MR of the endolymphatic duct and sac: findings in Menière disease.

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MR of the Endolymphatic Duct and Sac: Findings in Meniere Disease

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PURPOSE: To compare the visibility of the endolymphatic duct and sac on high-resolution MR images with the symptoms and clinical course in patients with Meniere disease. **METHODS:** Twenty-two patients with unilateral Meniere disease were sorted into two groups on the basis of the clinical stage of their disease at the time of imaging. Group 1 included patients in the acute phase, who presented with vertigo. Group 2 comprised patients in the nonacute phase of the disease, who were studied 9 days or more after an episode of vertigo. **RESULTS:** During acute attacks, the endolymphatic duct and sac were not adequately visible in the affected ear but were visible in the unaffected ear. During remission, the endolymphatic duct and sac were not observed in clinically advanced patients, but they were seen in patients in the early and intermediate stages. **CONCLUSION:** High-resolution MR imaging can be used to evaluate the endolymphatic duct and sac: visible abnormalities and lack of a visible endolymphatic duct and sac correlate with the clinical course of Meniere disease.

Index terms: Meniere disease; Temporal bone, magnetic resonance

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Histopathologic studies of the temporal bone region have revealed that endolymphatic hydrops is related to Meniere disease. Dysfunction of the endolymphatic sac has been implicated. These findings have been documented by pathologic studies of patients with Meniere disease (1–4) and by animal experiments (5, 6). The functioning of the endolymphatic sac is not completely understood. Multidirectional tomography (7) and high-resolution computed tomography (CT) (8) have been used to delineate the region, but this radiologic technique can only outline the bony canal of the vestibular aqueduct. High-resolution MR imaging with a surface coil and thin sections has recently enabled the endolymphatic duct, sac, and peripheral tissues in the vestibular aqueduct to be seen (9, 10). This imaging method seems helpful for understanding abnormalities of this region. Accordingly, we attempted to delineate the contents of the vestibular aqueduct of healthy subjects and of both ears in patients with unilateral Meniere disease.

Subjects and Method

Forty healthy subjects and 22 patients with Meniere disease (11 each in the acute and nonacute phases) were examined with three-dimensional Fourier transform (3DFT) gradient-echo magnetic resonance (MR) imaging. The patients with unilateral Meniere disease were sorted into two groups on the basis of the clinical stage of their disease at the time of imaging. Group 1 included six men and five women who had residual vertigo from a recent episode (acute phase). Group 2 included two men and nine women who did not have vertigo (nonacute phase). Meniere disease was diagnosed by the otolaryngologist using the criteria cited by Deatsch (11). Patients with a jugular bulb diverticulum were excluded, as this condition may cause symptoms resembling Meniere disease (12, 13).

A superconductive MR imager with a static magnetic field strength of 1.5 T and an 8-cm-diameter surface coil were used along with a 3DFT gradient-echo fast low-angle shot with a spoiler gradient (10, 14) and flow-compensation technique. Images were obtained with a flip angle of 24° or 25°, 100/10/2 (repetition time/echo time/excitations) (conditions for proton density–weighted imaging), a

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TABLE 1: Patients in group 1 (acute phase of Meniere disease)

Patient	Age, y/Sex	Time Since Onset of Disease	Grade	
			R Ear	L Ear
1	34/F	2 mo	1	3*
2	21/M	1 mo	3*	1
3	70/M	2 mo	1	3*
4	72/F	1 mo	1	3*
5	40/M	5 y	1	3*
6	55/F	3 mo	1	3*
7	72/F	1 y	3*	1
8	47/M	7 y	3*	1
9	54/M	4 mo	1	3*
10	74/F	4 y	3*	1
11	41/M	1 mo	1	3*

* Affected side.

