Technical Modifications of Suboccipital Craniectomy for Prevention of Postoperative Headache

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ABSTRACT

A retrospective review of 53 consecutive patients who underwent a retrosigmoid vestibular nerve section (VNS) or microvascular decompression (MVD) through a modified suboccipital craniectomy with a minimum follow-up of 2 years was performed. Technical modifications to the suboccipital craniectomy included a skin incision designed to avoid the lesser and greater occipital nerves; a small, 2-cm diameter craniectomy with no intradural drilling of bone; and a simplified closure to prevent muscle adhesion to dura without the need for cranioplasty. The presence, duration, and severity of postoperative headache were the primary outcome measures. Craniectomy-related complications, operative time, and length of hospital stay were also reviewed. The incidence of postoperative headache after suboccipital craniectomy was 7.5% at 3 months (4/53), 3.8% at 1 year (2/53), and 3.8% at 2 years (2/53). Complications related to craniectomy included cerebrospinal fluid leakage (5.7%), aseptic meningitis (1.9%), and superficial wound infection (1.9%). The mean operative time was 145 and 98 minutes for VNS and MVD, respectively. The mean hospital stay was 2.2 and 3.6 days for VNS and MVD, respectively. Technical modifications of suboccipital craniectomy during retrosigmoid VNS and MVD lowered the incidence of postoperative headache and craniectomy-related complications and had no adverse effect on operative time or length of hospital stay.

KEYWORDS: Suboccipital craniectomy, vestibular nerve, microvascular decompression, headache

The retrosigmoid (RS) approach provides excellent exposure and access to the neurovascular structures of the cerebellopontine angle (CPA). Many authors advocate it as the procedure of choice during vestibular nerve section (VNS) for intractable peripheral vestibular disorders, microvascular decompression (MVD) for hyperactive cranial nerve syndromes, and hearing preservation during surgery for vestibular schwannomas. However, a major concern regarding the RS approach is the high incidence of postoperative headache, which ranges from 12 to 83%.¹⁻⁷ The incidence of postoperative headache in patients undergoing RS VNS or MVD is lower, but also significant, ranging from 5 to 75%.⁸⁻¹²

The cause of postoperative headache after the RS approach, which requires a suboccipital craniectomy, remains a source of debate in the otolaryngological and neurosurgical literature. Adhesion of cervical musculature to exposed dura at the craniectomy site with subsequent traction during neck motion has been proposed as a cause and provides the rationale for cranioplasty advocated by some authors.¹³⁻¹⁶ Injury to the greater and lesser occipital nerves has also been proposed as a possible mechanism. These nerves may be damaged directly during the skin incision or during retraction of the incised soft tissue.^{3,4,8,17} Another possible cause is

chemical meningitis from bone dust contaminating the subarachnoid space during drilling of the internal auditory canal (IAC).^{3,7,9} The development of postoperative headache after suboccipital craniectomy likely involves a combination of these mechanisms.

This article presents several important modifications to our suboccipital craniectomy technique and reports the efficacy of this modified technique in reducing the incidence of postoperative headache after RS VNS and MVD. The hope is not only to reduce surgical morbidity and improve patient outcomes, but also to further elucidate the pathophysiology of postoperative headache associated with suboccipital craniectomy and the RS approach.

MATERIALS AND METHODS

Patient Population

From July 1995 to October 1998, 53 consecutive patients (21 males and 32 females) undergoing RS VNS or MVD with a modified suboccipital craniectomy technique were reviewed retrospectively (Table 1). Their mean age was 54 years (range, 28 to 79 years). Twelve patients underwent

Table 1 Demographics of 53 Patients Undergoing a Modified Suboccipital Craniectomy

	VNS Patients (n = 12)	MVD Patients (n = 41)	All Patients (n = 53)
Mean age in years (range)	44.5 (28-60)	57.2 (30-79)	54.3 (28-79)
Gender (%)			
Male	5 (41.7)	16 (39.0)	21 (39.6)
Female	7 (58.3)	25 (61.0)	32 (60.4)
Clinical diagnosis (%)			
Meniere's disease	12 (100)	—	12 (22.6)
Trigeminal neuralgia	—	34 (83.0)	34 (64.1)
Hemifacial spasm	—	3 (7.3)	3 (5.7)
Pulsatile tinnitus	—	3 (7.3)	3 (5.7)
Glossopharyngeal neuralgia	—	1 (2.4)	1 (1.9)
Affected side (%)			
Right	8 (66.7)	28 (68.3)	36 (67.9)
Left	4 (33.3)	13 (31.7)	17 (32.1)
Mean follow-up in months (range)	40 (26-57)	40 (24-63)	40 (24-63)

