Fully Endoscopic Retrosigmoid Vestibular Nerve Section for Refractory Meniere Disease

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Abstract

Objective This study aims to report our results and technical details of fully endoscopic retrosigmoid vestibular nerve section.

Design A prospective observational study was conducted.

Setting A single academic, tertiary institution involving neurosurgery and neurotology.

Participants Previously diagnosed patients with Meniere disease, refractory to medical therapy, who underwent fully endoscopic vestibular nerve section.

Main Outcome Measures Postoperative improvement in vertiginous symptoms as well as hearing preservation, based on the American Association of Otolaryngology-Head and Neck Surgeons score and the Gardener and Robertson-Modified Hearing Classification. Facial nerve preservation based on the House–Brackman (HB) score.

Results Symptoms improved or resolved in 38 of 41 (92.2%) patients with only 1 of 41 (2.4%) reporting worsening symptoms. All 41 patients (100%) had a postoperative HB score of 1/6, demonstrating full facial nerve preservation. Hearing was stable or improved in 34 of 41 (82.9%) patients. Three complications took place for a rate of 7.3%, one cerebrospinal fluid leak, and two wound infections.

Conclusion The fully endoscopic approach to vestibular nerve sections is a safe and effective technique for the treatment of medically refractory Meniere disease. This technique also utilizes smaller incisions, minimal cranial openings, and no cerebellar retraction with improved visualization of the cerebellopontine angle neurovascular structures.

Keywords

- cerebellopontine angle
- endoscopy
- Meniere disease
- skull base

Introduction

Meniere disease is a chronic inner ear disorder that is characterized by intermittent episodes of vertigo, tinnitus, aural pressure, and sensorineural hearing loss.^{1–5} Although, currently there is no existing definitive cure, several treatment modalities are available. First-line therapy consists of medication and lifestyle modifications, while second-line therapies include various

surgical techniques such as endolymphatic sac surgery, intratympanic steroids, and intratympanic gentamicin.^{6,7} In the rare instance in which Meniere disease remains refractory to these treatments, surgical intervention in the form of labyrinthectomy⁸ and vestibular nerve section has demonstrated safe and efficacious results in improving vertiginous symptoms, with the later procedure providing hearing preservation when performed in the retrosigmoid approach.^{1,9–15}

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Vestibular nerve section traditionally involves a retrosigmoid craniotomy followed by a microscopic approach to the cranial nerve (CN) VII/VIII complex in the cerebellopontine angle (CPA). The vestibular nerve would then be carefully dissected from the cochlear and facial nerves before being sharply sectioned. The procedure is typically performed in a microsurgical fashion utilizing an operative microscope for visualization. This technique, however, has several drawbacks. The linear nature of the microscopic light source, originating outside of the surgical field, does not allow the surgeon to visualize the facial nerve before vestibular nerve sectioning due to the ventral location of CN VII to CN VIII, creating the risk for significant morbidity. In addition, this approach requires cerebellar retraction, significant soft tissue dissection, and cranial defects, all of which increase potential morbidity.

In recent years, several authors have introduced the surgical endoscope to the CPA and demonstrated superior visualization of the neurovascular structures.^{16–23} The endoscope allows the light source to be introduced into the operative field, closer to site of interest. Additionally, angled endoscopes permit visualization of structures ventral to pathology, allowing surgeons to identify the facial nerve and study its relationship to the vestibular nerve before sectioning. As a result, the endoscopic-assisted vestibular nerve section (VNS) procedure was developed with successful results,²⁴ however, this technique continued to utilize the operative microscope for the majority of the procedure, employing the endoscope only as an adjunct.

More recently, the fully endoscopic VNS has been developed, which does not require the operative microscope at any point. As a result, surgeons are provided with improved visualization, while eliminating all cerebellar retraction, minimizing soft tissue dissection and reducing the size of the craniotomy.²⁵ Despite its potential, the fully endoscopic VNS procedure has scarcely been reported. We present our results of the fully endoscopic VNS technique in patients with refractory Meniere disease in what is, to our knowledge, the largest reported series to date.