TABLE 2: Patients in group 2 (nonacute phase of Meniere disease)

Patient	Age, y/Sex	Time Since Onset of Disease	Days from Current Attack to Imaging	Grade		Symptoms at Imaging
				R Ear	L Ear	
1	36/M	1 mo	14	1*	1	Asymptomatic
2	41/M	2 mo	9	1	1*	Asymptomatic
3	61/F	2 y	60	1*	1	Low-frequency hearing impairment and tinnitus
4	34/F	3 mo	47	1	2*	High-frequency hearing impairment and canal paresis
5	61/F	3 mo	60	1	1*	High-frequency hearing impairment and dizziness
6	35/F	4 mo	54	1*	1	Low-frequency hearing impairment and tinnitus
7	41/F	6 y	25	1	3*	Flat hearing impairment (45 dB) and tinnitus
8	34/F	5 y	25	1	3*	Flat hearing impairment (34 dB)
9	28/F	2 y	20	3*	1	Flat hearing impairment (60 dB), dizziness, and canal paresis on R
10	66/F	2 mo	32	1	3*	Flat hearing impairment (30 dB)
11	21/F	4 mo	50	1	2*	High-frequency hearing impairment

* Affected side.

matrix of 256 × 256 × 16, and a field of view of 12 to 15 cm. A section thickness of 1 mm was used, and the images obtained were enlarged 1.8- to 2.0-fold. Both ears, first the affected ear and then the unaffected ear, were imaged with the same technical parameters. Window width (1026 to 2240) and level (72 to 350) for hard-copy filming were selected for optimal visibility of the endolymphatic duct and sac on a case-by-case basis by the radiologic technologists, keeping both sides at nearly the same setting.

Images of the endolymphatic duct and sac were sorted into three categories: grade 1 represented delineation of signal within the vestibular aqueduct, grade 3 represented no visualization of signal in the region of the vestibular aqueduct, and grade 2 represented partial delineation.

The hard-copy images were analyzed independently in a blinded fashion by our observers: two radiologists and two otolaryngologists. Each observer assigned a numerical score of 1 to grade 1, 2 to grade 2, and 3 to grade 3. The scores for each ear were averaged and rounded to the nearest whole number to arrive at a final grade for that ear.

Results

The endolymphatic sac was fully visible in all healthy subjects (40 of 40). The grades assigned to the images and the clinical data for patients in group 1 are summarized in Table 1 and those of patients in group 2 are summarized in Table 2. Among patients in group 1, imaged during acute attacks, the endolymphatic sac was visualized in the unaffected ear in all 11 cases. The affected ear was not visualized. In group 2, hearing loss was uniform in all four patients with grade 3 images; there was high-frequency loss in both patients with grade 2

