Pediatric skull base reconstruction: case report of a tunneled temporoparietal fascia flap

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The authors of this report present a pediatric case involving the use of a tunneled temporoparietal fascia flap to reconstruct a skull base defect for a multiply recurrent clival chordoma and cerebrospinal fluid leak, demonstrate the surgical technique through illustrations and intraoperative photos, and review the pertinent literature. A 9-year-old female patient underwent extensive clival chordoma resection via both the endoscopic and open approaches, which ultimately exhausted the bilateral nasoseptal flaps and other intranasal reconstructive options. Following proton beam radiation and initiation of chemotherapy, tumor recurrence was managed with further endoscopic resection, which was complicated by a recalcitrant cerebrospinal fluid leak. A tunneled temporoparietal fascia flap was used to provide vascular tissue to augment an endoscopic repair of the leak and reconstruction of the skull base. While the nasoseptal flap remains the workhorse for many pediatric and adult endoscopic skull base reconstructions, the tunneled temporoparietal fascia flap has demonstrated efficacy in adults when the nasoseptal flap and other intranasal flaps are unavailable. This report documents a pediatric case, serving as a step toward establishing this technique in the pediatric population.

http://thejns.org/doi/abs/10.3171/2015.6.PEDS1588

Key words pediatric; cranial base; skull base; endoscopic; reconstruction; tunneled temporoparietal fascia flap; chordoma; technique

The resection of skull base lesions can present a reconstructive challenge, particularly in pediatric patients in whom the consideration of surgical options must account for the degree of sinonasal and skull base development. Surgical management of the lesion may create a communication between the nasal and intracranial cavities, demanding reconstruction of the skull base to avoid cerebrospinal fluid (CSF) leakage, pneumocephalus, and/or central nervous system (CNS) infection. Advances in instrumentation and surgeon expertise have led to the performance of an increasing proportion of skull base resections and reconstructions via an endoscopic endonasal approach (EEA).9 Initially performed primarily in adults, EEA has been shown to be safe and efficacious in many pediatric patients.2

A variety of vascularized flaps within the nasal cavity are well described for endoscopic skull base reconstruction, with the nasoseptal flap often being the preferred reconstructive option.3,12,14 Intranasal flaps may not be available for reconstructive use if the donor site or its vascular supply is compromised by the primary pathology or as a result of prior radiation or surgical treatment. When intranasal flaps are unavailable, other reconstructive options include free-tissue grafts, regional extranasal flaps, and microvascular free-tissue flaps from distant donor sites.1

The temporoparietal fascia (TPF) flap is a regional scalp flap with well-established utility in open surgery for the reconstruction of lateral skull, auricular, and facial defects.3,6,8,15 The versatility of the TPF flap is due in part to its potentially large size, consistent pliability, and robust blood supply via the superficial temporal artery (STA). In 2007, surgeons described a novel use for the TPF flap whereby the flap is tunneled intranasally for the reconstruction of skull base defects after EEA surgery.4 This transpterygoid, or tunneled, TPF flap has since been used in the reconstruction of several adult skull base defects.10,11 This report documents the use of the tunneled TPF flap to reconstruct a large clival defect in a 9-year-old child, representing, to our knowledge, the first documented pediatric use of this reconstructive option. Emphasis is placed on demonstrating the relevant anatomy and surgical technique necessary to perform this procedure.

ABBREVIATIONS CNS = central nervous system; CSF = cerebrospinal fluid; EEA = endoscopic endonasal approach; EVD = external ventricular drain; ITF = infratemporal fossa; STA = superficial temporal artery; TPF = temporoparietal fascia.

SUBMITTED February 8, 2015. ACCEPTED June 17, 2015.

INCLUDE WHEN CITING Published online November 6, 2015; DOI: 10.3171/2015.6.PEDS1588.

