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Endoscope-Assisted Vestibular Neurectomy

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***Objective/Hypothesis:* In some instances endoscopes offer better visualization than the microscope and frequently allow less invasive surgery. This study was undertaken to determine whether endoscopy is safe and effective during neurectomy of the vestibular nerve. *Method:* Ten patients with intractable unilateral Meniere's disease underwent a retrosigmoid craniotomy for neurectomy of the vestibular nerve. Endoscopy with a Hopkins telescope was used during each procedure to study posterior fossa anatomic relationships and to assist the neurectomy. Preoperative and postoperative audiometric evaluation was performed in all patients undergoing vestibular neurectomy. Nine of these patients had preoperative electronystagmography, and four patients completed postoperative electronystagmography. The 1995 American Academy of Otolaryngology—Head and Neck Surgery's Committee on Hearing and Equilibrium guidelines for the diagnosis and evaluation of therapy in Meniere's disease were used. *Results:* Complete neurectomy was achieved in all 10 patients. Endoscopy allowed improved identification of the nervus intermedius and the facial, cochlear, and vestibular nerves and adjacent neurovascular relationships without the need for significant retraction of the cerebellum or brainstem. In addition, endoscopic identification of the cleavage plane between the cochlear and vestibular nerves medial to or within the internal auditory canal (n = 3) was not made with the 0-degree endoscope; however, identification was made with the 30- or 70-degree endoscope in all cases. In all patients with Meniere's disease, elimination of the recurrent episodes of vertigo (n = 10) or otolithic crisis of Tumarkin (n = 1) was achieved. *Conclusions:* Posterior fossa endoscopy can be performed safely. Endoscope-assisted neurectomy of the vestibular nerve may offer some advantages over standard microsurgery including increased visualization, more complete neurectomy, minimal cerebellar retraction, and a lowered risk of cerebrospinal fluid leakage.**

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INTRODUCTION

The rationale for unilateral deafferentation of a dysfunctional vestibular labyrinth is that the central nervous system is better able to compensate for a complete loss of vestibular function than a fluctuating partial loss. The single most common peripheral vestibular disorder requiring vestibular neurectomy is Meniere's disease, although the vast majority of these patients are successfully managed with medical therapy.[1,2] Rarely, recurrent vestibular neuronitis or traumatic labyrinthitis requires unilateral ablation of vestibular function to achieve compensation. Vestibular neurectomy has the advantage of preserving hearing, when patients have useful cochlear function. A survey of the American Otological Society and the American Neurotology Society performed nearly a decade ago revealed that almost 3000 vestibular neurectomies had been performed in the United States since the introduction of the operating microscope.[3] Contraindications to vestibular neurectomy include bilateral peripheral vestibular disease, vertigo from an only hearing ear, and indications of central nervous system disease such as multiple sclerosis, physiologic old age, and poor medical condition. Additional clinical consideration should be given before ablative surgical procedures in elderly patients, since they have more difficulty in compensating; however, destructive vestibular procedures remain an important treatment option for the elderly patient disabled by vertigo of peripheral origin. There are distinct advantages to each surgical approach and these are briefly reviewed in the context of the application of endoscopic techniques to this procedure.

Charcot, who was a contemporary of Prosper Ménière and director of a famous neurologic clinic in Paris, first suggested intracranial division of the auditory nerve to eliminate the symptoms of Meniere's disease in 1874. However, it was not until October 6, 1908, in Philadelphia, that Frazier[4] completed this procedure in a patient with persistent aural vertigo. A passage from the report of Frazier[4] summarizes the critical issue in the surgical management of patients with Meniere's disease: "Before this