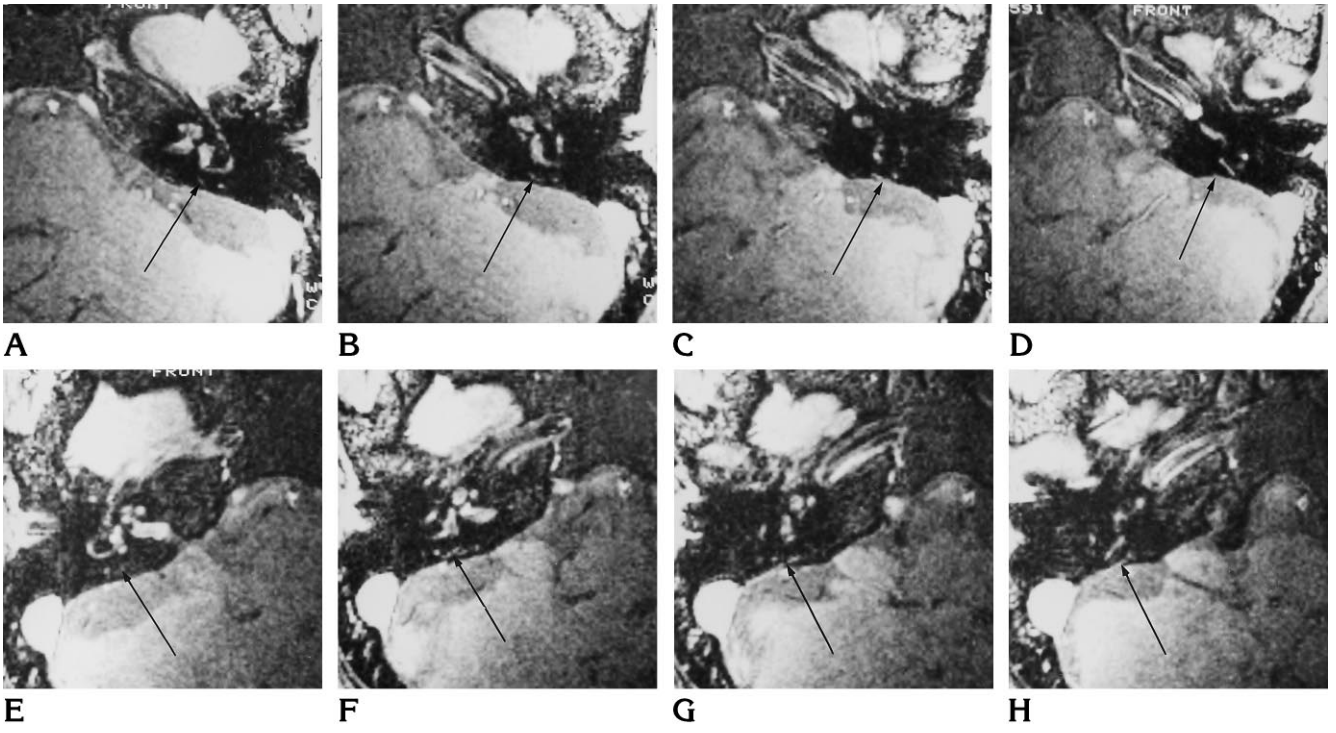

Fig 1. Grade 1 imaging findings in 61-year-old woman in nonacute phase of Meniere disease with high-frequency hearing loss. *A–D*, Affected left ear. *E–H*, Unaffected right ear. Bilateral endolymphatic sacs (*arrows*) are clearly visible.

