ORIGINAL ARTICLE

TEMPORALIS MUSCLE FLAP FOR RECONSTRUCTION OF SKULL BASE DEFECTS

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Accepted 3 April 2009
Published online 25 June 2009 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/hed.21170

Abstract: *Background.* The temporalis muscle flap (TMF) is a valuable reconstructive technique utilized in a variety of challenging defects. However, its use for repair of skull base defects is less commonly reported.

Methods. A retrospective chart review was conducted for 35 patients who underwent reconstruction of skull base defects between March 1999 and July 2006 at a tertiary referral hospital. Patients with skull base defects after trauma or extirpative surgery underwent reconstruction with a TMF. The measured outcomes were as follows: defect size/location, need for additional flaps, bone necrosis, hardware exposure, dehiscence, cerebrospinal fluid (CSF) leak, and meningitis.

Results. Forty-two patients underwent reconstruction with a TMF, and 35/42 patient records were available for review. No flap failures, 1 transient CSF leak, 3 hardware exposures distant from the temporalis recipient site, and 3 hydroxyapatite cement infections or foreign body reaction were observed.

Conclusion. The TMF represents a versatile reconstructive technique employed with minimal morbidity and a low complication rate to repair defects of the skull base. © 2009 Wiley Periodicals, Inc. *Head Neck* **32:** 199–203, 2010

Keywords: temporalis muscle flap; regional flap; skull base surgery; skull base trauma; cerebrospinal fluid leak

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Anterior and lateral skull base surgery for both benign and malignant lesions often results in significant defects of the craniofacial skeleton and surrounding soft tissues, allowing potential free communication between the extracranial and intracranial compartments. Tumor resection and trauma can result in osseous defects, violated dura, and contamination of the intracranial compartment with bacterial flora from the upper aerodigestive tract. It is necessary to separate these compartments to prevent the potential complications of cerebrospinal fluid (CSF) leak, meningitis, bone flap necrosis, hemorrhage, and exposure of hardware. Successful early outcomes in skull base surgery are dependent on adequate healing at the surgical site. Therefore, reconstruction of the skull base is most appropriately accomplished with vascularized tissue.

The temporalis muscle flap (TMF) is a reliable, nonbulky, myofascial flap, which has had a role in a wide variety of maxillofacial reconstructive problems over the last 100 years.

Although many authors credit Golovine (1898) with the TMF's original description, recent articles have demonstrated that his method of reconstructing orbital exenteration defects was a forehead skin flap and not a myofascial flap.[1–3] Probably, the first use of any part of a TMF has its origin in the surgical treatment of temporomandibular joint ankylosis, as portions of a TMF were used by Lentz (1895) and possibly by Verneuil (1872) during an interposition arthroplasty following resection of the conydylar neck of the mandible.[3,4] The first use of the entire TMF as a true transposition flap for maxillofacial reconstruction can be traced to Gillies (1917), who utilized the TMF in rehabilitating a cheek deformity resulting from traumatic loss of the zygomatic arch.[1,5] Modifications of the surgical technique and creative applications have extended the TMF for use in every location to which the pedicle's length and arc of rotation will allow. Sheehan (1935) augmented TMF mobilization by introducing temporary removal and replacement of the zygomatic arch. Rambo (1958) used this reliable flap to obliterate the middle ear and mastoid cavities in cases of chronic ear disease.[3,6] This study reviews our experience with the application of TMF for the repair of ablative and traumatic defects of the skull base.

PATIENTS AND METHODS

A retrospective chart review was conducted identifying patients who underwent a temporalis flap for reconstruction of a skull base defect. Forty-two patients were identified from March 1999 to July 2006 treated at a tertiary referral medical system by the senior author (Y.D.). Data were collected on the age of patient, size of defect, area of defect, cause of defect, follow-up, and complications. Thirty-five patient records were complete and available for review. The Institutional Review Board's approval was obtained for this study.

Surgical Technique. A standard hemicoronal or bicoronal incision is used to harvest the TMF and to furnish access in most skull base approaches in this study. When required, transfacial approaches were combined with coronal incisions to allow appropriate access. The coronal incision is placed 1.5 cm posterior to the anterior hairline, although a more posterior orientation can accommodate patients with receding hair lines. Care should be observed laterally in the preauricular area to preserve the superficial temporal vessels. The supraorbital and supratrochlear vessels are freed from their foramen, if necessary, by using a 3-mm osteotome. This maneuver allows for an extended inferior reflection of the bicoronal flap without placing excessive traction on the vessels and nerves within the operative field.