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operation is undertaken in the future one should determine by every means of precision whether the case falls in the category for which this form of treatment is especially applicable." It was Walter Dandy[5] (Fig. 1) who first recognized that selective neurectomy of the vestibular nerve was possible: "In one of the patients the vestibular and cochlear branches of the auditory nerve were separate and distinct. Such an anatomic variation would lend itself to division of the vestibular nerve without injuring the cochlear nerve and the hearing." McKenzie[6] of Montreal was the first to selectively section the vestibular nerve while preserving hearing in July 1932. Hugh Cairns of London performed a similar operation in February 1933, and Dandy performed this selective neurectomy in March 1933.[7,8] However, Dandy popularized the procedure, performing 607 neurectomies in 587 patients with Meniere's disease between 1924 and 1946.[8] The use of the middle cranial fossa approach to section the vestibular nerve was first reported in 1904.[9] There have been numerous advances in the surgical deafferentation of the peripheral vestibular system, and for a broader perspective the reader is referred to a recent review of this topic.[10]

Endoscopic techniques have revolutionized the practice of surgery in a number of specialties. This is evident when one looks at the impact of endoscopy in otolaryngology,[11] neurosurgery,[12] laparoscopy in abdominal surgery, arthroscopy in orthopedic surgery, and thoracoscopy in cardiothoracic surgery. In many situations smaller incisions and exposures are possible, resulting in decreased postoperative pain, shorter recuperation, better cosmetic results, and shorter hospitalizations. Endoscopes have the ability to provide high magnification and illumination of the operative field; however, in contrast to the operative microscope, the endoscopic view is not limited to the linear line of sight. Thus, with flexible and angled endoscopes one can look "around corners," past obstructing tissue and structures. Initial reports of endoscope-assisted otologic and neurotologic surgery have been published, and the limits of these techniques are continuing to be explored.[13–17] This report describes the use of endoscopes during surgery for neurectomy of the vestibular nerve.

Fig. 1. Walter Edward Dandy (1885–1946). Emil Seletz sculpture of Dandy.

MATERIALS AND METHODS

Patients

Ten patients with intractable unilateral Meniere's disease (Table I) underwent a retrosigmoid craniotomy for neurectomy of the vestibular nerve. Endoscopy with a Hopkins telescope was used during each procedure to study posterior fossa anatomic relationships and to assist the neurectomy. Inclusion criteria for the sequential patients reported included a minimum of 6 months of follow-up data. Preoperative and postoperative audiometric evaluation was performed in all patients undergoing vestibular neurectomy. Nine of these patients had preoperative electronystagmography (ENG), and four patients completed postoperative ENG. The 1995 American Academy of Otolaryngology—Head and Neck Surgery's Committee on Hearing and Equilibrium guidelines for the diagnosis and evaluation of therapy in Meniere's disease were used (Tables I–V).[18]

Operative Technique: Vestibular Neurectomy

Each patient was positioned supine with the head turned in the opposite direction of the affected ear. After 1 g/kg mannitol and 10 mg dexamethasone (Decadron) were administered intravenously, hyperventilation was performed to achieve maximum cerebellar relaxation. A 4- to 6-cm linear skin incision was made approximately 10 to 15 mm posteromedial from the estimated position of the sigmoid sinus extending caudally for 6 cm, beginning at the level of the transverse sinus. After incising the nuchal muscles and elevating the periosteum, a single Adson cerebellar retractor was placed into the wound. A retrosigmoid (suboccipital) approach was performed in all patients. The diameter of the craniotomy was 18 to 25 mm (Fig. 2B). After the craniotomy or craniectomy was performed, the dura was opened parallel to the transverse and sigmoid sinuses and secured to the adjacent soft tissue. The cerebellum was gently elevated to expose the cisterna magna, that upon opening allowed release of cerebrospinal fluid (CSF). The lateral surface of the cerebellum was protected by placement of moist cottonoids before retracting it medially exposing the cerebellopontine angle (CPA) and the vestibulocochlear nerve/facial nerve complex (Fig. 2C). The cerebellum was maintained in this position by gravity or by means of a small Greenberg retractor blade.