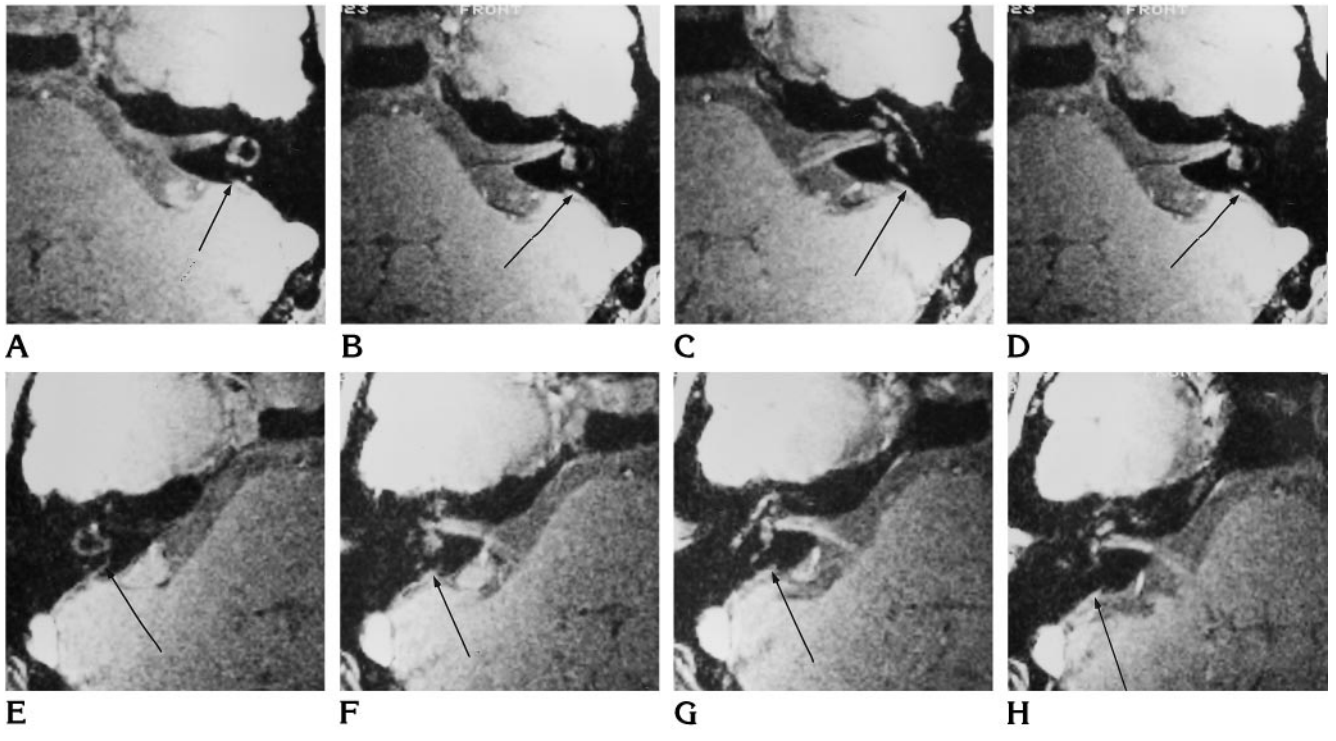

Fig 2. Grade 2 imaging findings in 34-year-old woman in nonacute phase of Meniere disease with high-frequency hearing loss. There is poor visibility of the contents of the vestibular aqueduct in the affected left ear (*A–D*) as compared with the unaffected right ear (*E–H*). *Arrows* show the endolymphatic duct and sac. Note difference in visibility between the affected side and the unaffected side.