The surgical anatomy of the TMF has been reviewed in detail in previous publications,[7] and only the vascular supply and available dimensions as it relates to surgical harvest will be reviewed briefly herein.

The main vascular supply to the flap is provided by the anterior and posterior branches of the deep temporal artery, which originates from the second (pterygoid) portion of the internal maxillary artery and enter the deep surface of the muscle, most commonly at the inferior third of the muscle and usually in the posterior half of the muscle.[8] The deep temporal artery courses between the skull and temporalis muscle, anastomozing with the middle temporal artery within the temporalis muscle. The middle temporal artery is a branch of the superficial temporal artery (STA), which usually originates 0 to 2 cm below the zygomatic arch and runs slightly posterior to the STA. The middle temporal artery then enters the deep temporal fascia immediately superior to the zygomatic arch.[9] It continues its course superiorly and sends some perforators deep into the temporalis muscle. Careful subperiosteal dissection will preserve the vascular supply as it enters the temporalis muscle on the deep surface. Once harvested, the TMF typically spans a length of 12 to 16 cm, with a thickness of 0.5 to 1.0 cm, provides an available surface of 4 cm $\times$ 5 cm, and tolerates an arc of rotation up to 135°.[8,10]

The pericranium is then incised and elevated from the skull as a separate flap based on either its anterior or lateral vascular supply, should the pericranial flap be required for use during the procedure. To preserve the temporal branches of the facial nerve, the superficial layer of the deep temporal fascia should be incised over the superficial temporal fat pad. Dissection should proceed at a level just superficial to the deep temporalis fascia proceeding inferiorly to the zygomatic arch.

Following tumor removal and/or neurosurgical intervention, the temporalis flap may be used to cover defects of the anterior, middle, or posterior cranial fossa, cribiform plate, ethmoid sinus, sphenoid sinus, orbital walls, and to provide cover and protection for calvarial bone grafts that might be incorporated within the skull base repair. The zygomatic arch is often osteotomized as part of the skull base approach to maximize the mobility of this pedicled flap and prevent uncomfortable geometries of the flap's vascular supply.

The TMF is incorporated into the repair of any remaining dural defects and is suspended to the osseous margins of a craniotomy window to prevent prolapse of the flap into the postsurgical defect, thereby minimizing the risk of CSF leakage. Such "water-tight" closures are assured with proper peripheral flap suspension to prevent flap herniation as well as orientation of the fascial surface of the TMF toward the upper aerodigestive tract. The TMF may be exposed safely to the pharyngeal or nasal airway and allowed to mucosalize. Skin grafts are not required and were not utilized in this series of patients. Fibrin glue and other tissue sealants are helpful adjuncts in securing the skull base repair. Bone flaps are then rigidly fixated with miniplates. The coronal flap is closed over a suction drain, which is gently removed on either the first or second postoperative day.

RESULTS

Thirty-five patient charts met criteria for the retrospective analysis. Major complications such as flap loss, meningitis, brain abscess, or permanent injury to the temporal branch of the facial nerve were considered. Minor complications included localized infection, seroma, hematoma, temporary nerve palsy, hair loss, trismus, and esthetic donor site complications. Each patient had either an extensive deficit created by the removal of a lesion in the skull base or an active CSF leak following skull base trauma (Figures 1–3). Eleven of the lesions were malignant, 21 were aggressive benign processes, and the remaining 3 represented persistent CSF leak following skull base trauma. Of the malignant

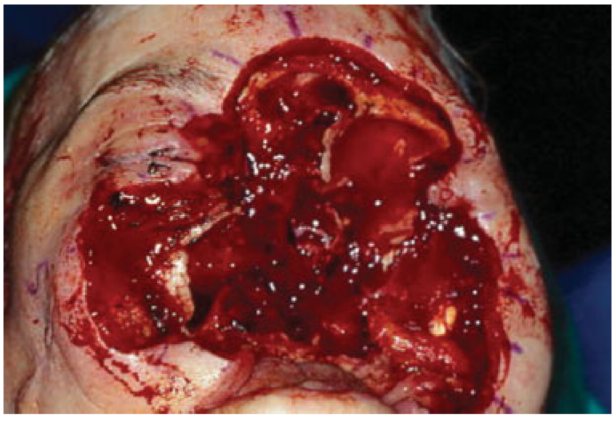

FIGURE 1. Defect resulting from the resection of a massive midfacial basal cell carcinoma. Resection extends to include anterior cranial fossa and dura. [Color figure can be viewed in the online issue of this article, which is available at www.interscience.wiley.com.]

