Use of Titanium Mesh for Middle Cranial Fossa Skull Base Reconstruction

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Abstract

Objectives Temporal bone encephaloceles are usually encountered in the setting of a congenital defect of the tegmen or as an acquired defect after mastoid surgery. A variety of methods have been described in the literature for rigid reconstruction of tegmen defects. We introduce a new method of repair using orbital floor titanium mesh reconstruction plates to reconstruct the floor of the middle cranial fossa, and evaluate the outcomes, complications, and recurrence rates of temporal bone encephaloceles with this technique.

Design Retrospective chart review of consecutively treated patients.

Setting Tertiary care academic center.

Participants Eight patients with middle cranial fossa skull base defects from January 2007 to February 2011.

Main Outcome Measures Outcome measures included resolution of cerebrospinal fluid leak (CSF) and development of postoperative infection.

Results One of nine patients had a postoperative CSF (cerebrospinal fluid) leak. There were no long-term complications of CSF leak or infection.

Conclusions Titanium mesh is a safe and effective substitute for bone grafts in reconstruction of the middle cranial fossa skull base when rigid reconstruction is required.

Keywords

- encephalocele
- middle cranial fossa
- titanium mesh
- tegmen defects

Introduction

Encephaloceles of the mastoid and middle ear are now less common than in the pre-antibiotic era when surgical treatment of otogenic intracranial abscesses would often result in a violation of the dura and subsequent herniation of intracranial contents into the temporal bone.¹ Currently, temporal bone encephaloceles are usually encountered as an acquired defect after mastoid surgery, in the setting of a congenital defect of the tegmen, or following trauma.² Several theories have been put forth regarding the pathophysiology of spontaneous encephaloceles of the temporal bone. These include congenital defects in the floor of the middle cranial fossa, the presence of arachnoid granulations causing bony erosion, and

elevated intracranial hypertension. The latter is a common associated clinical finding, and an empty sella can be a concomitant radiologic finding.^{3,4}

The first surgical repair of a postoperative dural defect was reported in 1913; the dural defect was sutured and reinforced with canine allograft.⁵ Thirty years later, Dandy corrected these defects with fascia.⁵ Subsequently, a variety of techniques were used including the use of temporalis fascia, pedicled temporalis muscle grafts, fascia lata grafts, and bone grafts.⁵ Savva et al² demonstrated that a multilayer closure has a higher success rate, although there is no consensus in the literature about which technique provides the best closure rate. In recent years, there has been a particular

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Fig. 1 Middle fossa craniotomy centered over defect. The encephalocele (arrow) is visible through the mastoidectomy defect.

emphasis on incorporating rigid materials including bone grafts and pate for reconstruction of the bony defect.^{3,6} This is based on the principle that without a secure bony reconstruction of the middle cranial fossa, dural herniation can recur. To date, titanium mesh has not been used in place of a bone graft for rigid reconstruction. This retrospective study reviews our institution's experience with an innovative technique using orbital floor titanium mesh reconstruction plates to reconstruct the floor of the middle cranial fossa for patients with temporal bone encephaloceles and cerebrospinal fluid (CSF) leak.

Methods

This report includes eight patients with spontaneous CSF otorrhea associated with encephaloceles who underwent a

Fig. 2 Dynamic malleable orbital floor reconstruction plate (Stryker/Leibinger, Kalamazoo, MI, USA; Universal 2, catalog no. 54-03003).

middle cranial fossa approach for repair, including rigid reconstruction with titanium mesh. The patients were evaluated and treated between 2007 and 2010. During that time, a total of 17 patients were operated on for CSF otorrhea. Six were repaired via a transmastoid approach alone. Eleven underwent repair via the middle cranial fossa, with or without simultaneous mastoidectomy. One of these had a bone graft placed, and one was repaired with fascia alone. One of the nine remaining patients required skull base repair in the setting of tumor excision and is excluded from the review.