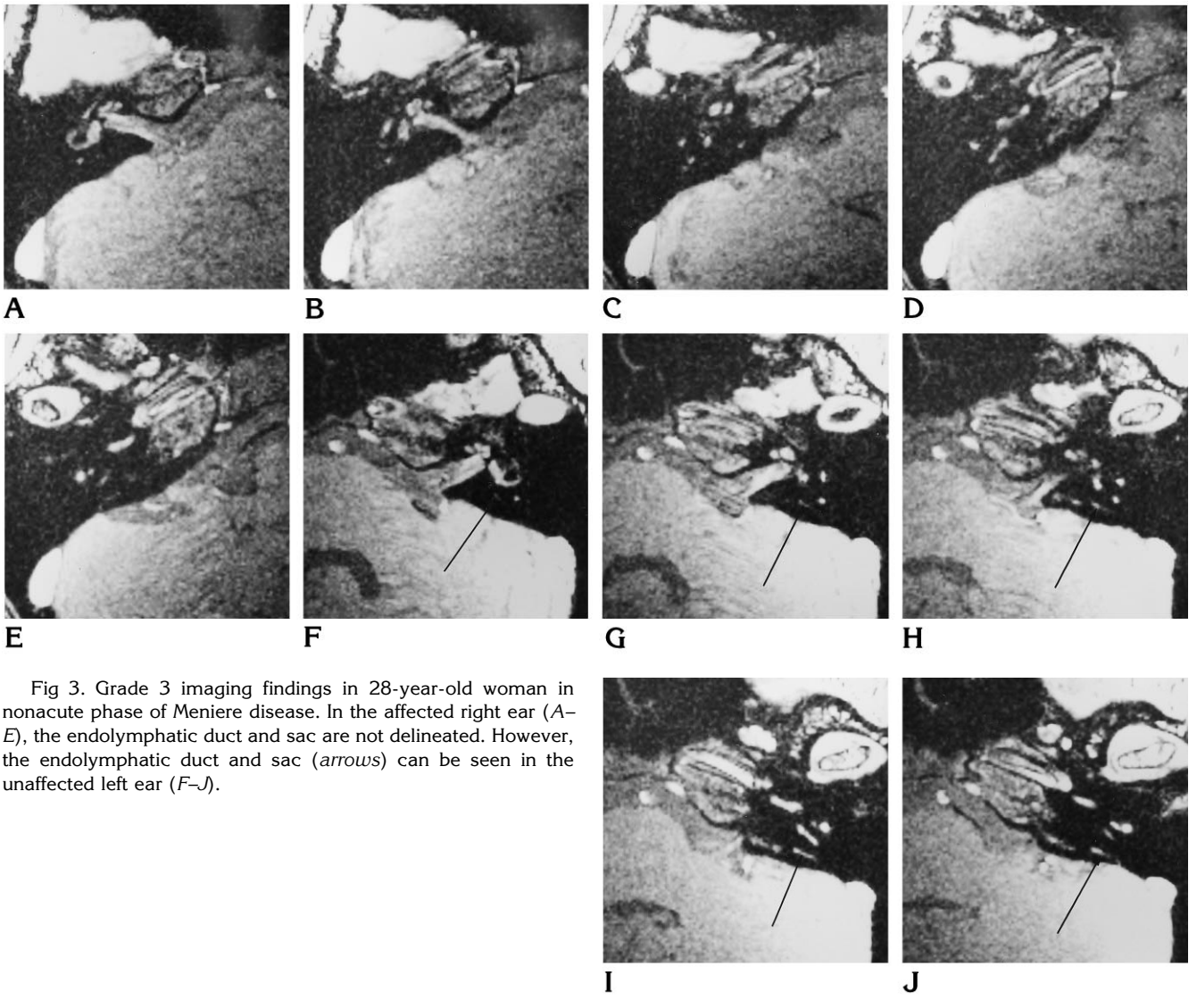

Fig 3. Grade 3 imaging findings in 28-year-old woman in nonacute phase of Meniere disease. In the affected right ear (*A–E*), the endolymphatic duct and sac are not delineated. However, the endolymphatic duct and sac (*arrows*) can be seen in the unaffected left ear (*F–J*).

images, and low-frequency loss in one patient and no loss in two of the five patients with grade 1 images.

Representative images of one patient in the acute phase and four patients in various stages of the nonacute phase are shown in Figures 1 through 5, respectively.

Discussion

Various experiments have been conducted on the pathogenesis of Meniere disease. Kimura (5) was successful in reproducibly inducing endolymphatic hydrops in guinea pigs by blocking the endolymphatic duct on the vestibular side. Subsequently, Beal (6) produced endolymphatic hydrops in rabbits and cats using similar methods. Recently, increasing attention has been paid to the endolymphatic sac that resorbs the endolymph. Hallpike and Carins (2) performed a histopathologic study of Meniere disease and found fibrosis in the connective tissue surrounding the endolymphatic sac. Many other investigators have confirmed similar findings by studying the temporal bones of patients with Meniere disease. Perisaccular fibrosis was also the major finding of Shambaugh et al (15) and Saito et al (16) in surgical specimens obtained at the time of endolymphatic decompression and revascularization in patients with Meniere disease. Absence of veins in the perivestibular canaliculus was implicated in the pathogenesis of fibrosis in the connective tissue surrounding the endolymphatic sac by Gussen (17). Yuen and Schuknecht (18) studied ears with and without Meniere disease and concluded that the