RS VNS for intractable vertigo due to Meniere's disease. All together, 41 patients underwent MVD: 34 for trigeminal neuralgia, 3 for hemifacial spasm, 3 for pulsatile tinnitus, and 1 for glossopharyngeal neuralgia. The suboccipital craniectomy performed during either RS VNS or MVD was identical, and patients undergoing either procedure were grouped together for the purpose of this study.

A minimum follow-up of 2 years was required for inclusion in the study, and three patients were excluded due to inadequate follow-up. Patients were contacted by telephone and interviewed by a single investigator (DAS) using a pre-established patient questionnaire. Patient demographic information, clinical diagnosis, and the date of surgery were checked for accuracy using outpatient clinic notes and operative reports from the medical record.

Postoperative headache was defined as headache on the same side as the craniectomy site that was not present before surgery. For the purposes of this study, self-limited headaches in the immediate postoperative period (7 to 10 days) were not considered to be significant. The presence, duration, and severity of postoperative headaches served as the primary outcome measures. Headache severity was quantified using the grading system introduced by Catalano et al⁷ (Table 2). The mean follow-up was 40 months (range, 24 to 63 months).

Operative Technique

All operations were performed by the same neurosurgeon (JHL) and one of two senior neurotologists (GBH or SEK) at the Cleveland Clinic Foundation. After endotracheal general anesthesia was administered, a lumbar drain was placed for posterior fossa decompression. For Meniere's patients undergoing RS VNS or hemifacial spasm patients undergoing MVD, electrodes were placed for intraoperative monitoring of facial nerve function and the brain stem auditory evoked response (BAER). The patient was placed supine with the head fixed in a Mayfield clamp. The head was rotated to the contralateral side and the neck was slightly flexed. A 4- to 5-cm curvilinear retroauricular skin incision was made overlying the asterion. The incision was thus placed a few centimeters lateral to the greater occipital nerve and just medial to the lesser occipital nerve (Fig. 1A). Starting at the time of skin incision, approximately 60 to 90 cm³ of cerebrospinal fluid (CSF) were drained through the lumbar drain. A 2-cm diameter craniectomy extending inferiorly from the asterion was then made using a 6-mm cutting bur. A triangular opening was made in the dura with the intact dural base along the medial edge of the sigmoid sinus (Fig. 1B). By the time the dura was opened, the posterior fossa was completely decompressed, making it easy to expose the CPA with minimal or no cerebellar retraction.

After the CPA was exposed, VNS or MVD was performed in the standard fashion using an operating microscope and minimal arachnoid dissection. In an attempt to minimize contamination of the subarachnoid space with bone dust, drilling stopped when the dura was incised and the posterior fossa was entered. When the intracranial portion of the procedure was completed, the dura was reapproximated and exposed mastoid air cells were sealed with bone wax. A piece of Gelfoam cut to the size and shape of the craniectomy defect was placed over the dura to absorb any blood from the dural surface. Gelfilm was then placed over the first piece of Gelfoam to prevent the muscle from adhering to the dura. Another piece of Gelfoam was used to fill

Table 2 Grading System for Severity of Postoperative Headache

Headache Severity	Description of Headache
Grade 0	No headache
Grade 1	Mild headache requiring no pain medication
Grade 2	Moderate headache requiring nonprescription pain medication
Grade 3	Severe headache requiring prescription pain medication
Grade 4	Severe headache refractory to prescription medication

Figure 1 Schematic representation of the modified suboccipital craniectomy technique, which incorporates (A) a curvilinear skin incision placed to avoid the lesser and greater occipital nerves, (B) a small 2-cm diameter craniectomy, and (C) a simplified closure using a combination of Gelfoam and Gelfilm without the need for cranioplasty. Printed with permission of The Cleveland Clinic Foundation, Cleveland, Ohio.

the craniectomy defect and to absorb any epicranial blood (Fig. 1C). The muscle, fascia, and skin were closed in layers.

