Cerebrospinal Fluid Leak Rate after Vestibular Schwannoma Surgery via Middle Cranial Fossa Approach

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Abstract

Objective Evaluate the cerebrospinal fluid (CSF) leak rate after the middle cranial fossa (MCF) approach to vestibular schwannoma (VS) resection.

Design Retrospective case series.

Setting Quaternary referral academic center.

Participants Of 161 patients undergoing the MCF approach for a variety of skull base pathologies, 66 patients underwent this approach for VS resection between 2007 and 2017.

Main Outcome Measure Postoperative CSF leak rate.

Results There were two instances of postoperative CSF leak (3.0%). Age, gender, and BMI were not significantly associated with CSF leak. In the two cases with CSF leakage, tumors were isolated to the internal auditory canal (IAC) and both underwent gross total resection. Both CSF leaks were successfully treated with lumbar drain diversion. For the 64 cases that did not have a CSF leak, 51 were isolated to the IAC, 1 was located only in the cerebellopontine angle (CPA), and 12 were located in both the IAC and CPA. 62 patients underwent gross total resection and 2 underwent near-total resection. Mean maximal tumor diameter in the CSF leak group was 4.5 mm (range: 3–6 mm) versus 10.2 mm (range: 3–19 mm) in patients with no CSF leak ($p = 0.03$).

Conclusions The MCF approach for VS resection is a valuable technique that allows for hearing preservation and total tumor resection and can be performed with a low CSF leakage rate. This rate of CSF leak is less than the reported rates in the literature in regard to both translabyrinthine and retrosigmoid approaches.

Keywords
- vestibular schwannoma
- middle cranial fossa
- cerebrospinal fluid leak
- complication

Introduction

The middle cranial fossa (MCF) approach is a well-established surgical approach for resection of small and medium-sized vestibular schwannomas (VS) as well as other pathologies of the lateral skull base. Advantages of this approach for teams well-versed in the technique include good facial nerve function and hearing preservation outcomes with low morbidity and mortality.[1,2] Postoperative complications are uncommon after MCF approach but remain a significant concern as for all intracranial procedures, especially in light of the low morbidity associated with nonsurgical treatments for VS which include observation and stereotactic radiosurgery.[3,4]

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Cerebrospinal fluid (CSF) leak is among the more frequent postoperative complications following MCF approach to VS resection. Previous studies have reported variable CSF leak rates following VS resection, ranging from 1 to 30%.[5–9] Studies looking specifically at CSF leak rates following MCF approach have reported more consistent rates of approximately 10%.[1,6,7,10,11] Postoperative CSF leak is associated with significant morbidity as well as an increase in financial outlays due to the increased risk for bacterial meningitis, possible return to the operating room, and a longer hospital stay.[6,7,11]

In the present study, we aim to evaluate the CSF leak rate after MCF approach to VS resection at a tertiary and quaternary referral center and to analyze tumor and patient characteristics associated with postoperative CSF leak.

Methods

Study Design

A retrospective case series of patients undergoing MCF approach to VS resection from 2007 to 2017 at a quaternary referral academic center. The study was approved by our Institutional Review Board.

Surgical Technique

All cases were performed under general anesthesia with intraoperative monitoring. A lumbar drain (LD) was routinely placed preoperatively and removed at the end of surgery. A standard temporal craniotomy was performed and the temporal lobe was retracted medially to gain access to the MCF floor. The internal auditory canal (IAC) was identified and the tumor was resected. Meticulous attention was then given to wound closure. The dura was kept intact and any dural laceration was sutured in a water-tight fashion. Closure technique included obliterating any open air cells with bone wax, placing temporalis muscle in the IAC, placing temporalis fascia over the MCF floor, covering the MCF floor with a fibrin sealant, and placing a piece of DURAFORM (Middleton, WI, USA) dural graft to cover the entire MCF floor.

