Anterior Skull Base Defects Reconstructed Using Three-Layer Method: 78 Consecutive Cases with Long-Term Follow-Up

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Abstract

Objectives Anterior skull base defects are potentially lethal and surgical treatment must be performed as soon as possible. The purpose of this study was to evaluate whether our technique is effective or not in long-term period.

Design Retrospective chart review of all patients whose data were entered into the Hospital Registry System between 1995 and 2015.

Setting/Participants This study was performed at the Gaziantep University School of Medicine, Gaziantep, Turkey, in 2015 and included 78 patients who in the past 20 years underwent three-layer reconstruction surgery for anterior skull base defects at the same university.

Main Outcome Measures Among the patients, defects repaired by transcranial approach had the lowest recurrence rate. Overall, successful repair was achieved in 100% of the patients.

Results Pure transbasal approach was used as a single procedure on 71 (91%) patients. Combined approaches were used in seven (9%) cases. The extended transbasal approach was combined with a transfacial approach in four patients and with a pterional approach in three patients.

Conclusion We encourage the use of three-layer reconstruction and recommend free fascia lata grafts and galeal flaps with vascularized pedicle as sealing material of choice in all types of cases such as tumor and trauma.

Keywords

- skull base defect
- pericranium
- reconstruction
- vascular flap

Introduction

Skull base defects are the results of tumor surgeries or craniofacial traumas involving the cranial base. Therefore, cerebrospinal fluid (CSF) leakage is often a problem following surgery or trauma of the anterior skull base where the dura

remains open.¹ Although endonasal approaches have been used as an alternative to cranial and craniofacial approaches, various open reconstruction techniques using local and regional flaps as well as free flaps by themselves or in conjunction with titanium mesh or vascularized bone flap have been described in literature. Majority of the series on

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craniofacial resections where complications were reported in depth have CSF leak rates from 3 to 20% with a mean of between 8 and 10%. In addition, postoperative meningitis occurs in 1 to 10% of cases.^{2,3} In a previous report, we described the utilization and short-term follow-up of triple-layer technique for repair of anterior skull base defect. In that report, it was demonstrated that vascularized pericranium graft was a good arterial feeder of dura mater for successful open reconstruction of skull base defects. This study was performed to examine the long-term outcome of this method. The advantages of the technique and ways to improve flap viability in long-term period are discussed.

Patients and Methods

A retrospective study was designed to review all patients whose data were entered into the Hospital Registry System between 1995 and 2015. All these patients accepted treatment after informed consent. The patients included 48 male and 30 female patients with an age range of 2 to 76 years (median: 36.5). Neurodiagnostic studies included MR imaging and axial and coronal computed tomography. Each patient was treated with an antibiotic regimen composed of ceftriaxone (30 mg/kg) and ornidazole (30 mg/kg). The first dose was administered 1 hour before induction of anesthesia and antibiotic therapy was continued until the nasal packing was removed, usually on the 10th postoperative day.

Surgical Technique and Reconstruction Procedure

As previously described in the study of Gök et al,⁴ bicoronal skin incision is made following the induction of anesthesia and a bifrontal scalp flap is created in the subgaleal plane anteriorly beyond the supraorbital ridges, protecting supraorbital and supratrochlear nerves and arteries. Vascularized pericranium is elevated down to the orbital ridges and laterally to the border of deep temporalis fascia on each side. For transbasal approach, bifrontal craniotomy extending from just above the supraorbital rims to the hairline and laterally to the anterior boundary of both temporal fossae is performed. Bilateral removal of the medial portion of the supraorbital rims and central portion of the supraorbital bar to the nasofrontal suture is added for an extended transbasal approach. The border for the lateral extent of supraorbital rim removal is the supraorbital notch. The frontal sinuses are cranialized, mucosal remnants exenterated, and the cavity is packed with abdominal fat tissue. After bilateral incision of the dura at the inferior edge of the craniotomy, the superior sagittal sinus is doubly ligated with sutures and divided after which the falx cerebri is transected in the direction of the crista galli. The lesion is then treated, for example, by removal of tumor, repair, and reconstruction. The dura is adherent to the cribriform plate around the olfactory nerves and their dural extensions. Therefore, it is easier to cut the dura surrounding the cribriform plate rather than tearing it by blunt dissection.