In summary, our modified suboccipital craniectomy technique included three features. A skin incision was strategically placed to avoid injury to the greater and lesser occipital nerves. The craniectomy was small (2-cm diameter) and there was no intradural drilling of bone. Finally, the closure was reinforced with Gelfoam and Gelfilm to prevent muscle adhesion to exposed dura without the need for cranioplasty.

Outcome Analysis

Statistical analysis with Fisher's exact test was used to compare the incidence of postoperative headache in the two groups and to justify combining the two

statistically similar datasets into one series of 53 patients (p -value > 0.99). Craniectomy-related complications (i.e., CSF leakage, meningitis, superficial wound infection), operative time, and length of hospital stay were also reviewed.

RESULTS

The incidence of postoperative headache was 7.5% (4/53) 3 months after surgery, 3.8% (2/53) 1 year after surgery, and 3.8% (2/53) 2 years after surgery. There was no statistically significant difference in the incidence of postoperative headache in the two groups (Fisher's exact test, p -value > 0.99). The mean severity of headache was 2.25 (range, 2 to 3), corresponding to 3 of 4 patients with postoperative headaches requiring nonprescription

Table 3 Summary of Postoperative Headache Data

	VNS Patients (<i>n</i> = 12) no. (%)	MVD Patients (<i>n</i> = 41) no. (%)	All Patients (<i>n</i> = 53) no. (%)
Patients with postoperative headache			
3 months	1 (8.3)	3 (7.3)	4 (7.5)
1 years	0 (0.0)	2 (4.9)	2 (3.8)
2 years	0 (0.0)	2 (4.9)	2 (3.8)
Mean headache severity*	Grade 2	Grade 2.3	Grade 2.2
Mean time until onset of headache (months)	2.0	1.5	1.6
Mean duration of headache (months)	5.0	24.3	19.5

*Headache severity was quantified using a five-point scale ranging from grade 0 (no headache) to grade 4 (headache refractory to prescription medication) as described in Table 2.

pain medication and 1 patient requiring prescription pain medication. The mean time interval between craniectomy and the onset of headache was 1.6 months (range, 2 weeks to 3 months). The mean duration of headache was 19.5 months (range, 1 to 46 months). There was no statistically significant difference in the severity, time of onset, or duration of postoperative headache in the two groups (Fisher's exact test, *p*-value > 0.99, Table 3).

Surgical complications related to craniectomy occurred in 5 of the 53 patients (9.4%). Three patients (5.7%) developed a CSF leak, 1 patient (1.9%) developed aseptic meningitis, and 1 patient (1.9%) developed a superficial wound infection. After conservative treatment with an SA (subarachnoid) drain and bed rest failed, re-exploration with duraplasty and mastoid obliteration was necessary in 2 of the patients with a CSF leak. The patient with aseptic meningitis was thought to have posterior fossa syndrome, which resolved spontaneously after 3 days. The only surgical wound infection was superficial and was treated successfully with a 7-day

course of a first-generation oral cephalosporin. There were no facial or cochlear nerve injuries and no other postoperative complications. The mean operative time was 145 minutes for VNS and 98 minutes for MVD. The mean hospital stay was 2.2 days for VNS and 3.6 days for MVD (Table 4).

DISCUSSION

The RS approach to the posterior cranial fossa provides easy access and optimal exposure of the neurovascular structures in the CPA. It is associated with a lower incidence of CSF leakage than the traditional retrolabyrinthine approach and obviates the need for abdominal fat to obliterate the surgical defect.^{10,11,18} The main disadvantage of the RS approach, which requires a suboccipital craniectomy, has been the relatively high incidence of postoperative headache.¹⁻¹² In an attempt to reduce the incidence of headache and to foster greater acceptance

Table 4 Summary of Surgical Complications and Operative Data

	VNS Patients (<i>n</i> = 12) no. (%)	MVD Patients (<i>n</i> = 41) no. (%)	All Patients (<i>n</i> = 53) no. (%)
Craniectomy-related complications			
CSF leak	0 (0.0)	3 (7.3)	3 (5.7)
Meningitis	1 (8.3)	0 (0.0)	1 (1.9)
Wound infection	0 (0.0)	1 (2.4)	1 (1.9)
Total complications	1 (8.3)	4 (9.8)	5 (9.4)
Mean operative time (minutes)	145	98	N/A
Mean hospital stay (days)	2.2	3.6	N/A

of this approach, several technical modifications directed at the etiology of postoperative headache have been proposed.