Methods

A prospective observational study was performed on 41 consecutive patients who underwent fully endoscopic vestibular nerve section for unilateral Meniere disease between 2005 and 2012 at our institution. All patients had clinically diagnosed Meniere disease that was uncontrolled with medical therapy. In addition, several patients had also undergone endolymphatic sac decompression without symptom improvement. Surgery was performed to section the ipsilateral vestibular nerve in a fully endoscopic manner, as described in detail in the following section. Both pre- and postoperative audiometric testing was performed in addition to neurological examinations that included thorough cranial nerve testing. Hearing was graded with both the American Academy of Otolaryngology-Head and Neck Surgeons hearing classification system²⁶ (AAO-HNS) as well as the Gardner–Robertson scale (GR).²⁷ Facial nerve function was evaluated via the House–Brackman scoring system (HB).

Perioperative data, including mean operative time, estimated blood loss and hospital length of stay were recorded. Additionally, operative complications such as cranial nerve palsies, wound infection, and cerebrospinal fluid (CSF) leaks are reported. Follow-up was a minimum of 1 year and patients were asked if their symptoms were resolved, improved, stable, or worsened from previous surgery. Finally, patient demographics such as age, gender, and side of symptoms are reported.

Technical Consideration

Operative Setup

Patients are placed under general anesthesia and undergo endotracheal intubation. They are then positioned supine with the head elevated approximately 30 degrees, to allow for maximal venous outflow, and rotated contralaterally. This positioning creates a natural operative corridor to the CPA, allowing gravity to assist in pulling the cerebellum away from the petrous temporal bone. It is essential that the head be fixated in pins as the need for neuromonitoring prevents the use of paralytics. As a result, movement of the head during surgery could potentially cause the endoscope, which is rigidly fixated with a holding arm, to impale the brainstem or damage surrounding structures. Once the patient is appropriately positioned, attention is turned to equipment setup. A polyaxial, pneumatic, holding arm is attached to the contralateral side of the operating table and arched over the head of the patient, minimizing potential obstruction for the surgeon. A high-definition (HD) monitor is then placed on the patient's contralateral side, giving the surgeon a direct line-of-sight during the operation. ►Fig. 1 illustrates appropriate patient positioning and ►Fig. 2 demonstrates the ideal operating room setup, maximizing space for surgeon while allowing easy visualization of the monitors. Finally, attention is then placed on localizing the incision site. A small amount of hair over the ipsilateral mastoid is clipped to approximately

Fig. 1 Preoperative patient positioning with the head elevated and rotated to the contralateral side. The polyaxial, multijointed, pneumatic holding arm is attached to the contralateral side of the bed and a HD monitor is also on the contralateral side of the patient. HD, high-definition.

Fig. 2 View of the operating room setup. The pneumatic arm arches over the patient's head and rigidly holds the endoscope in place, allowing the surgeon to operate with bimanual dexterity. The HD monitor is strategically placed to allow the surgeon to easily view the screen while operating. HD, high-definition

two to three fingerbreadths behind the ear. The transverse sinus is approximated by marking a line from the ipsilateral zygomatic root to the external occipital protuberance, while creating a line parallel and lateral to the posterior mastoid groove localizes the sigmoid sinus. The intersection of these lines represents the approximate location of the transverse-sigmoid (TS) junction. The incision is then marked with a 2 to 3 cm linear line that is parallel, but posterior, to the hairline, transecting the TS junction, as demonstrated in ►**Fig. 3**. Electrodes are then placed for cranial nerve VII monitoring as well as brainstem auditory evoked potentials. Maximal cerebellar relaxation is obtained by infusing 1 to 2 g/kg mannitol, 20 mg furosemide, and lowering the $Paco_2$ to 28 mm Hg.

