Use of titanium mesh to reconstruct lateral skull base defects through three different approaches

Original Article

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Abstract

Aim: Evaluate the treatment of tegmen defects with titanium mesh through three different approaches – middle cranial fossa or transmastoid alone or a combination of both, evaluating and comparing their outcomes.
Material & Methods: Retrospective data collection of patients submitted to surgical correction of middle cranial fossa SB defects with titanium mesh reconstruction plates between 2021 and 2023 in a tertiary hospital.
Results: We included 5 patients with meningoencephalocele, mean age 54 years (range 15-81 years). A combined transmastoid and middle fossa craniotomy approach was used in three cases. There were no post-operative complications. During the follow-up period, none of the titanium plates were rejected or became infected.
Conclusions: Our case series suggests that titanium mesh is safe and effective for reconstruction of large tegmen defects, with optimal closure rates. Although the combined approach provided better exposure, all the approaches resulted in reduced morbidity in the surgical treatment of these patients

Keywords: Meningoencephalic hernia; Transmastoid; Middle fossa craniotomy; Titanium mesh; Lateral skull base

Introduction

Bone defects in the lateral skull base are frequently associated with chronic suppurative otitis media and are typically managed via transmastoid approaches. Other causes of these defects include congenital anomalies or traumatic injuries to the skull base[1] (Table 1).
These defects can lead to meningoencephalic herniations or cerebrospinal fluid (CSF) fistulas[1]. Surgical management may involve the middle fossa approach with temporal lobe elevation, transmastoid approach,

Table 1
Etiology of lateral skull base defects

Iatrogenic
Accidental drilling during mastoidectomy Planned removal during a transmastoid approach
Neoplastic
Glomus Meningioma Middle ear carcinoma Metastases
Traumatic
Temporal bone fractures
Chronic otitis media
Chronic suppurative otitis media (simple/with cholesteatoma) Tuberculosis of the middle ear Temporal bone osteitis
Others
Congenital dehiscence Langerhans cell histiocytosis Fibrous dysplasia of the temporal bone

or a combination of both techniques. The transmastoid approach, which is considered more conservative, is often recommended due to its lower procedural morbidity . The combined approach is generally reserved for correcting large bone defects, while the subtemporal approach via craniotomy is preferred for anterior defects where hearing preservation is crucial[1]. The choice of surgical approach depends on factors such as the etiology, location, and size of the bone defect, as well as the degree of preoperative hearing loss and presence of chronic middle ear infection[2]. A variety of materials have been used for reconstructing lateral skull base defects, including autologous or homologous cartilage or bone, homologous freeze-dried dura mater, titanium or carbon fiber meshes, and free or pedicled myofascial flaps[1]. Each material has its specific advantages along with disadvantages that can lead to reconstruction failure, adverse reactions, or complications.

Lateral skull base defects are assessed using computed tomography (CT) and magnetic resonance imaging (MRI). These complementary diagnostic modalities not only detect the presence and extent of the defects but also assist in guiding surgical planning and reconstruction[3].

This study aimed to evaluate the use of titanium mesh for the correction of lateral skull base bone defects via three surgical techniques, the middle fossa approach with temporal lobe elevation, transmastoid approach, or a combination of both, and to compare their outcomes.

Materials and methods

This retrospective longitudinal study included all patients who underwent reconstruction of lateral skull base defects with titanium mesh between January 1, 2021 and December 31, 2023 at a tertiary hospital. Data were collected from the patients' computerized medical records. The study analyzed the following parameters: (1) demographic data (sex and age); (2) clinical presentation; (3) complementary diagnostic tests; (4) surgical treatment and approach used; and (5) postoperative outcomes, including the anatomical integrity of the tegmen, absence of CSF fistulas, side effects, mesh extrusion, and incidence of complications.