One likely mechanism for headache after the RS approach is adhesion of cervical musculature to exposed dura at the craniectomy site. The dura of the posterior fossa is richly innervated and capable of producing headache as a result of traction during neck motion.^{6,19} Several authors have described cranioplasty with calvarial bone grafts, methyl methacrylate, or titanium mesh-acrylic in an attempt to circumvent this process.¹³⁻¹⁶ However, the benefit of cranioplasty has been questioned by subsequent clinical studies that failed to show any reduction in the incidence of postoperative headache in these patients.^{7,12} It has also been suggested that the cranioplasty material may increase local tissue reaction, potentially leading to a higher incidence of headache.¹²

To minimize the possibility of dural adhesion, we prefer a 5-cm skin incision overlying the asterion, a small 2-cm diameter craniectomy, and a three-layered closure using a combination of Gelfoam and Gelfilm. The inner layer of Gelfoam absorbs residual epidural blood and the Gelfilm prevents the cervical musculature from adhering to the dura. The outer layer of Gelfoam absorbs epicranial blood, which is a potential source of inflammation and irritation of the overlying soft tissue and musculature. This closure technique effectively minimizes dural adhesion, as demonstrated by the two patients who required re-exploration and duraplasty for persistent CSF leakage after their suboccipital craniectomy. It also obviates the need for cranioplasty, which is associated with its own morbidity and increases operative time.

Injuries to the greater and lesser occipital nerves have also been proposed as a potential cause for postoperative headache. These nerves may be injured directly by the incision or secondarily by retraction of the incised soft tissue.^{8,17} The possibility of a traumatic occipital nerve neuroma or occipital nerve entrapment syndrome must be considered in patients with postoperative headache who describe a sharp or burning pain in the operated

occipital region associated with a trigger point near the incision.^{3,4} To prevent nerve injury, our incision is placed a few centimeters lateral to the greater occipital nerve and made in a curvilinear fashion so that the inferior limb of the incision is directed away from branches of the lesser occipital nerve. Because of the relatively small size of the craniectomy (2-cm diameter), the need to retract soft tissue is minimized. The combination of these two factors reduces the likelihood of injury to the greater or lesser occipital nerves and may contribute to a lower incidence of postoperative headache.

Another proposed etiology for postoperative headache is chemical meningitis caused by bone dust contaminating the subarachnoid space of the posterior fossa. Although the exact mechanism is not well elucidated, chronic meningeal irritation from bone dust liberated during drilling of the IAC is thought to contribute to persistent postoperative headache.^{3,8} Aggressive irrigation and suctioning of debris during intradural drilling have been proposed to circumvent this process.^{2,7} In our modification, the RS VNS or MVD were performed with no drilling of bone once the dural incision was made, thus eliminating this mechanism as a contributing factor to headache. The incidence of postoperative headache in our series (7.5% at 3 months, 3.8% at 1 and 2 years) compares favorably to that of previous studies reporting a 5 to 12% incidence of postoperative headache when RS VNS was performed without drilling the IAC.⁸⁻¹¹

Although the etiology of postoperative headache after the RS approach is likely a combination of the mechanisms described, we suspect that contamination of the subarachnoid space with bone dust during drilling of the IAC may play a larger role than previously recognized. Such contamination would help to explain the large difference in the incidence of postoperative headache between RS VNS or MVD, which can be performed without intradural drilling of bone, and vestibular schwannoma resection, which requires extensive drilling of the IAC.⁸ However, the potential for dural adhesion to cervical musculature and occipital nerve injury after suboccipital craniectomy remains a

legitimate concern. By addressing each of the proposed mechanisms of headache, our modified suboccipital craniectomy technique lowered the incidence of postoperative headache compared with similar RS VNS and MVD series in the literature. Subsequent studies directed at further clarifying the relative importance of each of the proposed mechanisms for headache will include analysis of the efficacy of our modified suboccipital craniectomy technique in preventing postoperative headache after RS vestibular schwannoma resection.

Our outcomes associated with the modified suboccipital craniectomy technique are consistent with published reports of surgical complications after RS VNS or MVD.⁹⁻¹² Our complications were limited to CSF leakage (5.7%), aseptic meningitis (1.9%), and superficial wound infection (1.9%). Scant data are available on operative times and length of hospitalization, but our operative times were considerably lower and hospitalization was not affected adversely compared with historical controls within our institution. With the accumulation of additional expertise and experience using the modified suboccipital craniectomy technique, our mean operative time continues to improve and now approximates 60 to 90 minutes for both RS VNS and MVD.