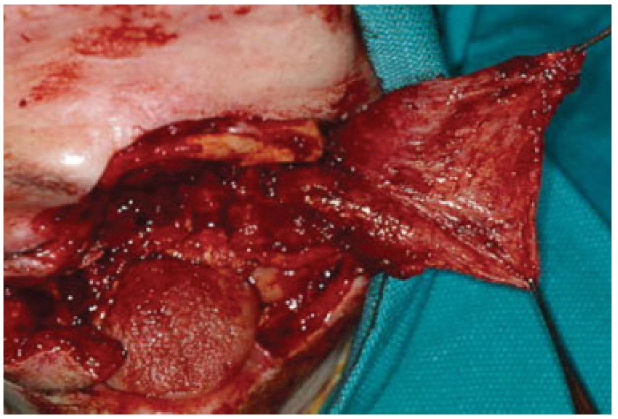

FIGURE 2. Temporalis muscle flap raised and prepared for the reconstruction of the anterior cranial fossa. [Color figure can be viewed in the online issue of this article, which is available at www.interscience.wiley.com.]

FIGURE 3. Postoperative result following reconstruction. [Color figure can be viewed in the online issue of this article, which is available at www.interscience.wiley.com.]

processes, all lesions were classified as either T_3 or T_4. The most common pathologic diagnosis was meningioma ($n = 9$). The average age of the patient was 50.9 years (range, 18–72), and there were 12 men and 23 women. The mean follow-up period for this study was 16.0 months (range, 3–62 months).

For the purpose of this study, width was measured in a medial to lateral dimension, and the length was measured in an anterior to posterior dimension. Average defect width was 4.8 cm, and average defect length was 4.9 cm. Of the 35 TMFs, 15 were left-based and 20 were pedicled from the right side. Six patients received preoperative radiation therapy, and 15 patients received postoperative radiation therapy. One patient had received preoperative chemotherapy, and 6 patients received postoperative chemotherapy. Twenty patients received an average of 30.2 g of hydroxyapatite cement for a cranioplasty as part of a primary reconstruction of the TMF donor site.

Defect locations included the base of middle cranial fossa in 21 cases, base of anterior cranial fossa in 8 cases, and combined defect in the remaining patients studied. Defect location did not appear to be correlated to the development of complications. We can easily and reliably utilize the temporalis to reach the cribriform in the midline superiorly and the superior aspect of the hypopharynx inferiorly. The key to such reach is tapering the temporalis pedicle to the central third of the zygomatic arch region with or without adjunctive use of coronoidectomy if needed for further mobilization. All exposures of hydroxyapatite cement occurred in patients who received postoperative radiation therapy ($p < .01$). The senior author routinely uses suction drains on all skull base operations, in which a bicoronal flap is utilized, irrespective of whether dural reconstruction is performed or not. He feels that water-tight closure of the dura is the most important factor in the development of CSF leaks and that suction drains (directed to posterior scalp) have no causative role in the development of such leaks but do play a role in preventing unwanted tissue swelling and postoperative seromas and hematomas.

Throughout the follow-up period, only minor complications were noted, and all were temporary in nature. No patients suffered partial or total flap loss requiring debridement. Two patients experienced a temporary neuropraxic injury to the temporal branch of the facial nerve, and each resolved completely within 4 months after surgery. Two patients developed a seroma over the hydroxyapatite cement reconstruction, and this area was treated conservatively with serial sterile needle drainage and compressive dressings. Total resolution of the seroma without infectious sequela was achieved.

One patient had exposure of the zygomatic hardware during the follow-up period. Three patients were eventually found to have an infection or foreign body reaction to the hydroxyapatite cement material, and this cranioplasty material was subsequently removed. One patient currently experiences trismus as a result of scarring around the temporomandibular joint (TMJ) area, which worsened after radiation therapy. One further patient underwent partial cement removal for delayed foreign body reaction. There were 2 cases of minor hardware exposure (superficial) treated with local wound care and local rotation flap coverage. One patient had extensive hardware exposure 3 years after radiation therapy, necessitating reconstruction with a free tissue flap in the temporal and orbital area. Notably, the patient's TMF flap covering the intracranial defect survived, but the thin skin at the TMF donor site underwent necrosis after radiation therapy. Seventy percent of patients underwent zygomatic arch osteotomy to improve the arc of rotation of the TMF. Seventeen percent of patients required coronoidectomy to further lengthen arc of rotation. There were no major complications and no deaths as a result of the procedures performed. Twenty-six percent of our patients underwent secondary lipotransfer to further refine the aesthetic result at the donor site.