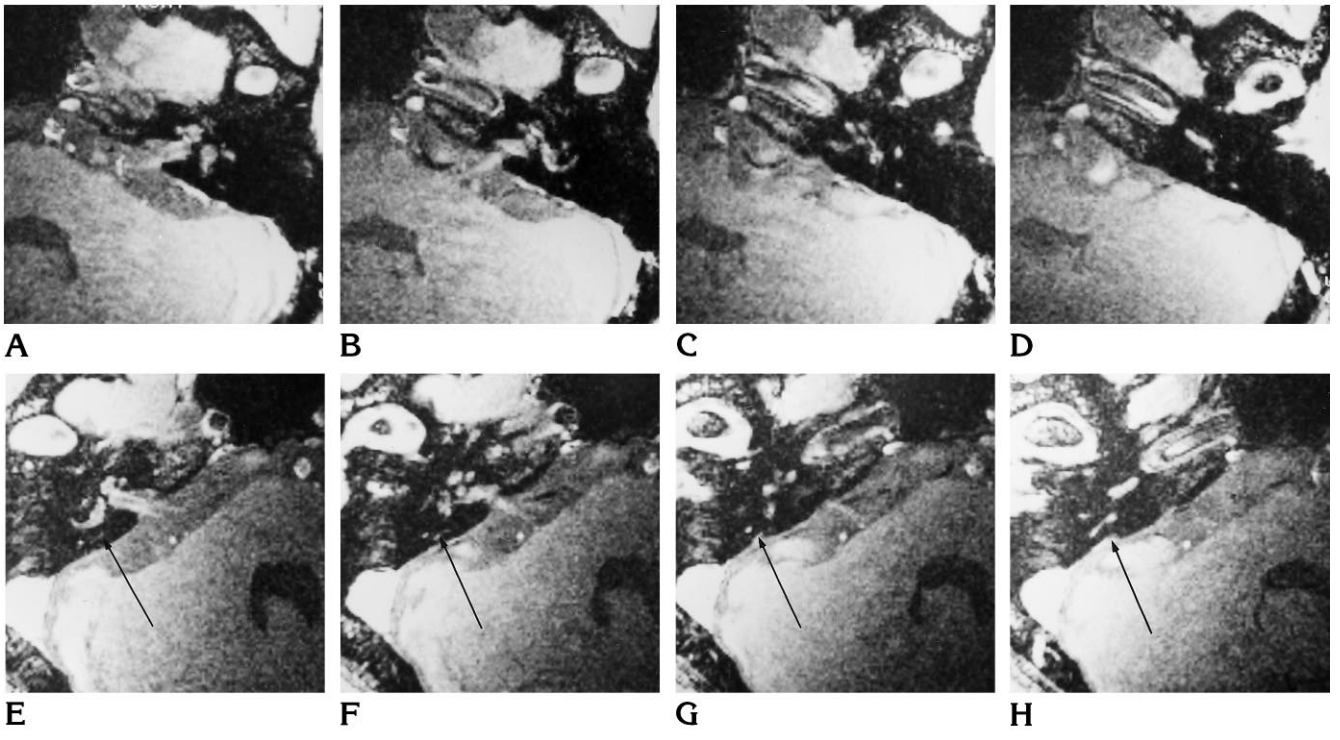

Fig 4. Grade 3 imaging findings in 34-year-old woman in nonacute phase of Meniere disease with flat hearing impairment. The affected left ear (*A–D*) does not show the endolymphatic duct and sac; however, the endolymphatic duct and sac are clearly visible in the unaffected right ear (*E–H*).

vestibular aqueduct of the ears with Meniere disease was not different in diameter from that in normal ears, but that the endolymphatic duct was significantly narrower in affected ears than in the normal ears. These findings suggest that dysfunction of the endolymphatic sac is involved in the pathogenesis of endolymphatic hydrops, which may secondarily cause the collapse of the endolymphatic duct. The endolymphatic hydrops of Meniere disease caused by a small, underdeveloped, malfunctioning endolymphatic sac, abnormally placed since birth, could be considered a congenital disorder of the endolymphatic sac (19). This misplaced endolymphatic sac is usually associated with a forward and lateral position of the lateral venous sinus (20). Poor pneumatization and periductal sclerosis of the temporal bone around the vestibular aqueduct is usually evident (19).

Shea (21) proposed a classification of Meniere disease that divided the disease into five stages, with the characteristic signs and symptoms, pathology, natural course, and treatment of each stage. The disease may or may not progress from one stage to the next, depending on the disease present, and, with treatment, ears in stage II may return to stage I, and ears in stage I may appear to be cured but, because the abnormal endolymphatic sac remains, may, over time, return to a prior stage of disease (21).

We previously reported detection of unilateral Meniere disease with the use of high-resolution MR imaging (22). That study was somewhat different, since all those patients had clinically advanced disease. Another study assessing high-resolution MR imaging of the inner ear used only T1- or T2-weighted parameters (14). In the current study, we used proton density–weighted parameters, because these images could be obtained with the highest signal-to-noise ratio. We think these parameters are most suitable for use in minute structures, such as the inner ear.