CSF Leak Management Protocol

Our treatment protocol for postoperative CSF leaks includes LD placement with drainage of 5 to 10 cc/hour of CSF for 5 days. Treatment is done in an in-patient setting. On the 5th day, we clamp the LD for 24 hours. A leak-test is performed, in which the patient is instructed to sit and bend forward with head and arms down for 3 minutes. If the leak-test is negative, we remove the LD and the patient is discharged home. If the leak test is positive management options include continued LD or surgical management.

Chart Review

Patients' charts were reviewed for demographic data, body mass index (BMI), previous skull base radiation, previous surgical resection, tumor size defined as maximal diameter on preoperative magnetic resonance imaging (MRI), pre- and postoperative facial nerve function assessed by House–Brackmann scores,[12] surgical approach, tumor location (IAC or the cerebellopontine angle [CPA]), extent of tumor resection, tumor pathology, presence of postoperative CSF leak and associated management strategies, length of hospital stay (LOS), and early readmission (defined as readmission within the first 30 days of discharge). Gross total resection was defined as complete tumor resection, whereas near-total resection was defined as resection of 95 to 99% of tumor burden.

Statistical Analysis

Statistical analysis was performed in the R programming environment (R Foundation for Statistical Computing, Vienna, Austria). The student's *t*-test was used for numerical data and the Pearson's Chi-squared test was used for categorical data.

Results

A total of 161 MCF approaches were performed at our institution for a variety of indications over the study period, including 66 MCF approaches for VS resection. Mean age was 51.7 years. Thirty-two patients (48.5%) were male and 34 were female (51.5%). Mean and median BMI were 29.6 and 28.9 kg/m^2, respectively (range: 19.4–42.6 kg/m^2). Patients' preoperative characteristics are summarized in ►**Table 1**. No patient had a history of previous radiation therapy or previous tumor resection. Preoperative House–Brackman score was 1 in all patients.

There were two instances of postoperative CSF leak (3.0%), diagnosed clinically based on the presentation of CSF rhinorrhea on postoperative day 4 and 6. Both cases were successfully treated with LD diversion for 5 days per our protocol described above. Gross total resection was accomplished in both cases. For the 64 patients that did not experience a CSF leak, 62 underwent gross total resection and two underwent near total resection. Both tumors in the CSF leak group and the majority of tumors in the non-CSF leak group (79.7%) were located in the IAC. Tumor characteristics are summarized in ►**Table 2**. There were no cases of meningitis. Five patients had early readmission, only one of which was in the CSF leak group. Postoperative outcomes are summarized in ►**Table 3**.

Table 1 Preoperative characteristics of patients undergoing VS resection via MCF approach.

	CSF leak $n = 2$ (3%)	No CSF leak $n = 64$ (97%)	*p*-Value
Mean age (y)	51.0	51.7	0.95
Gender	1 male	31 males	1.00
	1 female	33 females	
Mean BMI	33.7	29.3	0.30
Median BMI	33.7	28.9	
BMI range (kg/m^2)	31.8–35.5	19.4–42.6	

Abbreviations: BMI, body mass index; CSF, cerebrospinal fluid; MCF, middle cranial fossa; VS, vestibular schwannoma.

Table 2 Tumor characteristics in patients undergoing VS resection via MCF approach

	CSF leak $n = 2$ (3%)	No CSF leak $n = 64$ (97%)	*p*-Value
Tumor laterality	2 left	33 right 31 left	0.49
Mean maximal tumor diameter (range), mm	4.5 (3–6)	10.2 (3–19)	0.03
Tumor location	IAC–2	IAC–51 CPA–1 IAC + CPA − 12	0.99
Gross total resection	2 (100%)	62 (96.88%)	1.0

Abbreviations: CPA, cerebellopontine angle; CSF, cerebrospinal fluid; IAC, internal auditory canal; MCF, middle cranial fossa; VS, vestibular schwannoma.

Table 3 Postoperative outcomes in patients undergoing VS resection via MCF approach

	CSF leak $n = 2$ (3%)	No CSF leak $n = 64$ (97%)	*p*-Value
Mean postoperative HB score (range)	1.5 (1–3)	1.7 (1–6)	0.82
Early readmission	1	4	0.15
Mean LOS (d)	8	4.4	< 0.001

Abbreviations: CSF, cerebrospinal fluid; HB, House–Brackmann; LOS, length of hospital stay; MCF, middle cranial fossa; VS, vestibular schwannoma.