Seven patients underwent complete mastoidectomy, both to confirm the nature of the pathology and to localize the site of the leak, thus allowing the craniotomy to be tailored to the needed exposure. Middle fossa craniotomy was then

Fig. 3 (A) Freer elevator placed through the tegmen defect, demonstrating the communication between the mastoid (a) and middle cranial fossa (b). (B) Tegmen defect in the floor of the middle cranial fossa. (C) First layer of repair, consisting of autologous temporalis fascia or Neuro AlloDerm.

performed, centered over the site of the identified defect (→Fig. 1). One patient underwent middle fossa craniotomy alone, without mastoidectomy. The floor of the middle fossa was exposed and the defect delineated. Herniated glial tissue is typically excised via the mastoid, to avoid reduction of potentially contaminated tissue into the intracranial space. An orbital floor titanium mesh reconstruction plate (Stryker/Leibinger, Dynamic, Malleable Orbital floor reconstruction plate (catalog no. 54-03003), Kalamazoo, MI, USA) (→Fig. 2)

was cut to an appropriate size and shape to reconstruct the bony defect in the floor of the middle fossa, allowing the flanges to extend through the floor of the craniotomy and be secured in the zygomatic root and bony buttress of the superior mastoid cortex. After fashioning the plate, a soft tissue layer of either autologous temporalis fascia or Neuro AlloDerm (LifeCell Corp., Branchburg, NJ, USA) graft was placed to cover the floor of the middle fossa (→Figs. 3A–C). The titanium mesh plate was then reinserted and secured

Fig. 4 (A) An orbital floor titanium mesh plate is placed and secured to the zygomatic root or superior mastoid cortex. (B) A second layer of fascia or Neuro AlloDerm is placed over the orbital plate. (C) Coronal diagram of multilayered reconstruction of middle cranial fossa floor demonstrating the orbital floor titanium mesh plate sandwiched by two layers of fascia or Neuro AlloDerm. (D) Postoperative three-dimensional reconstruction bird's-eye view of a left middle cranial fossa defect repair, demonstrating the plate (asterisk) in place on the floor of the middle fossa. (E) Coronal computed tomography illustrating contouring of the titanium plate.

Table 1 Patient demographics of eight cases of temporal bone encephalocele repair

Mean age, y	55.3 ± 8.3
Mean BMI, kg/m ²	40.7 ± 8.7
Male-to-female ratio	1:7
Side of defect	Right: 6
	Left: 2
Presentation symptom	
CSF leak/Otorrhea/Rhinorrhea	6/8
Identified on prior surgery	1/8
Headache	1/8

Abbreviations: BMI, body mass index; CSF, cerebrospinal fluid.

with 3 or 4 mm self-drilling, self-tapping screws. A second layer of soft tissue graft was inserted between the plate and the dura, and the entire reconstruction covered with synthetic fibrin sealant (Evicel, OMRIX Pharmaceuticals, Ramat Gan, Israel) (►Figs. 4A–E). The bone flap was replaced and secured, and the wound was closed in layers. A pressure dressing was applied. For patients in whom intracranial hypertension is suspected, a lumbar drain may be inserted intraoperatively and maintained for 48 hours postoperatively.

Results

Patient Demographics

Nine patients underwent surgical repair of temporal bone defects via the middle cranial fossa using titanium mesh at this institution during the study period. Of these, eight were associated with spontaneous encephaloceles with no prior trauma, surgery, or chronic otitis identified, and one was associated with a chondrosarcoma of the skull base. The following demographics pertain to those patients presenting with spontaneous encephaloceles (►Table 1). There was a strong female predominance; seven of the eight patients (87.5%) were female. Average age of the patients was 55.3 ± 8.3 years, ranging from 43 to 68 years.

Fig. 5 (A) Coronal computed tomography (CT) scan of migration into the cranial vault of the distal end of the bone graft (asterisk) away from the skull base defect (white arrow). (B) Coronal CT scan of bone graft (asterisk) protruding above the floor of the middle fossa due to the bone's inability to contour.

The average body mass index (BMI) of the patients was 40.7 ± 8.7. All of these patients had BMIs > 30 kg/m², categorizing them as obese per the Centers for Disease Control and Prevention's interpretation. The right side was the more frequent side of presentation (six of eight patients). The presenting symptom for five patients (56%) was otorrhea. With three of these cases, symptoms manifested following tympanostomy tube placement for middle ear effusion and aural fullness; the other two presented spontaneously and with concurrent rhinorrhea. The remaining case with a CSF leak presented with isolated rhinorrhea and middle ear effusion. An empty sella was identified on preoperative magnetic resonance imaging (MRI) in one patient (11%).

Operative Details

A combined transmastoid and middle cranial fossa approach was used in seven cases (87.5%); in the remaining case (12.5%), we used the middle cranial fossa approach alone. The surgical approach is detailed in the Methods section.