A three-chip camera was attached to the lens of the endoscope, and the image was displayed on a 19-inch video monitor and captured on a S-VHS recorder or a digital dye-sublimation printer. In all patients an initial examination was performed with the rigid Hopkins rod endoscopes (4 mm, 0 degrees; 2.7 or 4 mm, 30 degree; Karl Storz, Culver City, CA). Specific attention was paid to cranial nerves V–XI, the internal auditory canal (IAC), and the vascular anatomy (Fig. 2C). Identification of the cleavage plane between the cochlear and vestibular nerves was sought, and in those cases where this division was not evident, 30- or 70-degree endoscopes were used to identify this plane within the IAC (Fig. 2D). In no case was a transmeatal approach (opening the IAC) required. The surgical microscope was in the operating room and available for use if needed.

In patients with useful preoperative hearing, intraoperative auditory brainstem evoked response monitoring was performed, and in all patients, unilateral needle electromyography of the obicularis oris and oculi muscles was performed. A neurotologist and a neurosurgeon team (P.A.W./W.A.K. or D.S.P./F.G.B.) performed each procedure. If adequate visualization of the vestibulocochlear nerve and facial nerve complex was possible, the remainder of the vestibular neurectomy was performed with one of the co-surgeons holding the endoscope while the other co-surgeon identified the vestibular nerve and completed the neurectomy. As an alternative, an articulated endoscope holder (Codman, Randolph, MA) was used while performing the neurec-

TABLE I.
Raw Data of Meniere's Disease Patients Undergoing Vestibular Neurectomy (AAO-HNS, 1995 Reporting Criteria).

			FV/HT/WR/FL/C					Electronystagmography (Canal Paresis)*	
Patient No.	Stage	Age(y)/Sex/Side	Baseline	6 Mo	12 Mo	18–24 Mo	30 Mo	Preop (%)	Postop (%)
1	4	49/F/AD	5/88/0/4	0/88/0/1	0/85/0/1	0/85/0/1/A	0/90/0/1/A	44	100
2	1	56/F/AS	10/20/100/6	0/20/92/1	0/15/96/1	0/22/100/1/A	0/25/100/1/A	82	100
3	2	62/F/AS	4/30/88/5	0/27/84/3	0/40/84/1	0/38/86/1/A	—	73	100
4	1	43/F/AS	18/5/100/5	0/10/96/1	0/10/92/1	—	—	26	100
5	3	34/F/AD	5/60/44/5	0/60/36/2	—	—	—	29	NA
6	4	55/F/AS	3/75/20/4	0/72/20/1	—	—	—	0	NA
7	3	34/F/AD	2/63/44/4	0/56/40/1	—	—	—	0	NA
8	1	60/F/AS	4/23/92/6	0/24/88/2	0/34/92/1	—	—	90	NA
9	3	36/F/AD	12/45/78/4	0/45/80/1	0/35/88/1	0/63/50/1/A	—	38	NA
10	3	45/M/AS	2/49/84/4	0/48/84/1	0/38/84/1	0/44/90/1/A	—	NA	NA

* Canal paresis of affected ear, calculated following caloric irrigation.
AD = auris dexter; AS = auris sinister; FV = frequency of vertigo, definitive episodes per month for the previous 6 mo; HT = hearing thresholds, pure-tone average in decibels; WR = word recognition (speech discrimination) in percent; FL = functional level (1–6); C = class (after neurectomy); NA = not available.

tomy (Fig. 2A). The vestibular nerve was visually identified, and the location of the facial nerve was confirmed by stimulating the nerve with 0.05 mA current and recording the electromyographic activity of the obicularis oculi and oris muscles. The vestibular nerve was then sharply sectioned. While retracting the vestibular nerve using the microsuction instrument in a lateral to medial direction, the vestibular nerve was again sectioned, completing the neurectomy (Fig. 2E and F). After closure of the dura, hydroxyapatite cement cranioplasty (Leibinger, Dallas, TX) or methylmethacrylate cranioplasty was performed and the wound closed in layers.

