

MESOTHELIAL CELL PROLIFERATION IN THE SCALA TYMPANI: A REACTION TO THE RUPTURE OF THE ROUND WINDOW MEMBRANE

MICHIHIKO SONE

Department of Otorhinolaryngology, Nagoya University School of Medicine, Nagoya, Japan

ABSTRACT

The inner layer of the round window membrane is composed of mesothelial cells and this mesothelial cell layer extends to the scala tympani. This study describes the histopathologic findings of temporal bone analysis from a patient with bilateral perilymphatic fistula of the round window membrane. The left ear showed proliferation of mesothelial cells in the scala tympani of the basal turn adjoining the round window membrane. This cell proliferation is thought to be a reaction to the rupture of the round window membrane.

Key Words: Perilymphatic fistula, Round window membrane, Mesothelial cell, Scala tympani

INTRODUCTION

Perilymphatic fistula causes various types of problems with hearing or vestibular function, including fluctuating or severe hearing loss, tinnitus, episodic vertigo, and disequilibrium with or without hearing loss.¹⁻⁴⁾ Temporal bone study of animals with experimentally induced perilymphatic fistula have been described,⁵⁻⁷⁾ although there have been few studies of human temporal bones with perilymphatic fistula. The inner ear can't be biopsied, even if patients have been diagnosed as having perilymphatic fistula. A recent histopathologic study of human temporal bones described a patient with a clinical diagnosis of idiopathic perilymphatic fistulas who had a patent fistula ante fenestram and fistula connecting the round window niche and the posterior semicircular canal.⁸⁾

The most common sites of perilymphatic fistula are the round window membrane and the oval window membrane. However, no human temporal bone studies have reported on the perilymphatic fistula of these membranes. The round window membrane (RWM) is important in that it provides an anatomical separation between the middle ear and inner ear, as well as a functional connection between them.

Temporal bone histopathology and the clinical findings of a patient who had bilateral perilymphatic fistula of the round window membrane are described in this report, focusing mainly on the reaction which occurred in the scala tympani, adjoining the round window membrane.

Address for correspondence: Michihiko Sone, MD, Department of Otorhinolaryngology, Nagoya University School of Medicine, 65 Tsurumai-cho, Showa-ku, Nagoya 466-8560, Japan
Telephone: 81-52-744-2324 Fax: 81-52-744-2325

CASE REPORT

Clinical history

This woman had a three-year history of intermittent disequilibrium and acute vertigo with approximately two attacks per year. At the age of 48, she had experienced intermittent tinnitus and pressure in her left ear. An audiogram showed a unilateral high frequency hearing loss in the left ear at 8 kHz, with 96% speech-discrimination at 45 dB. The clinical diagnosis was atypical vestibular Meniere's disease on the left, and an endolymphatic sac enhancement procedure was performed.

She had no pressure in her left ear postoperatively, but the dizziness returned a week later. A revision of the endolymphatic sac procedure was performed eight months after the first operation. After the revision, she did well, but had occasional dizziness. Two years after the second operation, she suffered a sudden hearing loss in the left ear and nausea. This hearing loss was considered to be related to a prior flight in an airplane. An audiogram showed a 50 to 60 dB sensorineural hearing loss at 250 Hz through 8000 Hz, with 36% speech-discrimination at 85 dB.

An exploratory tympanotomy performed 17 days after the onset of her hearing loss revealed numerous adhesions overlying the round window membrane, and poor reflex in the round window. A minor leak from the round window membrane was observed, and the membrane was grafted with soft tissue. The postoperative audiogram revealed a 30 to 45 dB elevation at 250 Hz through 2000 Hz, with 96% speech-discrimination at 60 dB (Fig. 1). After the operation, her balance remained relatively stable, with mild dizziness upon motion that was about 10% of that reported previously.

Five years later, she suffered sudden hearing loss on the right side following an airplane ride. There was no aural pressure nor intolerance for loudness, but there was moderate tinnitus. An audiogram of the right ear showed 20 to 35 dB sensorineural hearing loss at 250 Hz through 8000 Hz, with 80% speech-discrimination at 75 dB. The preoperative diagnosis was right perilymphatic fistula, and an exploratory tympanotomy was performed 14 days after the onset of the right hearing loss. Thin adhesions were observed overlying the round window niche, and slight moisture was observed on the round window membrane. These findings were suspicious of a perilymphatic fistula, and the round window niche was packed with connective tissue. The postoperative audiogram revealed a 15 to 20 dB elevation in hearing at 250 Hz through 8000 Hz (except for hearing at 500 Hz), with 100% speech-discrimination at 80 dB (Fig. 2).

Three years after the operation on her right ear, she underwent three courses of chemotherapy with cis-platinum for ovarian cancer, and succumbed to that disease shortly thereafter.

Histopathologic findings

(Left ear)

The external auditory canal appeared normal. The tympanic membrane was irregular in thickness, where a pressure-equalizing tube had been inserted. The middle ear was almost clear except for bone-chips in the middle ear cavity and granulation tissue in the round window niche. The fissure connecting the round window niche and ampulla of the posterior canal was closed by bone or loose connective tissue.