Operative Detail

A small, 2 cm, linear incision is made over the previously marked site. Monopolar cautery is used for soft tissue dissection, with bone wax utilized to obtain hemostasis from bleeding emissary veins. The asterion and the occipitomastoid suture should be located and exposed. A high-speed drill is then used to create a 14-mm craniectomy inferior to the asterion and one-third anterior, two-thirds posterior to the occipitomastoid suture until the TS junction is exposed (►**Fig. 4**). Drilling should start in the posteroinferior corner and performed in a superolateral fashion to avoid injury to the sinuses. Once the TS junction is appropriately skeletonized, the dura is opened sharply in a curvilinear fashion, adjacent to the TS junction, allowing for the dural flap to be reflected in a posteromedial direction. A 4 mm 0-degree endoscope is then cannulated along the junction of the petrous temporal bone and tentorium. Continuous suctioning of CSF allows for further relaxation of the cerebellum, thereby enlarging the operative corridor in the CPA. As the corridor grows from CSF egress, the endoscope is slowly advanced until the petrosal vein is encountered. We routinely cauterize and cut the petrosal vein, creating an unobstructed view of the CN VII/

Fig. 3 A line is drawn from the root of the zygoma to the external occipital protuberance, estimating the transverse sinus. Another line is drawn just posterior to the mastoid groove, estimating the sigmoid sinus. The intersection of these two lines approximates the TS junction, an important landmark in this procedure. TS, transverse-sigmoid.

Fig. 4 A 14-mm craniectomy is performed, skeletonizing the TS junction in the superolateral corner of the cranial defect. A US quarter is placed in the field for size reference. TS, transverse-sigmoid; US, ultrasound.

VII complex. At this point, the 0-degree endoscope can be exchanged for the 30-degree endoscope which allows the surgeon to visualize ventral to CN VIII, locating the precise location of CN VII and nervus intermedius along with their relationship to CN VIII. The 30-degree endoscope is then exchanged back to the 0-degree endoscope for the remainder of the operation. Once the endoscope is appropriately

positioned, a cleavage plane is found and developed, separating the vestibular and cochlear nerves. Once adequate separation has been obtained, the vestibular nerve is sharply sectioned with extreme care to avoid damage to the nearby CN VII (►Fig. 5). The use of stimulating instruments also assists in identification of the facial nerve. After adequate sectioning, meticulous hemostasis is obtained and the endoscope is removed. The dura is closed in a watertight fashion, bone cement is used to fill the craniectomy defect, and the skin is closed in layers with absorbable suture.

Results

Among the 41 patients, 15 were males (36.5%) and 26 were females (63.5%). The mean age at the time of surgery was 50.1 years with a range of 22 to 81 years. The side of surgery was nearly evenly split with 21 patients (51%) undergoing surgery on the right side while 20 patients (49%) underwent left-sided surgery. Resolution or improvement of symptoms was seen in 38 of 41 patients (92.7%), with 23 patients (56.1%) stating complete resolution and 15 patients (36.6%) reporting improvement. Only one patient (2.4%) reported worsened symptoms after surgery, while two patients (4.9%) stated that they had no change.

Pre- and postoperative clinical data are listed in ►Tables 1 to 5. All 41 patients maintained intact facial nerve function, HB 1/6, postoperatively. In addition, 34 patients (82.9%) were found to have stable or improved hearing on postoperative audiometric testing, scored on

Table 1 Committee on hearing and equilibrium guidelines for the evaluation of hearing preservation in acoustic neuroma classification system (AAO-HNS grade)

Class	PTA (dB)	WRS (%)
A	≤ 30	> 70
B	> 30, ≤ 50	≥ 50
C	> 50	≥ 50
D	Any level	< 50

Abbreviations: AAO-HNS, American academy of otolaryngology-head and neck surgeons hearing classification system; PTA, pure-tone average; WRS, word recognition score.

