left rectus abdominis free flap (RAFF) for left lateral temporal bone reconstruction. (D) Inset of RAFF into left lateral temporal bone defect.

Figure 2 (Continued) (E) Split-thickness skin graft (STSG) placed over RAFF reconstruction of left lateral temporal bone defect to reconstruct epithelial lining. (F) Left profile view of RAFF with STSG reconstruction of left lateral temporal bone defect. (G) Left profile view with left auricular prosthesis placed over RAFF with STSG reconstruction.

fasciomyocutaneous anterolateral thigh free flap provide excellent soft tissue bulk for obliterating the space after temporal bone resection (Figs. 2 and 3).⁷⁻⁹ The latissimus dorsi, anterolateral thigh, and rectus free flaps have lengthy pedicles for access to donor vessels of the neck, allowing us to avoid the use of vein grafts in all but five cases. Branches of the external carotid artery were favored for arterial anastomoses in this series, the transverse cervical artery was often used in irradiated patients as it was out of the heavily radiated field. Donor veins from the upper neck were preferable as well. In contrast to other series,²⁻⁶ we avoided use of the superficial temporal vessels, primarily because of the frequently inadequate quality of the vein and poor vessel geometry. Furthermore, we found that latissimus and rectus flap pedicles routinely reach easily lower in the neck (Fig. 4).^{10,11}

The majority of our patient series (48 of 68, or 70.6%) had defects resulting from the resection of malignant tumors. Of these, 21 cases had undergone bicortical calvarial resection, 17 at the same time as reconstructive surgery. In the other four cases, previous craniectomies had been performed without free flap

reconstruction, and subsequent wound breakdown threatened the intracranial cavity, necessitating vascularized tissue coverage. A single patient developed a CSF leak following lateral temporal bone resection and required a second operation for closure. One patient developed postoperative seizures due to a bacterial cerebritis, but ultimately recovered with medical treatment alone. One patient developed cerebral herniation requiring calvarial bone flap removal for decompression; unfortunately, this patient passed away 2 months postoperatively due to basal cell carcinoma invasion of the frontal lobes. The second most common indication for surgery was chronic infection or osteomyelitis (20 cases, 29.4%), frequently as a result of previous radiation and/or surgery.

The most unusual cases in this second group involve two patients who had cochlear implants with persistent wound infections despite multiple debridements and attempts at local flaps. One patient had his initial implant removed, was treated for the infection, and had the implant reimplanted. Once the overlying skin broke down again, it became necessary to cover the

Figure 3 (A) A 64-year-old woman with two previous latissimus dorsi free flap and split-thickness skin graft (STSG) reconstructions of a posterolateral scalp defect with subsequent wound breakdown and tissue loss. Note two separate areas of wound breakdown and exposed calvarium. (B) Left posterolateral scalp defect following resection of nonviable soft tissue and underlying necrotic calvarium. (C) Left anterolateral thigh free flap (ALT) with vascular pedicle. (D) Inset of ALT flap to superior aspect of posterolateral scalp defect to reconstruct soft tissue contour. STSG over inferior aspect of defect where deep soft tissue was viable. (E) Posterior view of left posterolateral scalp reconstruction at 3-month postoperative follow-up.

area with vascularized free tissue. The second patient developed a chronic wound overlying his cochlear implant as well that also required free tissue transfer for coverage. In both cases, radial forearm free flaps were used to reconstruct the scalp overlying the cochlear

implants. Both of the patients recovered uneventfully following their free tissue reconstructions.

Overall, there was a single free flap failure (15 months postreconstruction) and a 14.7% major and 19.1% minor complication rate (detailed in Table 2).

Table 2 Complication Characteristics

Complication	No.
Flap failure	1 (delayed)
Wound dehiscence	6 (4 major, 2 minor)
Neck hematoma	1
Vascular pedicle thrombosis	1
Donor site hematoma	3
Donor site seroma	7
Intracranial complications	2
Cerebrospinal fluid leak	1
Calvarial osteomyelitis	1
Postoperative delirium	1

The complication rates presented here are comparable to or less than other published series of scalp or scalp/forehead reconstructions.²⁻⁵ Of note, most of the minor complications in this series were latissimus donor site seromas. Our rate of 10.4% seroma formation at the free flap donor site is lower than the published rate in the breast reconstruction literature of 20 to 79%.¹² Several techniques have been described to avoid seroma formation, including the use of sharp rather than electrocautery dissection,¹³ the use of tacking sutures,¹²⁻¹⁴ and even the application of fibrin glue.^{6,15}

One of six patients in this series who underwent anterolateral thigh free flap reconstruction had two

Figure 4 (A) Scalp bone defect in left frontal calvarium reconstructed with titanium mesh. Mesh anchored to calvarial bone with craniofacial reconstruction screws. (B) Latissimus dorsi muscle-only flap inset over titanium mesh in scalp defect. Soft tissue thickness match between latissimus muscle and native scalp skin is ideal. Note flap pedicle draped anterior to the auricle to rest in the upper neck, making anastomosis to cervical vessels possible. (C) Latissimus dorsi muscle-only flap now covered with meshed split-thickness skin graft. Note aesthetically pleasing closure of preauricular and cervical incision. The meshed skin graft once fully healed provides an excellent aesthetic appearance due to reducing light reflection when compared with nonmeshed skin grafts.

prior reconstructions with latissimus muscle-only flaps and had slowly developed chronic wound breakdown at the posterior edge of the flap each time (Fig. 3). We suspected this to be pressure-related, as the patient was noncompliant with postoperative instructions to avoid resting on her reconstructed scalp. Her final reconstruction with an anterolateral thigh flap was successful; the cutaneous paddle proved to be heartier than a skin graft, and the thickness of the flap was cosmetically appealing. As our experience with the anterolateral thigh flap improved, the flap became, and remains, a viable alternative for scalp reconstruction. The large body habitus in our patient population and poor skin color match limits its use. In the future, we may employ this flap more frequently when the donor site thickness is appropriate, as it can be harvested with ease, without turning the patient, and has been used successfully by others for this application.¹⁶ In our opinion for the majority of scalp defects, the latissimus dorsi muscle flap with a skin graft still provides the optimal contour and aesthetics.

Microvascular free tissue transfer is most useful for scalp and lateral temporal bone defects that are large, previously operated or radiated fields, actively infected, or include bicortical skull defects. In our experience, the cosmetic results are favorable and durable, and the surgery is safe and reliable, with a low rate of major complications. We favor the use of latissimus muscle-only free flap with skin graft coverage for scalp defects and rectus abdominis or anterolateral thigh free flaps for lateral temporal bone defects.

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