In this study, we found that in patients experiencing an acute episode of Meniere disease, the endolymphatic duct and sac were not adequately visible in the affected ear but were seen well in the unaffected ear. During remission, the endolymphatic duct and sac were not visible in patients with clinically advanced disease, but

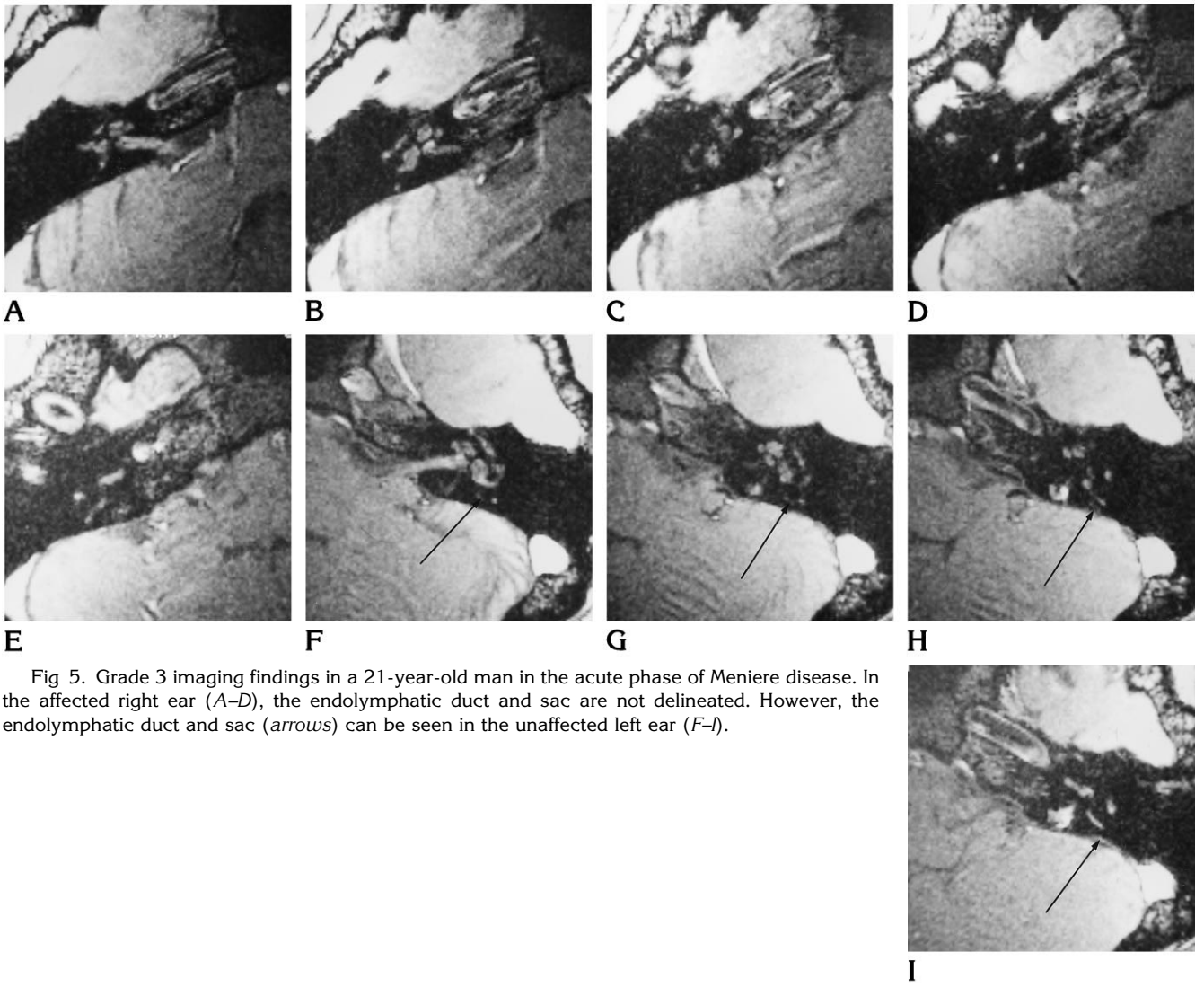

Fig 5. Grade 3 imaging findings in a 21-year-old man in the acute phase of Meniere disease. In the affected right ear (*A–D*), the endolymphatic duct and sac are not delineated. However, the endolymphatic duct and sac (*arrows*) can be seen in the unaffected left ear (*F–I*).

were seen well in the early to intermediate stages of disease.

Because the endolymphatic sac was consistently not visible in our group 1 patients, we conclude that high-resolution MR imaging may be used as a confirmatory examination when the diagnosis of Meniere disease in a patient with vertigo is in question. For group 2 patients, subject to verification by statistical analysis of larger patient populations and longitudinal studies, MR imaging may become a useful means for ascertaining treatment strategies and prognosis.