CONCLUSION

The technical modifications of suboccipital craniectomy we have instituted during RS VNS and MVD have lowered the incidence of postoperative headache compared with previous reports. This technique not only is efficacious in addressing the problem of postoperative headache but also minimizes craniectomy-related complications. It also caused no adverse effect on operative time or length of hospitalization. We advocate incorporating these technical modifications of suboccipital craniectomy as a routine part of the RS approach for VNS and MVD.

REFERENCES

1. Levo H, Pyykko I, Blomstedt G. Postoperative headache after surgery for vestibular schwannoma. *Ann Otol Rhinol Laryngol* 2000;109:853-858
2. Hanson MB, Glasscock ME III, Brandes JL, Jackson CG. Medical treatment of headache after suboccipital acoustic tumor removal. *Laryngoscope* 1998;108:1111-1114
3. Driscoll CL, Beatty CW. Pain after acoustic neuroma surgery. *Otolaryngol Clin North Am* 1997;30:893-903
4. Pedrosa CA, Ahern DK, McKenna MJ, Ojemann RG, Acquadro MA. Determinants and impact of headache after acoustic neuroma surgery. *Am J Otol* 1994;15:793-797
5. Harner SG, Beatty CW, Ebersold MJ. Headache after acoustic neuroma excision. *Am J Otol* 1993;14:552-555
6. Schessel DA, Nedzelski JM, Rowed DW, Feghali JG. Pain after surgery for acoustic neuroma. *Otolaryngol Head Neck Surg* 1992;107:424-429
7. Catalano PJ, Jacobowitz O, Post KD. Prevention of headache after retrosigmoid removal of acoustic tumors. *Am J Otol* 1996;17:904-908
8. Jackson CG, McGrew BM, Forest JA, et al. Comparison of postoperative headache after retrosigmoid approach: vestibular nerve section versus vestibular schwannoma resection. *Am J Otol* 2000;21:412-416
9. Silverstein H, Norrell H, Smouha E, Jones R, Rosenberg S. An evolution of approach in vestibular neurectomy. *Otolaryngol Head Neck Surg* 1990;102:374-381
10. McKenna MJ, Nadol JB Jr, Ojemann RG, Halpin C. Vestibular neurectomy: retrosigmoid-intracanalicular versus retrolabyrinthine approach. *Am J Otol* 1996;17:253-258
11. Glasscock ME III, Thedinger BA, Cueva RA, Jackson CG. An analysis of the retrolabyrinthine vs. the retrosigmoid vestibular nerve section. *Otolaryngol Head Neck Surg* 1991;104:88-95
12. Lovely TJ, Lowry DW, Jannetta PJ. Functional outcome and the effect of cranioplasty after retromastoid craniectomy for microvascular decompression. *Surg Neurol* 1999;51:191-197
13. Wazen JJ, Sisti M, Lam SM. Cranioplasty in acoustic neuroma surgery. *Laryngoscope* 2000;110:1294-1297
14. Feghali JG, Elowitz EH. Split calvarial graft cranioplasty for the prevention of headache after retrosigmoid resection of acoustic neuromas. *Laryngoscope* 1998;108:1450-1452
15. Soumekh B, Levine SC, Haines SJ, Wulf JA. Retrospective study of post-craniotomy headaches in suboccipital approach: diagnosis and management. *Am J Otol* 1996;17:617-619
16. Harner SG, Beatty CW, Ebersold MJ. Impact of cranioplasty on headache after acoustic neuroma removal. *Neurosurgery* 1995;36:1097-1100
17. Schessel DA, Rowed DW, Nedzelski JM, Feghali JG. Postoperative pain following excision of acoustic neuroma

- by the suboccipital approach: observations on possible cause and potential amelioration. *Am J Otol* 1993;14:491–494
18. Silverstein H, Norrell H, Haberkamp T. A comparison of retrosigmoid IAC, retrolabyrinthine, and middle fossa vestibular neurectomy for treatment of vertigo. *Laryngoscope* 1987;97:165–173
19. Kimmel DL. Innervation of spinal dura mater and dura mater of the posterior cranial fossa. *Neurology* 1961;11:800–809