RESULTS

Complete neurectomy was achieved in all 10 patients (Fig. 2; Table I). Endoscopy allowed improved identification of the nervus intermedius and the facial, cochlear, and vestibular nerves and adjacent neurovascular relationships without the need for significant retraction of the cerebellum or brainstem. In addition, endoscopic identification of the cleavage plane between the cochlear and vestibular nerves medial to or within the IAC (n = 3) was not seen with the 0-degree endoscope; however, they were identified with the 30- or 70-degree endoscope in all cases (Fig. 2D). After identifying the cleavage plane between the cochlear and vestibular nerves within the IAC, it was developed medially before neurectomy. Vascular loops and branches of the anterior inferior cerebellar artery (AICA) passing into the IAC were also better appreciated. In all patients with Meniere's disease, elimination of the recurrent episodes of vertigo (n = 10) or otolithic crisis of Tumarkin (n = 1) was achieved (Table I). One of the patients (patient 2) experienced episodes of recurrent vertigo or otolithic crisis of Tumarkin before to vestibular neurectomy. All patients who underwent postoperative ENG (n = 4) were found to have complete vestibular deafferentation. None of the patients experienced postoperative CSF leakage. No patient experienced postoperative headache or facial nerve dysfunction.

DISCUSSION

Vestibular Neurectomy

The advantages and limitations of the various approaches to vestibular neurectomy have recently been reviewed.[19] These approaches include the middle cranial fossa (MCF) and the posterior fossa approaches, which include a number of variations such as the retrolabyrinthine (RL) approach, the retrosigmoid-internal auditory canal (RSG-IAC) approach, and the combined retrolabyrinthine-retrosigmoid (RL-RS) approach.[3,20] The MCF approach provides the only exposure that allows resection of the primary afferent vestibular ganglia. This accomplishes two goals: complete deafferentation of the vestibular periphery while preserving auditory function and elimination of the possibility of vestibular nerve regeneration. There are two significant advantages of posterior fossa over MCF vestibular neurectomy: decreased risk of facial nerve injury and hearing loss. There are two principal disadvantages to posterior fossa vestibular neurectomy: first, the vestibular nerve fibers co-mingle with cochlear nerve fibers proximal to Scarpa's ganglia and, consequently, it is possible to have an incomplete vestibular deafferentation or a partial hearing loss[21,22]; and second, with sectioning the vestibular nerve the potential for regeneration exists, whereas with the MCF vestibular neurectomy, resection of the primary afferent somata within Scarpa's ganglia eliminates any possibility of regeneration.[23,24] We resect a segment of the vestibular nerve (Fig. 2E and F) in order to avoid this possibility. In contrast to the 98% elimination of vertigo reported after MCF vestibular neurectomy,[25] 90% to 92% of patients undergoing posterior fossa vestibular neurectomy are relieved of vertigo.[3,20] This difference may reflect imperfect patient selection or incomplete transection of the vestibular nerve.

The incidence of early CSF leakage in vestibular neurectomy is reported to be approximately 10%.[3] The