Results

During the study period (2021–2023), five patients (Table 2) underwent surgical treatment of lateral skull base defects using titanium meshes. Four of these patients were women, with an average age of 54 years (15–87) at the time of surgery. All patients presented with meningoencephalic herniation. Four cases were associated with chronic otitis media (COM) with cholesteatoma, and had undergone surgery at other institutions, while one patient had a temporal bone fracture with an active CSF fistula. Tegmen dehiscence measured over 12 mm in all cases. The combined approach was used in three patients for skull base reconstruction, while the middle fossa approach or transmastoid approach alone were used in the remaining two patients (Table 2) . In all cases, the herniated tissue was repositioned in the intracranial compartment. During the transmastoid approach, the previous open mastoidectomy was first revised, focusing on eradication of chronic disease, followed by dissection of the residual meningeal tissue located at the tympanic and mastoid tegmen bone defects. Once these steps were completed, the bone defect was exposed (Figure 1) and measured (Figure 2) to determine the appropriate size of the titanium mesh for reconstruction. The mesh was then secured to the skull with screws (Figure 3) and a temporal muscle flap was created to overlay the corrected defect, which provided additional support and promoted healing.

The combined approach was selected in cases with large herniation or presence of inflammatory tissue in the mastoid. All patients initially underwent an open mastoidectomy or revision of a previous mastoidectomy, during which meningoencephalic herniation was confirmed (Figure 4). Subsequently, a temporal craniotomy was performed (Figure 4) to optimize the visualization of the defect. The bone defects were closed using an inlayer homologous of dura positioned between the herniated dura and the remaining bone circumference, followed by the placement of a titanium mesh (Figure 5) and an overlayer of temporal muscle between the titanium mesh and mastoidectomy cavity to provide additional support and promote healing.

The patient selected for the middle fossa approach alone had undergone a closed mastoidectomy approximately 30 years earlier

Table 2
Summary of the patients' characteristics

Patient	Age (years)	Ear	Etiology of the defect	Otological history	Defect size (major axis)	Preoperative auditory condition	Approach
1	59	Right	COM with cholesteatoma	Open mastoidectomy in 2020	3 cm	Moderate conductive hearing loss	Transmastoid
2	15	Right	Traumatic	-	4 cm	Normal	Combined
3	81	Left	COM with cholesteatoma	Open mastoidectomy in 1985	1,2 cm	Moderate to severe mixed hearing loss	Combined
4	46	Right	COM with cholesteatoma	Open mastoidectomy in 1990	1,5 cm	Moderate conductive hearing loss	Combined
5	70	Right	COM with cholesteatoma	Closed mastoidectomy in 1991	2 cm	Mild to moderate mixed hearing loss	Middle fossa