Table 2 Clinical characteristics and outcomes for eight patients with spontaneous temporal bone encephalocele repair

	1	2	3	4	5	6	7	8
Age/Sex	50/F	43/F	55/F	68/F	54/M	62/F	48/F	62/F
Clinical presentation	MEE CSF leak	CSF leak	CSF leak AOM Meningitis	Conductive hearing loss	Conductive hearing loss	CSF leak MEE	Aural fullness CSF leak	CSF leak
Etiology	Spontaneous	Spontaneous	Spontaneous	Spontaneous	Spontaneous	Spontaneous	Spontaneous	Spontaneous
Reconstruction	Combined	MCF	Combined	Combined	Combined	Combined	Combined	Combined
Follow-up interval, mo	2	12	2	18	17	3	2	3
Complications/ Infection	None	None	None	Postoperative CSF leak	None	None	None	None

Abbreviations: AOM, acute otitis media; CSF, cerebrospinal fluid; MCF, middle cranial fossa; MEE, middle ear effusion.

Table 3 Advantages and disadvantages of bone graft versus titanium mesh repair

Bone grafts		Titanium mesh	
Advantages	Disadvantages	Advantages	Disadvantages
Readily available	Donor site morbidity	Easily contoured and sized	Cost
Biocompatible	Difficult to contour	Thin Biocompatible	Infection risk?
Inexpensive	No fixation (can migrate)	No donor site morbidity	
	Increased surgery time for harvest with potential increased cost	Rigid fixation	
		Saves time in the operating room	

Patient Outcomes

Average follow-up was 7.4 ± 7.1 months (range: 2–18 months). During this period, temporal bone defect reconstruction with titanium mesh plates immediately prevented CSF leak and symptom recurrence in seven of the eight patients. One patient experienced an early postoperative CSF leak and was readmitted 11 days postoperative with otorrhea for lumbar drain placement. The lumbar drain was removed after 5 days, and there was no recurrence with 18 months of follow-up. No other patients experienced CSF leak. There were no cases of postoperative meningitis, seizures, postoperative sensorineural hearing loss, or facial paralysis (► **Table 2**).

Discussion

Although many techniques for repair of bony defects have been described, perhaps the most commonly cited method in current literature is the use of a bone graft surrounded by fascia on either side.^{7,8} Traditionally, authors have recommended a transmastoid or middle fossa approach, or a combination of the two. Lundy et al suggested that a combined approach affords the best exposure for repair and reported no recurrent encephaloceles or CSF leaks in a series of 19 cases.⁸ We demonstrate successful repair is possible with either a combined approach or access via the middle cranial fossa alone. However, we generally favor a combined approach for several reasons. First, a combined approach permits the surgeon to confirm the diagnosis via the transmastoid access. Second, this technique helps to prevent reduction and permits resection of potentially infected or necrotic glial tissue. Third, it aids with the definitive localization of the site of the defect that facilitates a smaller and more targeted craniotomy.

Our technique is in accordance with the fundamental principles of repair, which are providing a rigid support to span bony defect and the use of tissue juxtaposed to the dura of the temporal lobe. Titanium mesh provides the rigidity of a bone graft without the donor site morbidity and increased operative time. It is easily contoured and rigidly fixed in place, unlike bone grafts that have been shown to migrate and protrude into the cranial vault (► **Figs. 5A, 5B**). Although titanium mesh is biocompatible, it is conceivable that risk of

infection would be higher as it would be for other synthetic materials that have been used for reconstruction (i.e., bone cement, fibrin glue, silastic sheets) (► **Table 3**). However, in our review of the literature, titanium mesh was consistently demonstrated to have a low rate of graft infection in craniofacial repair when compared with alternatives such as autogenous bone, autoclaved bone, and polymethyl methacrylate (PMMA).^{9,10} By way of example, Matsuno et al found the rate of infection in delayed cranioplasties to be 25.9% for autogenous bone and only 2.6% for titanium mesh.¹¹

Our postoperative CSF leak rate of 11.1% compares favorably with that reported in other studies using bone grafts for repair (range: 8.6–28.6%).¹² We had no cases of postoperative meningitis, sensorineural hearing loss, or seizures, which also compares well with similar studies.^{2,12,13}

Conclusion

Both rigid and soft tissue elements are necessary for the reconstruction of middle cranial fossa defects. Titanium mesh is a safe substitute for bone grafts and can be used in a layered closure for successful repair. Surgical approach can be via the middle fossa alone or combined with transmastoid access.

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