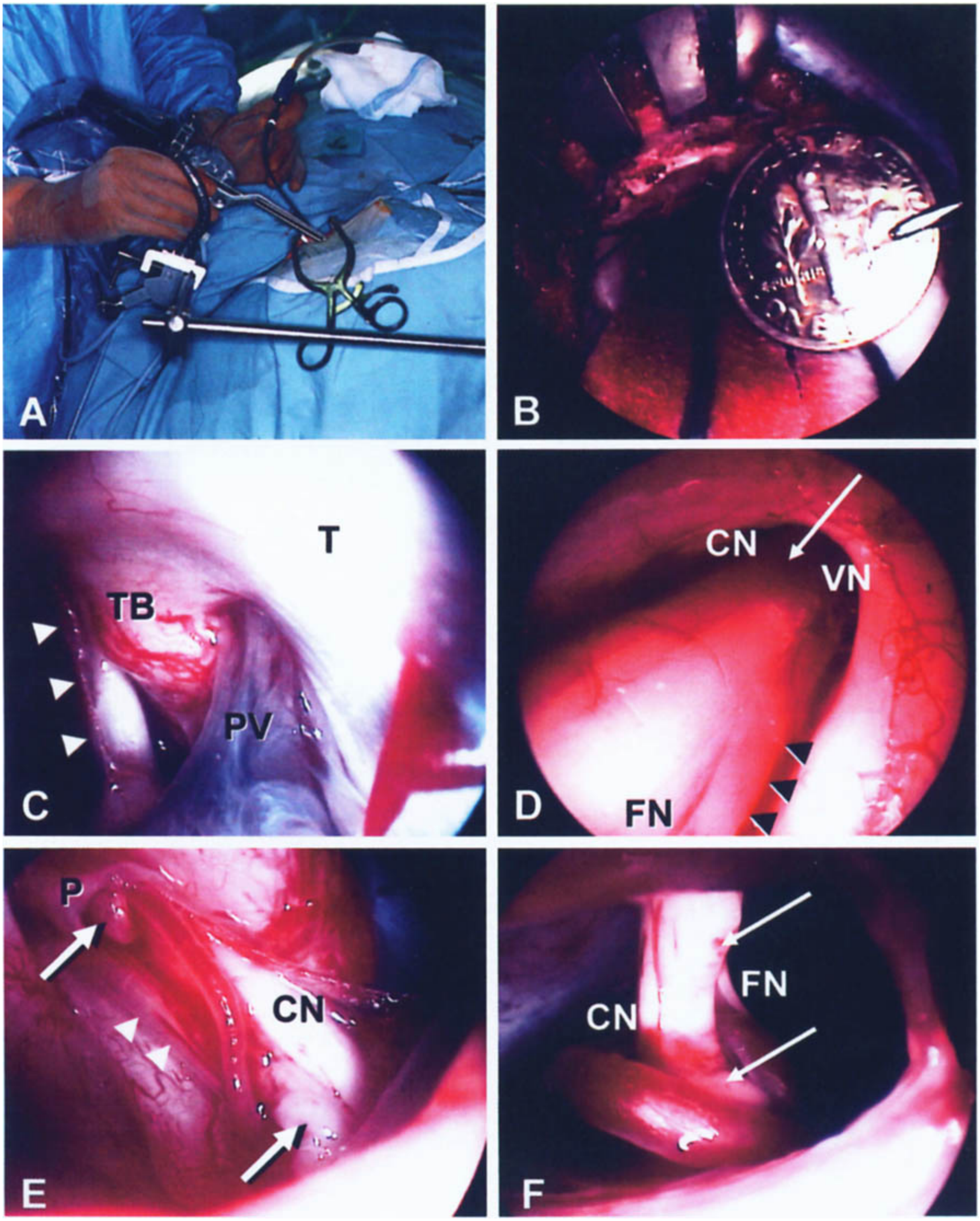

Fig. 2. Endoscopic vestibular neurectomy for Meniere's disease. **(A)** With the use of an articulated endoscope holder, the operating surgeon is free to use both hands in performing the neurectomy. **(B)** The retrosigmoid craniectomy can be as small as the diameter of a sterilized dime. **(C)** An initial survey is performed with a 0-degree endoscope to gain orientation within the posterior fossa. Arrowheads = seventh and eighth nerve complex; T = tentorium; TB = posterior face of the temporal bone; PV = petrosal vein forming the superior petrosal sinus. **(D)** When a cleavage plane cannot be identified medial to the internal auditory canal (IAC), a 30-degree (or 70-degree) endoscope can be used to identify the cleavage plane (arrow) between the cochlear nerve (CN) and the vestibular nerve (VN) within the IAC. The endoscope was placed at the porus acusticus (seen at bottom right, posterosuperior quadrant of IAC, below the nerve complex); however, the lateral lip of the porus (top right) appears much farther away, because of the optical illusion of distance produced by the 30-degree endoscope. Arrowheads = nervus intermedius; FN = facial nerve. **(E)** The cut ends of the vestibular nerve (bold arrows) are seen via a 30-degree endoscope beneath a large branch of the anterior inferior cerebellar artery (AICA) looping through the porus acusticus (P) into the IAC. Arrowheads = facial nerve. **(F)** A 0-degree endoscopic view following vestibular neurectomy shows the cut ends of the vestibular nerve (arrows) and the CN. Multiple looping branches from the AICA are seen, one of which separates the CN and VN from the FN.