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Case Report

History and Examination

A 7-year-old female patient presented with diplopia on right lateral gaze, hoarseness, and headaches. Magnetic resonance imaging and CT revealed a destructive clival lesion, and biopsy confirmed an atypical chordoma (Fig. 1). The initial phase of treatment included a transclival EEA to debulk the tumor. The right nasoseptal flap pedicle was sacrificed, and bilateral middle turbinates were removed during this surgery. Dura mater overlying the brainstem was preserved, thereby avoiding a CSF leak, and the defect was reconstructed using free fat, with partial coverage by the right nasoseptal flap and free mucosa providing additional coverage. Gentle nasal packing was used to support the reconstruction. A right retrosigmoid craniotomy was performed to further debulk disease compressing the brainstem. The extensive disease and bilateral carotid artery encasement precluded total resection. Postoperative proton beam radiotherapy was then administered (72 cobalt Gray equivalent in 40 fractions).

One year following the completion of radiotherapy, tumor recurrence was identified at the right orbital apex and cavernous sinus when the child presented with acute vision loss and extraocular movement palsy. The optic nerve was decompressed, and the tumor was debulked via revision EEA. This surgery resulted in an intraoperative CSF leak at the midclival level. The CSF leak was successfully repaired with a Duragen onlay/underlay butterfly graft, free fat, mucosa, and Tisseel (Baxter Healthcare Corp.). A lumbar drain was placed for 5 days. Fourteen days after discharge home, the child sneezed with a closed mouth, resulting in an immediate headache. Further workup revealed pneumocephalus and a recurrent CSF leak. We endoscopically placed a right inferior turbinate flap that was ultimately unsuccessful, and the leak persisted despite prolonged lumbar drainage. Eventual ventriculoperitoneal shunting provided control. Once the leak was controlled, the child began chemotherapy, but 6 weeks into this therapy she was noted to have a recurrence of her CSF leak. At this point no further intranasal vascularized flaps were available, and further attempts to control the leak with free-tissue grafts were deemed unlikely to succeed. The decision was made to bring regional vascularized tissue intranasally to the CSF leak site via a tunneled TPF flap.

Surgical Technique

Step 1: Harvesting the TPF Flap. The skin in the temporal region is incised in the fashion of a hemicoronal incision, and the skin and subcutaneous tissue are elevated off the TPF. Care must be taken to avoid injury to the superficial temporal artery (STA) and vein at the inferior extent of the incision. The TPF is exposed to the zygomatic arch, and incisions are planned in the TPF to create a flap of adequate length and width. If additional length is needed, extension above the temporal line with inclusion of galea into the flap can be performed. Elevation of the TPF flap is accomplished by gentle dissection of the loose areolar tissue between the deep surface of the TPF flap and the shiny appearing temporalis muscle fascia that envelops the temporalis muscle. Dissection posterior to the hairline protects the facial nerve (Fig. 2).

Step 2: Endoscopic Medial Maxillectomy. The ipsilateral middle and inferior turbinates are resected, and the entire medial maxillary wall/lateral nasal wall is resected, resulting in direct communication between the nasal cavity and maxillary sinus. A high-speed drill with protected shaft facilitates complete removal of the inferior portion of the lateral nasal wall to prevent a ridge between the maxillary sinus floor and nasal floor, thereby minimizing stasis of secretions in the maxillary sinus. The posterior wall of the maxillary sinus and orbital floor are clearly delineated to facilitate further dissection (Fig. 3).

Step 3: Endoscopic Entry Into Pterygopalatine Fossa and Infratemporal Fossa. The posterior maxillary sinus wall is resected using Kerrison rongeurs. After resecting the bone, the exposed periosteum is incised, revealing the contents of the pterygopalatine fossa medially and the infratemporal fossa (ITF) as the dissection proceeds laterally (Fig. 4).

Step 4: Creating the ITF to Maxillary Sinus Tunnel. After endoscopic entry into the ITF in Step 3, attention is turned externally. Through the initial hemicoronal incision, dissection is carried from the temporal fossa through the ITF to arrive at the posterior maxillary sinus. Care is taken to avoid entry into the orbit by staying inferior to the inferior orbital fissure. A tunnel, hereafter referred to as the “ITF tunnel,” is created with endoscopic guidance and blunt dissection with a free elevator or similar instrument (Video 1).