This surgery creates a large defect in the cranial base; if the lesion was malignant, this can include ethmoid and sphenoid sinuses and medial orbital wall. Two pieces of fascia lata with sizes tailored to be larger than the dural and skull base defect were harvested. The fascia lata graft is then placed without tension between the brain and the remaining dura, is carefully sutured, and the distal edge is laid over the optic nerves and tuberculum sellae. The basal defect is packed with abdominal fat tissue and over laid with fascia lata graft, and the graft is secured with mini titanium screws over the cranial surface of both orbital ridges. Vascularized pericranium is rotated through the craniotomy above the supraorbital rims and into position between the two layers of fascia lata. The supraorbital bone flap is replaced. Vaseline gauze strip with antibiotic is applied to the reconstructed skull base to provide additional support for cranial base coverage (►Video 1).

Video 1

Traumatic anterior skull base defect reconstructed using three layered method: Operative video. Online content including video sequences viewable at: <https://www.thieme-connect.com/products/ejournals/pdf/10.1055/s-0036-1583310>.

Results

We reviewed 78 patients who underwent reconstruction of the anterior cranial base defect using triple-layer technique, in the past 20 years, between 1995 and 2015. The etiological examination of the patients revealed that the most frequently observed reason was tumoral lesions. It was followed by cranial traumas, gunshot wounds, a congenital anomaly, and a defect developing after ethmoid sinusitis complication respectively. Some of the nontraumatic bone defects and dural tears developed unintentionally after transbasal approach to the some brain lesions such as arteriovenous malformations and cavernous hemangioma that settled on the basal region of the frontal lobe. Forty patients had skull base surgery for repair of CSF leakage after cranial traumas and gunshot wounds. These patients had chronic rhinorrhea and frequent meningitis attacks. Twenty-five of the 36 patients with tumoral lesions had olfactory groove meningioma with bone infiltration, whereas the remaining 11 patients each had different tumoral lesions, some of which were invading the skull base whereas others were located in the inferior portion of the frontal lobe. A malignant tumor had infiltrated the brain parenchyma of a patient and pituitary adenoma had infiltrated both cavernous sinuses, the clivus, and extended to the third ventricle (►Table 1).

Pure transbasal approach was used as a single procedure on 71 (91%) patients. Combined approaches were used in seven (9%) cases. The extended transbasal approach was combined with a transfacial approach in four patients and with a pterional approach in three patients (►Table 2). Eight patients received postoperative radiotherapy. Orbital exenteration was performed on patients with basosquamous cell

Table 1 Etiologies of the skull base defects (n = 78)

Tumors	n (%)
Benign lesions	30 (38.4)
Olfactory groove meningioma	25 (32.0)
Orbital meningioma	1 (1.28)
Right optic glioma ^a	1 (1.28)
Left frontobasal cavernoma ^a	1 (1.28)
Frontobasal hydatid cyst ^a	1 (1.28)
AVM ^a	1 (1.28)
Malignant lesions	6 (7.69)
Basal cell carcinoma	1 (1.28)
Small round cell sarcoma metastasis	1 (1.28)
Nasopharyngeal Cancer	1 (1.28)
Non-Hodgkin lymphoma (right) ^a	1 (1.28)
Leiomyosarcoma	1 (1.28)
Invasive pituitary adenoma	1 (1.28)
Traumatic defects	32 (41.02)
Gunshot injuries	8 (10.25)
Congenital deformities	1 (1.28)
Nasoethmoidal encephalocele	1
Infectious reasons	1 (1.28)
Ethmoid sinusitis	1

Abbreviation: AVM, Arterio-venous malformation.

^aSkull base and dura mater defects made unintentionally by a surgeon during surgery of these lesions by using of transbasal approach.

carcinoma and the orbital cavity was filled with abdominal fat tissue. One patient died 2 months after surgery due to a pulmonary complication. Spinal drainage was not used in any of the patients. None of the patients experienced CSF leakage, meningitis, tension pneumocephalus, abscess, or flap necrosis during the follow-up period. The overall success rate was 100%. The duration of postoperative follow-up ranged from 7 to 312 months with an average period of 82.30 months.