Table 2 Gardner–Robertson-modified hearing classification

Class	Description	PTA (dB)	WRS (%)
I	Good to excellent	0–30	70–100
II	Serviceable	31–50	50–69
III	Nonserviceable	51–90	5–49
IV	Poor	91–maximum	1–4
V	None	Not testable	0

Abbreviations: PTA, pure tone audiometry; WRS, word recognition score.

both the AAO-HNS and GR scales. Among this group, 31 patients (75.6%) had stable hearing, while 3 patients (7.3%) were found to have improved hearing. Seven patients (17.0%) were found to have worsened hearing after surgery;

Fig. 5 (A) Intraoperative endoscopic view of CN VIII demonstrating the cleavage plane between the vestibular and cochlear nerves. (B) CN V is visible in the background. (C) The vestibular nerve has been carefully dissected and separated from the cochlear nerve. (D) The vestibular nerve being sectioned. The vestibular nerve has been fully sectioned, while the cochlear nerve remains intact. CN VII is slightly visible ventral to the CN VIII complex. CN, cranial nerve.

Table 3 Patient characteristics

Total patients	41
Age (y)	
Mean	50.1
Range	22–81
Gender	
Male	15 (37%)
Female	26 (63%)
Side of symptoms	
Right	21 (51%)
Left	20 (49%)

however, five of these patients did maintain “serviceable” hearing based upon the two hearing scales.

The mean operative time for the fully endoscopic procedure was 114.0 minutes with a range of 87 to 157 minutes. Estimated blood loss was minimal in the majority of cases, averaging 22.3 mL and ranging from 5 to 50 mL. The average length of hospital stay was 3.7 days, ranging from 2 to 7 days. A majority of these patients remained hospitalized due to transiently worsened vertiginous symptoms after surgery; however, all demonstrated rapid vestibular compensation over the first few postoperative days. Three patients (7.3%) suffered postoperative complications; however, two of these were minor complications: a CSF leak that was treated and resolved with a lumbar drain and a superficial wound infection that was treated with oral antibiotics. One patient (2.4%), however, re-presented with an intracranial abscess adjacent to the surgical site. This patient underwent a craniotomy for evacuation of the abscess and long-term antibiotic care with a full recovery to baseline neurological function. Zero patients suffered from postoperative CN palsies other than hearing loss.

Discussion

Meniere disease is a chronic ear disorder that creates intermittent vertiginous symptoms in middle-aged adults.^{1–5} Medical therapy remains the first-line treatment for this disorder, with nondestructive procedures such as endolymphatic sac surgery and intratympanic steroids providing effective second-line modalities.^{6,7} While these treatments have proven to be highly effective in Meniere disease, some patients have symptoms that remain refractory. It is these select patients that are candidates for ablative techniques such as intratympanic gentamycin and VNS, which preserve hearing, or labyrinthectomy, a hearing sacrificial procedure.

McKenzie and Dandy first introduced the VNS procedure through a suboccipital approach in the 1930s,²⁸ however, this technique fell out of favor when House detailed performing VNS via a middle cranial fossa technique.²⁹ A high rate of facial nerve paralysis and hearing loss,^{1,2,12,30} however, led to the development of VNS via the retrolabyrinthine approach. A

high rate of CSF leaks, however, popularized the retrosigmoid approach for VNS.¹⁵

Traditionally, CPA surgery is done almost exclusively via traditional open surgery utilizing the operative microscope for visualization. This technique, however, has several limitations in posterolateral skull base surgery. The linear light source of the operative microscope, located outside of the surgical field, creates significant difficulty for surgeons trying to optimally visualize the various and essential neurovascular structures of the CPA. As a result, skull base surgeons are forced to compensate for this shortcoming by creating larger cranial openings, requiring more soft tissue dissection, along with some degree of cerebellar retraction which can cause significant postoperative ataxia and morbidity. In addition, even with these compromises, visualization of structures ventral to pathology remains difficult. This can be especially hazardous for facial nerve preservation as CN VII sits ventrally to CN VIII, often the location of CPA pathology.