RSG-IAC approach has been associated with postoperative headache (described as severe) in 75% of patients.[3,26] The etiology of the headache is unclear, although bone dust has been suspected.[3,26] Both of these issues are related to opening the IAC, and with the procedure reported in the current study this transmeatal approach is not needed.[27] It should be emphasized, however, that we are reporting a small series of patients and it may be necessary to open the IAC in some cases, should the cleavage plane between the cochlear and vestibular nerves not be seen using the 30- or 70-degree endoscopes within the IAC.

Endoscope-Assisted Neurectomy

Endoscopy offers several distinct advantages over the operating microscope that make it an excellent adjunctive tool during cranial base microsurgery. The high magnification gives excellent definition of perforating blood vessels, cranial nerves, and neural structures, which in many cases is superior to that achieved with the microscope. Furthermore, the use of angled or flexible endoscopes allows one to look around corners and behind anatomic structures blocking the view seen via a 0-degree microscope. Endoscopy also has the theoretical advantage that a smaller operative procedure is required, which should reduce the operative morbidity.

There are several notable disadvantages of endoscopy. These include the problems associated with blood soiling the endoscope, making visualization difficult or impossible; the lack of readily available instrumentation designed specifically for endoscopic neurotology; and the poor overview of the operative field. This last point is an important one, since the endoscope is placed adjacent to the lesion and does not at the present time allow one to look backwards to prevent injury to structures next to the shaft of the telescope. Furthermore, the surgeon must be cognizant of potential thermal injury to structures caused by the heat generated by the light source. The present endoscopic technology limits the image that the surgeon sees to two dimensions, which results in certain unique problems when operating in a three-dimensional milieu. Because of this, there is a steep learning curve to acquire endoscopic dexterity and three-dimensional orientation. Also, bimanual operating requires the use of an articulated endoscope holder or the commitment of the co-surgeon to hold the endoscope.

There are additional limitations of endoscopic vestibular neurectomy. First, there is the lack of a significant true or expandable space through which one can manipulate multiple instruments. Second, it is necessary to navigate around the lattice of nerves and arteries present within the CPA. Third, instruments are usually not passed through working channels of the endoscope or portals as they are during intraventricular neuroendoscopic surgery,[12] but rather must be passed alongside the telescope. Because of these clinical problems, different endoscopic strategies and instruments, as described in the methods section, must be used.

Endoscope-assisted craniotomy is an extension of the concept of "keyhole," surgery which suggests that a strategically placed, small craniectomy, when combined with very high magnification and illumination, can offer excellent visual exposure of an intracranial lesion, sufficient to perform the necessary surgery (Fig. 2). The strategy is a valid one; with experience and a thorough understanding of the microsurgical anatomy, smaller incisions are possible and can be combined with minimized neural manipulation and retraction, thereby resulting in reduced operative morbidity. Although there are few proponents of these approaches, the procedures are likely to become popular as more neurotologists become comfortable working through progressively smaller cranial openings. With this specific application, the craniotomy size was decreased from 450 mm^2 (minimum retrosigmoid craniotomy,[26] excluding the addition of a mastoidectomy for the combined RL-RS approach) to 254 mm^2, or 56% of the original size.

One of the limitations of the operative microscope is that the angle of view is determined by the distance of the lens to the skull, retractor, or obstructing tissue, which is

TABLE II.
Diagnosis of Meniere's Disease (AAO-HNS, 1995 Reporting Criteria).