VIDEO 1. This intraoperative video demonstrates the endoscopic endonasal view during key steps of the tunneled temporoparietal fascia (TPF) flap procedure. In chronological order a freer elevator enters the intranasal space through the ITF to maxillary sinus tunnel, a suture is passed through the tunnel and attached to the tip of the TPF flap (suture attachment happens externally and is not seen in the video), the suture is retracted intranasally to guide the TPF flap through the tunnel to the intranasal space, the dural defect and

![FIG. 1. Axial (left) and sagittal (right) postcontrast T1-weighted MR images obtained in a 10-year-old girl, demonstrating a clival chordoma (asterisk) extending posteriorly to the preptontine and premedullary cisterns.](image-url)
CSF leak are demonstrated, an inlay/onlay temporalis fascia butterfly graft is placed, a dermal fat graft is placed, and the TPF flap is inset and secured with Tisseel. Copyright Jeffrey C. Rastatter. Published with permission. Click here to view.

This ITF tunnel can be dilated as previously described, and a forceps can be passed from the external opening through the tunnel to arrive internally within the maxillary sinus. This forceps is then used to grasp the end of a suture that is introduced to the nasal space and maxillary sinus through the ipsilateral nostril. The end of the suture is then brought externally to the scalp through the ITF tunnel (Fig. 5).

**Step 5: Transferring the TPF Flap Through the ITF Tunnel.** The externally drawn end of the suture is affixed to the distal tip of the TPF flap, and the distal portion of the flap is folded into the temporal fossa. Traction on the suture from the intranasal end will help guide the passage of the flap through the ITF tunnel, facilitating flap entry into the maxillary sinus and nasal cavity (Fig. 6).

**Step 6: Advancing the TPF Flap Into the Nasal Cavity.** Further traction on the intranasal end of the suture is used to draw the bulk of the TPF flap into the maxillary sinus and nasal cavity. Care is taken to avoid torsion of the flap and subsequent kinking of the pedicle. Prior to insetting...
the flap, the dural defect is repaired. In the current case an underlay/onlay butterfly graft of temporalis muscle fascia was used. If needed, as was the situation in the featured case, a dermal fat graft can be placed over the dural reconstruction to fill dead space and decrease the distance needed for the TPF flap to provide coverage (Fig. 7).

Step 7: Final Placement of the Tunneled TPF Fascia Flap. Forceps are used to manipulate, spread, and place the flap to provide complete coverage of the reconstruction site (Fig. 8). Tisseel or DuraSeal (Covidien) around the flap edges, Gelfoam, and gentle nasal packing are placed to support the reconstruction. In the featured case, a Foley balloon in the nasopharynx was used to provide further support.

In the current case, a right TPF flap was harvested and placed in the manner described above with apparent control of the CSF leak.

Postsurgical Course

The EVD provided CSF drainage, and the patient was kept on bedrest for 7 days. At postoperative Day 7, the flap was reevaluated intraoperatively, demonstrating resolution of the CSF leak and incorporation of the TPF flap. The EVD was clamped at this time, and monitoring over the next 7 days showed no recurrence of the CSF leak by postoperative Day 14. At this point, 2 weeks after the tunneled TPF flap reconstruction, disease progression at the brainstem level resulted in a severe pontine stroke and a
coma state requiring ventilator support. Two days later the family elected to withdraw care, and the patient died the same day.

**Discussion**

The TPF flap is a thin, pliable, vascularized flap that has many applications in the head and neck. Applications for this flap are well described in the literature, including its role in adults as a tunneled flap for endonasal skull base reconstruction when intranasal vascularized flaps have been exhausted. In this report we describe utilization of the tunneled TPF flap for skull base reconstruction after EEA in a pediatric patient.

The nasoseptal flap may not provide adequate coverage for large skull base defects in the pediatric population, especially in younger children. In this situation or when faced with challenging circumstances in which other vascularized options for skull base reconstruction have been exhausted, the tunneled TPF flap represents another option in the skull base surgeon’s array of vascularized rotational flaps.