COM, chronic suppurative otitis media

Figure 1
Meningoencephalic herniation visualized through the dehiscence

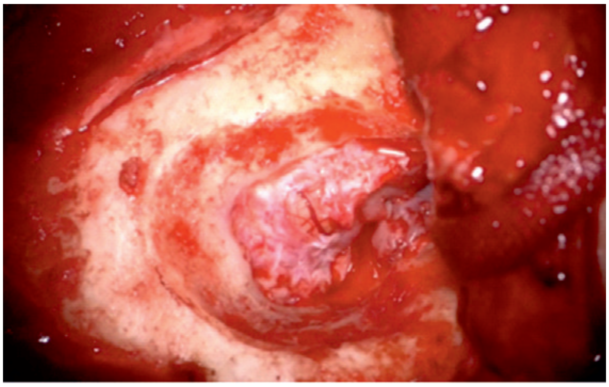


Figure 2
Measurement of the tegmen defect

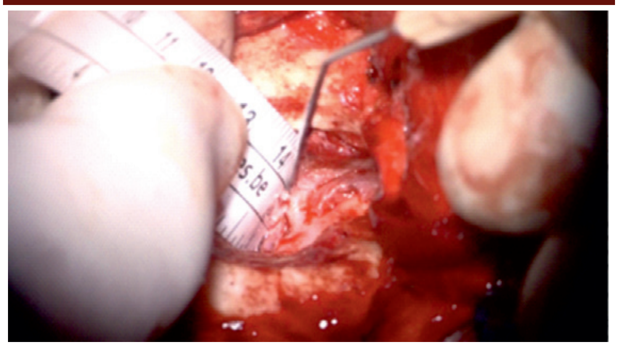
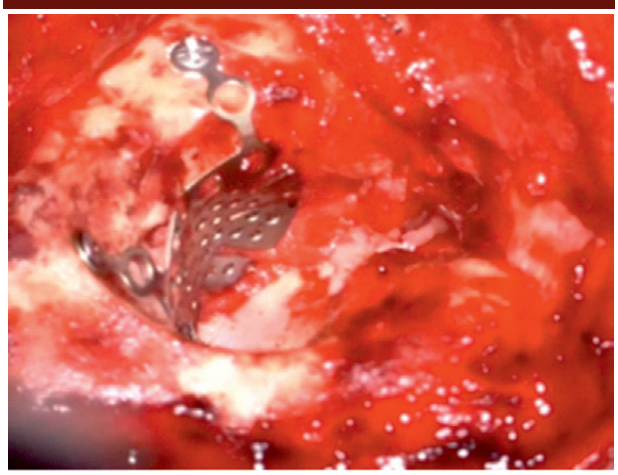


Figure 3
Mesh secured to the skull with two screws



and was later diagnosed with ipsilateral meningoencephalic herniation. A temporal craniotomy was performed, during which the dehiscence area was identified and reconstructed using a titanium plate. The temporal fascia was then interposed between the dura mater and titanium plate.

Figure 4
Combined approach showing meningoencephalic herniation (black arrow) and temporal craniotomy (blue arrow)

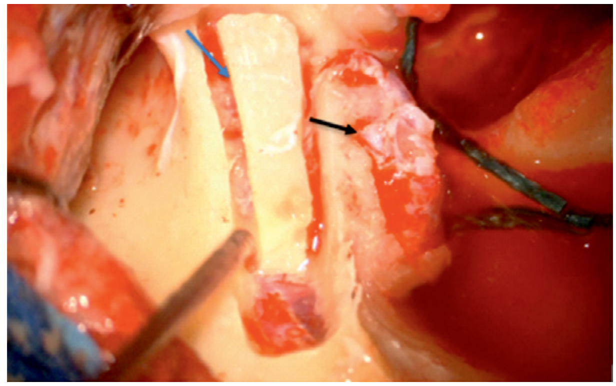
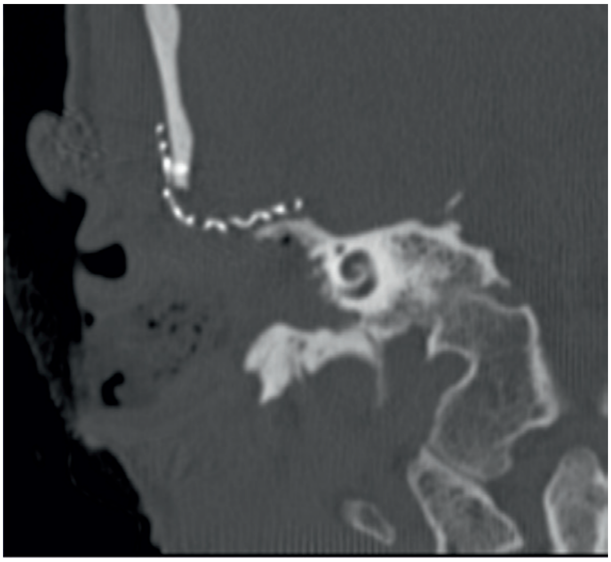


Figure 5
Defect closure with titanium mesh using the mixed approach

No postoperative complications, such as meningitis, seizures, or facial paralysis were documented. Postoperative imaging confirmed satisfactory anatomical contours (Figures 6 and 7). During the follow-up period (mean 21.8 months), none of the titanium meshes were rejected or showed signs of infection. Additionally, no cases of CSF fistula or meningoencephalocele recurrence were observed. Among the five patients, three demonstrated postoperative hearing improvements compared to previous evaluations. In the remaining two patients, hearing assessments were not possible because of cavity infection or loss to follow-up due to an extended period of absence from the country.