Discussion

Anterior skull base defects are responsible for particular problems that may arise after traumatic injury, tumor surgery, or some destructive problems such as infections and iatrogenic reasons.⁵ Many techniques are used to repair anterior skull base defects: open trans-cranial and transfacial

methods, pure endoscopic endonasal, or combined (endoscope assisted open microsurgery) approaches.^{6,7} Especially in recent years, thanks to 3D endoscopes and HD cameras becoming readily available, both the surgeon's field of view and the depth of both views is increased. Thus, the breadth of the endoscopic surgical resection is increased.⁸ Furthermore, endoscopic approaches are also used in large defects.⁹ Although all endoscopic advantages have gained popularity in the last two decades, open microsurgical approaches still remain reliable.¹⁰ Even allowing for open surgery or endoscopic approaches and endoscope-assisted open surgical techniques have gained more popularity.¹¹

Earlier studies about endoscopic or open surgery used only grafts without vascular pedicle, thus giving to recurrent episodes of meningitides and CSF leakages due to graft failure in the long-term period.¹² The cases in which pedicled temporalis muscle is used as a vascularized graft may result in the functional losses associated with chewing and cosmetic problems.¹³

The method we used in this study is also known as the "sandwich technique," containing a vascularized pericranium in the middle layer. We reported preliminary study to examine the results in 17 cases and emphasized the positive results of the patients who underwent surgery with this technique.⁴

Biological or non-biological materials have been used as grafts during neurosurgical procedures.^{14,15} Complications related to graft failure are not observed in the short-term period when the non-vascularized grafts are used. But they may arise due to insufficiency of graft vascularization in the long-term period. So, in three-layered method, vascularized pericranial galeal flap also feeds and supports upper and lower layers and poses long-term durability.^{4,16,17}

The most important disadvantage of open surgery is iatrogenic anosmia, as it is not possible to protect the olfactory nerve, especially in transbasal approaches. Interestingly, complication rates for open surgery have not been emphasized in the literature. Olfactory nerve may be sacrificed to lay the vascularized flap and the fascia lata over the skull base defect in transbasal approaches.³ In contrast, endoscopic endonasal approaches generally may protect olfactory nerve. It was important that CSF leakage was not observed among 78 patients in this series and the rate was very low in comparison with earlier transcranial (15–20%) and endoscopic (15%) surgeries. Although endoscopic surgical techniques have gained popularity in the last two decades, open surgical approaches are still very safe.^{1,3,18–20}

We did not reveal any problems related to graft failure in patients with the longest follow-up. If a patient needs postoperative radiotherapy, three-layer approach does not allow CSF leakage. On the contrary, CSF leakage may occur after radiotherapy in cases for which non-vascularized grafts have been used.¹⁶

Fat tissue taken from the abdomen or thigh for filling of the dead space of the paranasal sinuses also provides the reinforcing dural closure and mechanical support to the cranial base after resection of the frontal and/or the ethmoidal sinus mucosa. This approach reduces the necessity of inorganic rigid materials such as titanium mesh plates.²¹

Table 2 Surgical approach types (n = 78)

Approach type	n (%)
Pure transbasal	71 (91)
Combined approach	7 (9)
Extended transbasal + transfacial	4
Extended transbasal + pterional	3

Although our technique is not a new method, the number of patients in the series is of great importance both in terms of etiological differences and long-term follow-up. Absence of CSF leakage also confirms the safety of the technique in the long-term follow-up.⁴ Although it is difficult to perform an endoscopic approach in large defects located far from the midline, recent studies showed that success rate after the first surgical reconstruction was 91%.^{18,22}

In our opinion, the limitations of our study are that we did not measure the size of the defective areas in anterior skull base and also we did not compare our study with other studies that were performed using endoscopic approaches.¹⁸ Destructive pathologies such as large traumatic defects or tumoral lesions have led us to perform transcranial surgery in our series. Another major problem of this technique is that the vascularized pericranium of the patient has been used before. In this case, endoscopic nasal route using pedicled mucosal flap may be used. If the defect repairing is not appropriate nasally, use of pedicled temporal muscle grafts may be an appropriate, or the only, approach.^{6,13}

In conclusion, we believe that anterior transbasal approaches in combination with vascularized pericranial grafts seem safer in the long-term period if there is a cranium defect developing after trauma or tumor surgery in the anterior skull base. Surgical results of this technique, which is used with vascularized graft with vascular pedicle, are also positive in all types of skull base pathologies such as trauma, tumor, and others. However, we also believe that the reconstruction with the vascularized pericranial flap may be more reliable, especially in patients undergoing radiotherapy after surgery in the long-term period. It is cost-effective, safe, and easy to perform in the same field of surgery with suitable size and without complications.

Note

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or nonfinancial interest (such as personal or professional relationships, affiliations, knowledge, or beliefs) in the subject matter or materials discussed in this article.

Conflict of Interest

All authors declare no conflict of interest.

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