DISCUSSION

Rehabilitation of the donor site defect remains as 1 of the longstanding controversies in the use of the TMF. Multiple methods have been used to fill the temporalis muscle defect, including lyophilized bovine cartilage, silastic, polyethylene, dermal fat grafts, methylmethacrylate, and hydroxyapatite.[3] Recently, hydroxyapatite cements have become readily available. We used hydroxyapatite to reconstruct most of our temporal defects. The hydroxyapatite bone cement allows the surgeon to replace the volume defect that results from TMF harvest without either the contour irregularity or the potential donor site morbidity that other autologous reconstruction materials carry. Three of the TMF donor sites became infected and these hydroxyapatite reconstructions were subsequently removed without further reconstruction in 2 patients, whereas free tissue transfer was required by the resultant defect after complete removal of the material in another patient. One patient did have a large area of skin breakdown in the temporal area 3 years after initial treatment and postoperative radiation. We have observed clinically that TMF donor site skin and subcutaneous tissue thins significantly after postoperative radiation therapy.

We offer many of our patients secondary lipotransfer to the temporal fossa to soften the ultimate appearance of the TMF donor site and achieve symmetry with the nonoperated side and have found this to be a useful technique associated with favorable aesthetic outcomes in our patient population.[11] Skin grafting of the TMF has not been found to be necessary in flaps that are exposed to the upper aerodigestive tract.

Although free tissue transfer is occasionally required for skull base defect closure, the vast majority of such defects may be safely closed with temporalis and/or pericranial flaps. The added operative time, donor site morbidity, and comparable surgical alternatives in the majority of patients obviates the need for microvascular free tissue transfer in all but selective patients, such as those cases with massive through and through defects of the facial skin, orbit, and maxilla with wide dural/brain exposure.

CONCLUSIONS

The TMF is a thin, pliable, well-vascularized flap that is locally available and well suited to reconstruct a variety of skull base defects. No major complications were encountered, and the incidence of minor complications is consistent with that reported for other pedicled flaps used in the reconstruction of the skull base. Temporal fossa donor site abnormalities can be corrected with a variety of techniques, although we have found primary hydroxyapatite cement with occasional secondary lipotransfer to be safe, dependable, and aesthetically pleasing.[11] The TMF represents 1 of the workhorses of skull base reconstruction in our practice.

REFERENCES

1. Speculand B. The origin of the temporalis muscle flap. Br J Oral Maxillofac Surg 1992;30:390–392.
2. Hoyo JAD, Sanroman JF, Gil-Diez JL, et al. The temporalis muscle flap: an evaluation and review of 38 cases. J Oral Maxillofac Surg 1994;52:143–147.
3. Clauser L, Curioni C, Spanio S. The use of the temporalis muscle flap in facial and craniofacial reconstructive surgery. A review of 182 cases. J Craniomaxillofac Surg 1995;23:203–214.
4. Hanasono MM, Utley DS, Goode RL. The temporalis muscle flap for reconstruction after head and neck oncologic surgery. Laryngoscope 2001;111:1719–1725.
5. Cordeiro PG, Wolfe SA. The temporalis muscle flap revisited on its centennial: advantages, newer uses, and disadvantages. Plast Reconstr Surg 1996;98:980–987.
6. Thomson CJR, Allison RS. The temporalis muscle flap in intraoral reconstruction. Aust NZ J Surg 1997;67:878–882.
7. Smith JE, Ducic Y, Adelson R. The utility of the temporalis muscle flap for oropharyngeal, base of tongue, and nasopharyngeal reconstruction. Otolaryngol Head Neck Surg 2005;132:373–380.
8. Bradley P, Brockbank J. The temporalis muscle flap in oral reconstruction. J Maxillofac Surg 1981;9:139–145.
9. Abul-Hassan HS, Ascher GVD, Acland RD. Surgical anatomy and blood supply of the fascial layers of the temporal region. Plast Reconstr Surg 1986;77:17–28.
10. Huttenbrink K-B. Temporalis muscle flap: an alternative in oropharyngeal reconstruction. Laryngoscope 1986;96:1034–1038.
11. Ducic Y, Pontius AT, Smith JE. Lipotransfer as an adjunct in head and neck reconstruction. Laryngoscope 2003;113:1600–1604.