Figure 6
Postoperative computed tomography (CT) of the patient treated with the mixed approach

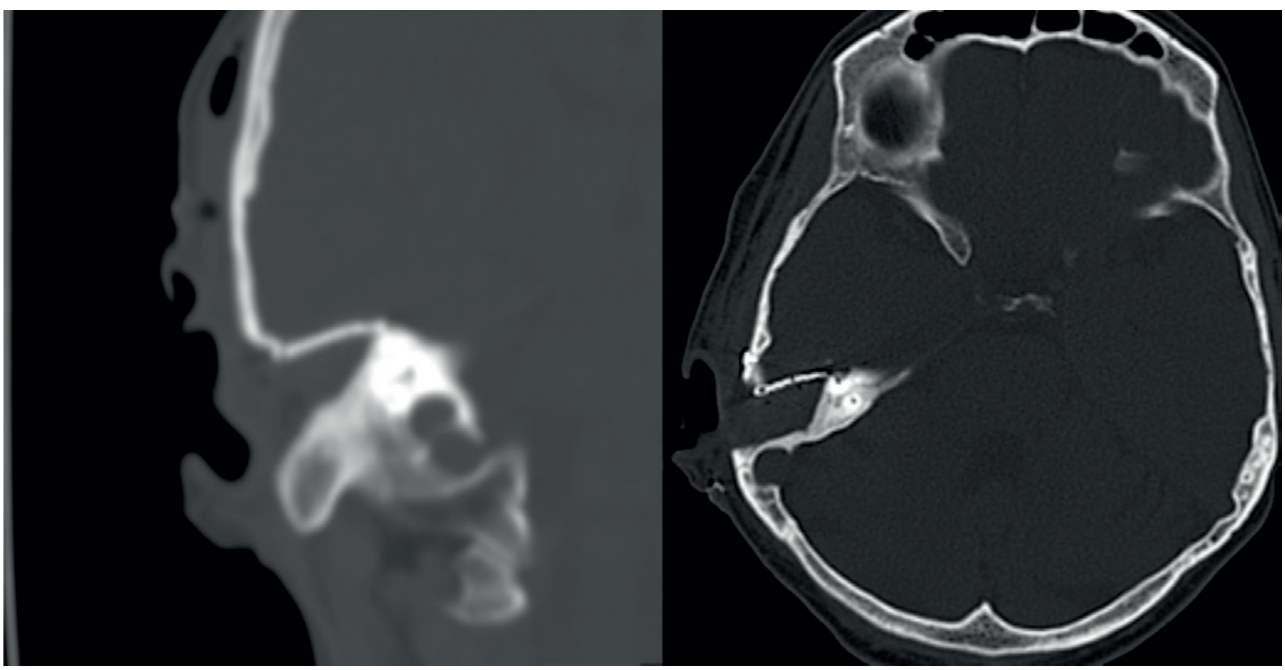


Discussion

Lateral skull base defects can be repaired using three different approaches, with the choice of approach depending on the etiology, size, and location of the defect, as well as the patient's prior hearing status[2]. The presence of chronic middle ear infection or an active CSF fistula identified intraoperatively can also influence this decision. Generally, herniated tissue is either resected or repositioned in the intracranial compartment[1]. The defect is then sealed using autologous, heterologous, or alloplastic materials, or a combination thereof, with the choice of material depending on the surgeon's experience, size of the defect, and volume of brain herniation[1].