Discussion

Postoperative CSF leak is cited as the most common major complication associated with VS resection, other than facial nerve weakness and hearing loss.[5,6,11] In the present case series, the rate of CSF leak following MCF approach for VS resection was 3%, which is lower than that reported in other large series.[1,6,7,10,11]

Selesnick et al[7] reported that age and other preoperative indicators were not associated with postoperative CSF leak following VS resection and our findings corroborate these observations. Although tumor size has been suggested as a risk factor for CSF leak, previous studies have not consistently supported this association.[1,6,13] Interestingly, Lüdemann et al found an inverse association between tumor size and CSF leak rate, similar to our results.[14] Further research from the same group showed that patients with small VS had more visible pneumatization of the posterior wall of the IAC.[15] The authors hypothesized that larger tumors may obliterate air cells neighboring the IAC, theoretically reducing the risk of postoperative CSF leak.

Previous reports have found an association between elevated BMI and postoperative CSF leak following VS resection.[16,17] However, these studies included all skull base approaches to VS resection with only a small percentage of cases performed via the MCF approach. In our series, BMI was not associated with increased risk for CSF leak following MCF approach for VS resection. There are conflicting reports about whether a particular surgical approach is independently associated with CSF leak rate. While Copeland et al reported a significantly higher CSF leak rate with the translabyrinthine approach,[17] others have found no association between surgical approach and CSF leak rate.[6,7,11,16] Considering the heterogeneity of approaches used in previous analyses of CSF leak rate after VS surgery, our results may provide a more accurate representation of the frequency of CSF leak following MCF approach to VS resection and can be used in risk assessment for patients being considered for this operation.

Meningitis has long been a feared complication associated with postoperative CSF leak. While some reports have not found a significant association between CSF leak and meningitis,[18,19] others were able to demonstrate a significant association between the two,[20,21] including a meta-analysis of 13 studies.[7] In the present series, there were no instances of meningitis, likely owing to the low rate of postoperative CSF leak. In addition, we hypothesize that removing the LD at the end of the procedure as opposed to leaving it in clamped, may have contributed to preventing meningitis in our patients, as the latter may be associated with an increased risk for meningitis.[22] We use the LD in the MCF approach primarily for brain relaxation and minimizing temporal bone retraction. We remove the LD at the end of the procedure as the prolonged drainage or alternatively leaving the drain in clamped could induce infection or other complications, such as pneumocephalus, transtentorial herniation, or hematoma, as well as persistent CSF hypotension requiring a blood patch.[22] We feel that the risks of keeping the lumbar drain outweigh the potential benefits, especially when the postoperative CSF leak rate is low. Lumbar drain reinsertion can be performed in indicated cases, such as a CSF leak.

Longer LOS is another expected implication of postoperative CSF leak, as was observed in the CSF leak group in this study.[6,11] Longer LOS in itself can be considered a risk factor for postoperative morbidity, as it has been associated with other complications including thromboembolic events, infection, mood and mental status changes, higher risk for readmission, as well as consumption of hospital resources.[23] Thus, LOS can be used as an indirect marker for postoperative outcome and minimizing factors associated with longer LOS may be beneficial to both patients and caregivers.

Limitations of our study include its retrospective design and small sample size, especially in light of the low rate of postoperative CSF leak. Nonetheless, there is limited literature investigating complications of the MCF approach to VS resection and the present analysis supports the notion that the MCF approach is associated with a low risk of postoperative CSF leak.

Conclusion

The standard MCF approach to VS resection is a valuable technique that allows for hearing preservation and total tumor resection. In experienced hands, the MCF approach can be performed safely and with a low rate of postoperative CSF leak. The observed rate of CSF leak in the present study is less than those reported for translabyrinthine and retrosigmoid approaches. At our center, for tumors that are amenable to remove via a MCF approach, we tend to favor this technique over the translabyrinthine or retrosigmoid approaches due to a lower CSF leak rate.

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