In the 1990s, several authors began studying the role of endoscopy in the CPA. Many reported improved visualization of the CPA neurovasculature via the surgical endoscope in comparison to the operative microscope.^{16–23} Miyazaki et al first introduced the endoscope to the VNS procedure in 2005 when he reported his endoscopic-assisted technique with good results and a low complication rate.²⁴

Recently, the fully endoscopic approach to CPA pathology has begun to be reported. This technique is performed with the endoscope alone; the operative microscope is not used at any point. Several authors have published success in performing microvascular decompressions in the CPA with the fully endoscopic technique.^{31–35} In addition, CPA tumors, such as vestibular schwannomas, meningiomas, and epidermoid cysts, have also been successfully resected via the fully endoscopic technique, without the operative microscope.^{36–45}

In 2012, Culter et al described a technique of fully endoscopic VNS in a series of 11 patients.²⁵ To our knowledge, this was the first fully endoscopic VNS report, however, the operative microscope was brought in for 5 of the 11 patients in this study. Nonetheless, 10 out of the 11 patients (91%) had improvement in vertiginous symptoms at follow-up with 1 patient (9%) suffering from a facial nerve palsy, HB 3/6, after surgery.

Our results are similar and, in some cases, more successful than the current reports of the traditional open VNS in the literature. A total of 38 of the 41 patients (93%) in our study demonstrated either complete resolution or improvement in vertigo symptoms at follow-up. In addition, all 41 patients (100%) retained full facial nerve function. While 7 of 41 patients (17%) had decreased hearing results after surgery, only two patients (4.8%) went from preoperative “serviceable” hearing to postoperative “nonserviceable” hearing. Our complication rate was low with only one CSF leak (2.4%), which was treated and resolved with a lumbar drain, and two infections (4.8%), one of which was superficial and did not require surgical intervention.

In our experience, the surgical endoscope provides improved visualization of CPA neurovasculature and pathology. As a result, we perform all VNS procedures in a fully endoscopic fashion as

Table 4 Patient data

Patient	Symptoms	Complication	Preop AC PTA (dB)	Preop WRS (%)	Preop AAO-HNS grade	Preop GR class	Postop AC PTA (dB)	Postop WRS (%)	Postop AAO-HNS grade	Postop GR class	Preop House-Brackman score	Postop House-Brackman score
1	Resolved	None	25	84	A	I	30	80	A	I	1/6	1/6
2	Resolved	None	5	96	A	I	5	96	A	I	1/6	1/6
3	Improved	None	40	82	B	II	50	72	B	II	1/6	1/6
4	Improved	None	30	88	A	I	30	84	A	I	1/6	1/6
5	Improved	None	10	96	A	I	15	92	A	I	1/6	3/6
6	Resolved	None	50	60	B	II	50	92	B	II	1/6	1/6
7	Resolved	None	25	88	A	I	20	92	A	I	1/6	1/6
8	Improved	None	60	60	C	III	75	72	C	III	1/6	1/6
9	Resolved	None	5	100	A	I	5	100	A	I	1/6	1/6
10	Improved	None	20	96	A	I	20	96	A	I	1/6	1/6
11	Resolved	None	5	100	A	I	5	100	A	I	1/6	1/6
12	Resolved	None	40	96	B	II	25	96	A	I	1/6	1/6
13	Improved	None	10	72	A	I	10	72	A	I	1/6	1/6
14	Resolved	None	10	100	A	I	5	96	A	I	1/6	1/6
15	Improved	None	35	84	B	II	75	8	D	IV	1/6	1/6
16	Resolved	Infection	50	96	B	II	70	64	C	III	1/6	1/6
17	Improved	None	60	72	C	III	65	72	C	III	1/6	1/6
18	Resolved	None	25	100	A	I	25	100	A	I	1/6	1/6
19	Resolved	None	50	96	B	II	50	88	B	II	1/6	1/6
20	Improved	None	10	92	A	I	10	92	A	I	1/6	1/6
21	No change	None	55	76	C	III	50	96	B	II	1/6	1/6
22	No change	CSF Leak	20	96	A	I	15	96	A	I	1/6	1/6
23	Resolved	None	30	90	A	I	30	90	A	I	1/6	1/6
24	Resolved	None	55	92	C	III	50	90	B	II	1/6	1/6
25	Resolved	None	65	72	C	III	60	64	C	III	1/6	1/6
26	Resolved	None	5	100	A	I	25	96	A	I	1/6	1/6
27	Resolved	Infection	30	100	A	I	40	100	B	II	1/6	1/6