Some studies have suggested that the transmastoid approach has less satisfactory outcomes compared to the middle fossa approach[4,5]. Ramalingam et al.[6] reported that 10 out of 13 revision mastoidectomies successfully repaired meningoencephalic herniations that developed following initial surgery for COM with cholesteatoma, with only one patient requiring a combined approach. Similarly, Sanna et al.[2] demonstrated the successful resolution of meningoencephalic herniations with an isolated transmastoid approach in 93 out of 122 patients, with no complications. In contrast, the middle fossa approach was associated with one case of meningitis and another of epidural hematoma. The transmastoid approach offers the advantage of visualization of the floor of the middle and posterior fossa without requiring a craniotomy[1]. However, it is less suitable for large defects (> 2 cm), multiple defects, or defects extending

Figure 7
Postoperative computed tomography (CT) of the patient treated with the transmastoid approach



anteriorly to the petrous apex[4]. Similar to our study, other studies have also employed the combined approach for managing larger hernias[7,8]. This approach enables the thorough removal of disease localized in the mastoid cavity, ensures effective closure of the dura, and provides adequate support for intracranial contents[9]. The three patients treated with the mixed approach had middle ear disease and extensive tegmen dehiscence (>1.2 cm) that could not be fully managed via the transmastoid route.

In both the transmastoid and combined approaches, local pedicled flaps rotated from the temporal muscle are used to form an overlayer that supports and partially obliterates the mastoid cavity, promoting rapid epithelialization.

Although technically more challenging, the middle fossa approach offers some advantages over the isolated transmastoid approach. First, it provides superior access to the entire tegmen, including the anterior portion, which is inaccessible through the transmastoid route. Additionally, it enables the inspection of a larger area of the middle fossa floor, aiding in the detection of multiple or non-contiguous defects[1]. The middle fossa approach is particularly recommended for patients with only one functional ear[10] and no active middle ear disease requiring treatment. Our case series demonstrates that successful surgical correction of lateral skull base defects can be achieved using any of the three approaches. We prefer the combined approach because it allows the surgeon to confirm the diagnosis through the transmastoid route. Furthermore, this approach offers the advantage of accurate identification of the defect's location, thereby enabling a smaller and more targeted craniotomy. Titanium mesh provides the rigidity of a bone graft without the morbidity associated with donor harvesting, in addition to requiring less surgical time. It can be easily molded to fit the defect site, yet remains rigid and secure once in place. Other studies have revealed no complications with the use of titanium mesh[11]. The benefits of titanium include its radiolucency, non-magnetic properties, and exceptional biocompatibility compared to other metals. Alloplastic materials must be used in a sterile cavity free of active disease, and integration into biological tissues and use of prophylactic antibiotic therapy are recommended. Although titanium mesh is biocompatible, it is reasonable to assume that the risk of infection may be higher than that associated with autologous materials, as observed with other synthetic materials used in reconstruction. However, a literature review revealed that titanium mesh consistently demonstrates a low infection rate compared to alternative materials[11]. Matsuno et al. reported an infection rate of 25.9% for cranioplasty using autologous bone, while titanium mesh had an infection rate of only 2.6%[12].

Similarly, other studies on titanium mesh have reported the absence of meningitis, sensorineural hearing loss, or seizures in the postoperative period[2,13,14].

Conclusion

The potential for neurological complications resulting from meningoencephalic herniation into the mastoid cavity or formation of CSF fistulas underscores the importance of diagnosing and adequately managing bone defects in the lateral skull base. The combined approach demonstrated superior exposure; however, all surgical approaches were associated with reduced patient morbidity. This case series suggests that titanium mesh is a safe and effective option for reconstructing large defects of the lateral skull base, and achieves excellent closure rates.

Conflict of Interests

The authors declare that they have no conflict of interest regarding this article.

Data Confidentiality

The authors declare that they followed the protocols of their work in publishing patient data.

Human and animal protection

The authors declare that the procedures followed are in accordance with the regulations established by the directors of the Commission for Clinical Research and Ethics and in accordance with the Declaration of Helsinki of the World Medical Association.

Privacy policy, informed consent and Ethics committee authorization

The authors declare that they have obtained signed consent from the participants and that they have local ethical approval to carry out this work.

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Scientific data availability

There are no publicly available datasets related to this work.

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