Some limitations of the tunneled TPF flap are evident in the current case. In an extensive, deep clival defect, the TPF flap may not provide complete reach and coverage unless a portion of the dead space resulting from clival bone removal is reconstructed. While the adult literature does not describe limitations in the coverage of clival defects with the TPF flap, in this case adjunctive dermal fat grafting was required to fill dead space to allow sufficient reach and coverage with the tunneled TPF flap. As is the case when considering the use of a nasoseptal flap,
the adequacy and appropriateness of the TPF flap must be carefully considered preoperatively, and the potential extent of its reach and coverage should be considered. There is currently no validated or generally accepted method of precisely predicting how much skull base coverage is possible with a tunneled TPF flap in an individual. The decision to proceed must rely on surgeon experience and careful study of the patient’s anatomy and preoperative imaging. A recent study described a method of radioanatomical analysis of CT scans to attempt to predict the adequacy of a nasoseptal flap for various skull base defects at different pediatric ages.\textsuperscript{13} Not surprisingly, young children with relatively small faces and nasal septae and relatively large craniums predicted incomplete coverage with a nasoseptal flap at some distant skull base sites, compared with older children and adults. Interestingly, this size limitation of the nasoseptal flap in very young children may be a size benefit for the tunneled TPF flap because the donor site is the scalp of a relatively large cranium. Even with a TPF flap of sufficient predicted size, however, adequate sinonasal development would be required to create the ITF tunnel and to inset the flap endoscopically. It is reasonable to assume that development sufficient for an EEA-type resection surgery should allow sufficient development and space to inset a tunneled TPF flap once brought intranasally. As the ITF is rich with vital anatomy, further study and consideration should be given to establish the safety of creating the infratemporal fossa–maxillary sinus tunnel in very young children. The current case demonstrates a safely performed tunneled TPF flap in a 9-year-old child, but represents only 1 case. Further research and clinical experience are necessary to establish the procedure’s safety and efficacy for a wider range of pediatric ages.

Until further clinical experience and anatomical study (cadaveric and radioanatomical) are available, we recommend use of the tunneled TPF flap as a salvage reconstructive procedure when other vascularized flaps, particularly intranasal flaps such as the nasoseptal flap or inferior turbinate flap, are inappropriate options. The absence of an appropriate flap can be attributable to an intranasal flap size that is inadequate to reconstruct the defect, previous usage of an intranasal flap, or flap damage from the primary disease. In the current case all intranasal flap options were previously used and therefore unavailable. An alternative option considered was a microvascular free-tissue transfer with a radial forearm free flap. We ultimately decided the patient’s condition was too fragile to tolerate a long microvascular reconstruction at that time, choosing instead after careful anatomical and imaging analysis to proceed with the tunneled TPF flap, a technique previously described only in adults.

Despite potential limitations in the extent of coverage, the TPF flap carries the advantage of being distant from the nasopharynx and spared from the effects of endonasal surgery or nasopharyngeal radiation, which in certain situations allows for a more reliable vascular pedicle and flap utility.

Conclusions

While the nasoseptal flap remains the workhorse for many pediatric and adult endoscopic skull base reconstructions, the tunneled TPF flap has a demonstrated efficacy in adults when the nasoseptal flap and other intranasal flaps are unavailable. This report documents a pediatric case using the tunneled TPF flap for skull base reconstruction and serves as a step toward establishing this technique as a useful option in the pediatric population. Careful consideration must be given to the defect size and location, potential TPF flap size and reach, and the status of sinonasal development when considering utilization of this reconstructive option in a pediatric patient.

Acknowledgment

Special thanks to Michael Gallagher for his artistic vision and expert skill as he created the wonderful drawings contained in this paper.
References


Disclosure

The authors report no conflict of interest concerning the materials or methods in this study or the findings specified in this paper.

Author Contributions

Conception and design: all authors. Acquisition of data: Rastatter, Alden. Analysis and interpretation of data: all authors. Drafting the article: Rastatter, Walz. Critically revising the article: all authors. Reviewed submitted version of manuscript: Walz, Alden.

Supplemental Information

Videos


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