Table 4 (Continued)

Patient	Symptoms	Complication	Preop AC PTA (dB)	Preop WRS (%)	Preop AAO-HNS grade	Preop GR class	Postop AC PTA (dB)	Postop WRS (%)	Postop AAO-HNS grade	Postop GR class	Preop House- Brackman score	Postop House- Brackman score
28	Resolved	None	15	100	A	I	20	100	A	I	1/6	1/6
29	Resolved	None	5	96	A	I	5	96	A	I	1/6	1/6
30	Improved	None	25	100	A	I	60	84	C	III	1/6	1/6
31	Improved	None	30	84	B	I	50	64	B	II	1/6	1/6
32	Improved	None	15	88	A	I	15	92	A	I	1/6	1/6
33	Resolved	None	25	100	A	I	45	88	B	II	1/6	1/6
34	Improved	None	30	92	A	I	15	100	A	I	1/6	1/6
35	Resolved	None	5	96	A	I	30	88	A	I	1/6	1/6
36	Resolved	None	40	96	B	II	40	96	B	II	1/6	1/6
37	Improved	None	5	100	A	I	5	96	A	I	1/6	1/6
38	Resolved	None	50	84	B	II	55	88	C	III	1/6	1/6
39	Worsened	None	10	100	A	I	10	100	A	I	1/6	1/6
40	Resolved	None	60	36	C	III	55	64	C	III	1/6	1/6
41	Improved	None	20	96	A	I	10	92	A	I	1/6	1/6

Abbreviations: AC, Air conduction; AAO-HNS, American academy of otolaryngology-head and neck surgeons hearing classification system; GR, Gardner-Robertson; PTA, pure-tone average; Preop, preoperative; Postop, postoperative; WRS, word recognition score.

Table 5 Operative details

Operative time	
Mean	114.0 min
Range	87–157 min
Estimated blood loss	
Mean	22.3 mL
Range	5–50 mL
Length of hospital stay (d)	
2	2
3	19
4	12
5	6
6	1
7	1
Mean	3.7

this technique allows us to visualize the location of CN VII, ventral to CN VIII, and its relationship to the vestibular nerve. After obtaining this information, we can proceed with the VNS with more confidence in facial nerve will not be damaged, something that has not happened to date. In addition, the improved visualization with the endoscope allows for the complete elimination of cerebellar retraction, reduces craniotomy size, and lessens the amount of soft tissue dissection, thereby decreasing potential morbidity.

The fully endoscopic technique, however, does not come without limitations. First, surgeons must have experience and comfort with the endoscope and pneumatic holding arm as inadvertent movement could have catastrophic results in CPA due to the valuable nature of the surrounding structures. We recommend cadaveric training in this technique before implementation into practice. In addition, traditional bayonet-style surgical instruments are difficult to use in such a small, long operative corridor. As a result, we recommend converting to instrumentation based on a rotational pistol-grip style. Finally, preoperative imaging must be carefully studied to ensure that the surgeon will have an adequate amount of CSF to release, without which an inappropriately small operative corridor will exist between the cerebellar hemisphere and adjacent petrous bone, rendering the approach impossible.

Conclusion

Fully endoscopic VNS is a safe and highly effective treatment modality for medically refractory Meniere disease. This procedure provides surgeons improved visualization of CPA neurovasculature while reducing soft tissue dissection, craniotomy size, and completely eliminating cerebellar retraction. While clinical results have been demonstrated to be positive, future studies involving a larger patient volume would be beneficial. In addition, we encourage skull base surgeons to become increasingly versed in utilizing endoscopy to treat CPA pathology.

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