References

1. Yamakawa K. Auditory organs in patients with Meniere's disease [in Japanese]. *J Otolaryngol (Japan)* 1938;44:2310–2312
2. Hallpike CS, Carins H. Observation on the pathology of Meniere's syndrome. *J Laryngol* 1938;53:625–655
3. Rollin H. Zur Kenntnis des Labyrinth hydrops und des druch ihn bedingten Meniere. *Hals-Nasen-Ohren-Arzt* 1940;31:73–109
4. Ikeda M, Sando I. Endolymphatic duct and sac in patients with Meniere's disease: a temporal bone histopathological study. *Ann Otol Rhinol Laryngol* 1984;93:504–546
5. Kimura RS. Experimental blockage of the endolymphatic duct and sac and its effect on the inner ear of the guinea pig. *Ann Otol Rhinol Laryngol* 1967;76:644–687
6. Beal D. Effect of endolymphatic sac ablution in the rabbit and cat. *Acta Otolaryngol* 1968;66:333–345
7. Hall SF, O'Connor AF, Thakker CH, Wylie IG, Morrison AW. Significance of tomography in Meniere's disease: visualization and morphology of vestibular aqueduct. *Laryngoscope* 1983;93: 1546–1550
8. Niedecker A, Pfaltz CR, Matefi L, Benz UF. Computed tomographic findings in Meniere's disease. *ORL J Otorhinolaryngol Relat Spec* 1985;47:66–75
9. Tanioka H, Machida T, Zusho H. High resolution MRI of the temporal bone using a surface coil: normal anatomy. *Jpn J Med Imaging* 1989;8:3–8
10. Brogan M, Chakeres DW, Sckmalbrock P. High resolution 3DFT

MR imaging of the endolymphatic duct and soft tissues of the otic capsule. *AJNR Am J Neuroradiol* 1991;12:1–11
11. Deatsch WW. Meniere's disease (proxymal labyrinthine vertigo). In: Krupp MA, Chatton MJ, Werdegar D, eds. *Current Medical Diagnosis & Treatment*. Los Altos, Calif: Lange Medical Publications; 1985:111–112
12. Dilenge D. The jugular "notch." *J Assoc Can Radiol* 1977;28:274–277
13. Jahrsdoerfer RA, Cail WS, Cantrell RW. Endolymphatic duct obstruction from a jugular bulb diverticulum. *Ann Otol* 1981;90: 619–623
14. Casselman JW, Kuhweide R, Deimling M, Ampe W, Dehaene I, Meeus L. Constructive interference in steady state 3DFT MR imaging of the inner ear and cerebellopontine angle. *AJNR Am J Neuroradiol* 1993;14:47–57
15. Shambaugh GE, Clemis JD, Arenberg IK. Endolymphatic duct and sac in Meniere's disease. *Arch Otolaryngol* 1986;89:815–825
16. Saito H, Kitahara M, Yazawa Y, Matumoto M. Histopathologic findings in surgical specimens of endolymphatic sac in Meniere's disease. *Acta Otolaryngol* 1977;83:465–469
17. Gussen R. Endolymphatic hydrops with absence of vein in paravestibular canalliculus. *Ann Otol Rhinol Laryngol* 1980;89:157–161
18. Yuen SS, Schuknecht HF. Vestibular aqueduct and endolymphatic duct in Meniere's disease. *Arch Otolaryngol* 1972;96:553–555
19. Sando I, Ikeda M. Histopathological studies in Meniere's disease. *Ann Otol Rhinol Laryngol [Suppl]* 1985;118:2–16
20. Paparella MM. Pathogenesis and pathophysiology of Meniere's disease. *Acta Otolaryngol (Stockh)* 1991:465(Suppl):26–35
21. Shea JJ Jr. Classification of Meniere's disease. *Am J Otol* 1993; 14:224–229
22. Tanioka H, Zusho H, Machida T, Sasaki Y, Shirakawa T. High resolution MR imaging of the inner ear: findings in Meniere's disease. *Eur J Radiol* 1992;15:83–88