Certain Meniere's disease
Definite Meniere's disease, plus histopathologic confirmation
Definite Meniere's disease
Two or more definitive spontaneous episodes of vertigo 20 min or longer
Audiometrically documented hearing loss on at least one occasion
Tinnitus or aural fullness in the treated ear
Other causes excluded
Probable Meniere's disease
One definitive episode of vertigo
Audiometrically documented hearing loss on at least one occasion
Tinnitus or aural fullness in the treated ear
Other causes excluded
Possible Meniere's disease
Episodic vertigo of the Meniere's type without documented hearing loss, or
Sensorineural hearing loss, fluctuating or fixed, with disequilibrium but without definitive episodes
Other causes excluded

TABLE III.
Staging of Definite and Certain Meniere's Disease (AAO-HNS, 1995 Reporting Criteria).

Stage	Four-Tone average (dB)
1	≤ 25
2	26–40
3	41–70
4	>70

Staging is based on the four-tone average (arithmetic mean rounded to the nearest whole number) of the pure-tone thresholds at 0.5, 1, 2, and 3 kHz of the worst audiogram during the interval 6 mo before treatment. This is the same audiogram that is used as the baseline evaluation to determine hearing outcome from treatment. Staging should be applied only to cases of definite or certain Meniere's disease.

TABLE IV.
Functional Level Scale for Meniere's Disease (AAO-HNS, 1995 Reporting Criteria).

Regarding my current state of *overall* function, *not just during attacks* (check the ONE that best applies):

1. My dizziness has no effect on my activities at all
2. When I am dizzy I have to stop what I am doing for a while, but it soon passes and I can resume activities. I continue to work, drive, and engage in any activity I choose without restriction. I have not changed any plans or activities to accommodate my dizziness
3. When I am dizzy I have to stop what I am doing for a while, but it does pass and I can resume activities. I continue to work, drive, and engage in most activities I choose, but I have had to change some plans and make some allowance for my dizziness
4. I am able to work, drive, travel, take care of a family, or engage in most essential activities, but I must exert a great deal of effort to do so. I must constantly make adjustments in my activities and budget my energies. I am barely making it
5. I am unable to work, drive, or take care of a family. I am unable to do most of the active things that I used to. Even essential activities must be limited. I am disabled
6. I have been disabled for 1 year or longer and/or I receive compensation (money) because of my dizziness or balance problem

a function of the lens focal length; the longer the focal length, the narrower the viewing angle. During most microsurgical procedures the focal distance varies between 200 and 400 mm. Using the previous analogy, if one looks through a door's keyhole at close range, nearly the entire room on the opposite side of the door can be seen, although nothing can be seen when the hole is viewed from a long distance. This is similar to what happens when using the endoscope with focal lengths ranging from 5 to 20 mm: a wider angle of view can be achieved.

CONCLUSION

Based on our early experience, we believe that endoscopes can be used safely during retrosigmoid (suboccipital) surgery within the posterior fossa for neurectomy of the vestibular nerve. As an adjunct to or substitution for the operative microscope, this modality does improve visualization of bony, neural, and vascular structures while minimizing cerebellar retraction. Endoscopic exploration of the IAC in cases where the cleavage plane between the cochlear and vestibular nerves cannot be identified medial to the IAC, using the 30- or 70-degree endoscope, can demonstrate this cleavage plane, which can be developed medially before neurectomy, thus obviating a transmeatal approach and the increased risk of postoperative CSF leakage. Although not the primary goal of the present study, endoscopic techniques may allow less invasive surgery in selected patients with peripheral vestibular dysfunction requiring complete neurectomy in the future.

TABLE V.
Summary of Reporting Guidelines for the Class of Meniere's Disease (AAO-HNS, 1995 Reporting Criteria).

Numerical Value	Class
0	A (complete control of definitive spells)
1–40	B
41–80	C
81–120	D
> 120	E
Secondary treatment initiated due to disability from vertigo	F

Numerical value = (X/Y) × 100, rounded to the nearest whole number, where *X* is the average number of definitive spells per month for the 6 mo 18 to 24 mo after therapy and *Y* is the average number of definitive spells per month for the 6 mo before therapy.

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