The cochlea showed no endolymphatic hydrops, but severe hair cell loss was noted in the basal turn, especially in the first 11.6 mm. There was a decreased number of ganglion cells in the basal turn. There was a proliferation of mesothelial cells in the scala tympani of the lower basal turn adjoining the round window membrane (Fig. 3). These proliferative cells also covered the orifice of the cochlear aqueduct, blocking its opening. The round window membrane was thick

MESOTHELIAL CELL IN THE SCALA TYMPANI

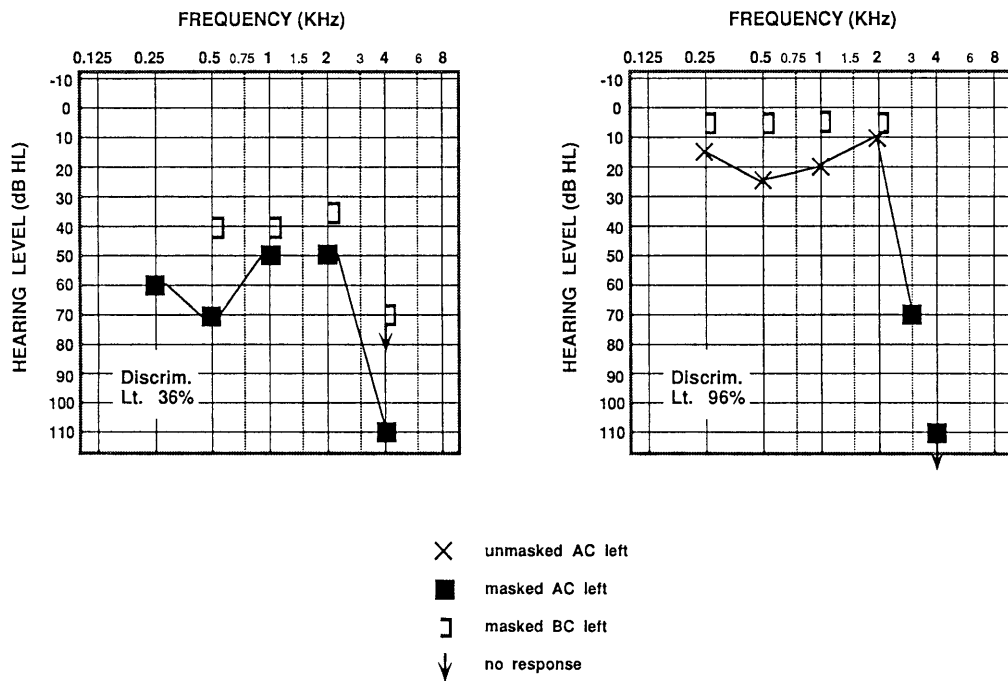


Figure 1. Preoperative (left) and postoperative (right) audiogram of the left ear after the perilymphatic fistula.

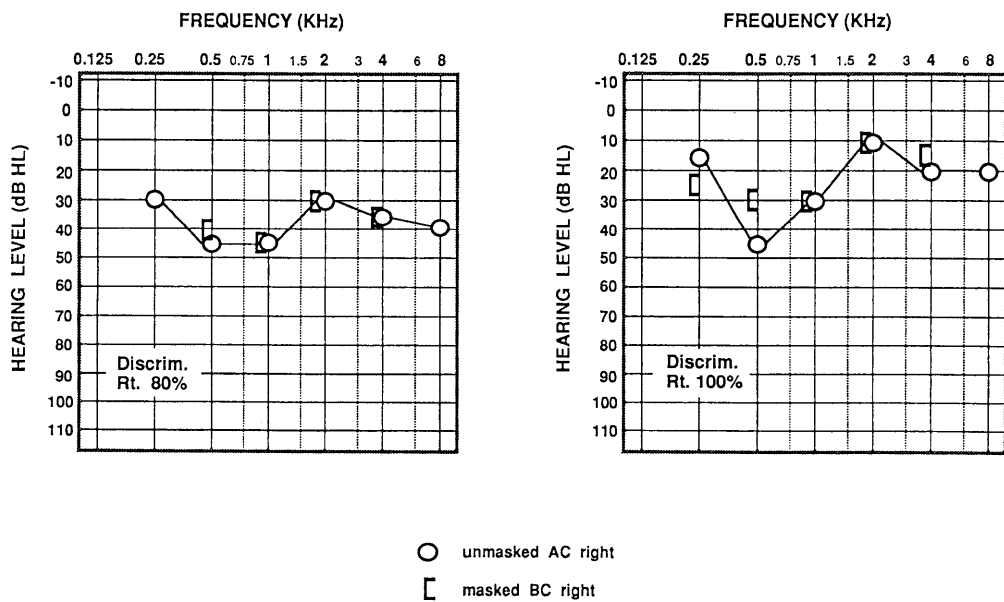


Figure 2. Preoperative (left) and postoperative (right) audiogram of the right ear after the perilymphatic fistula.

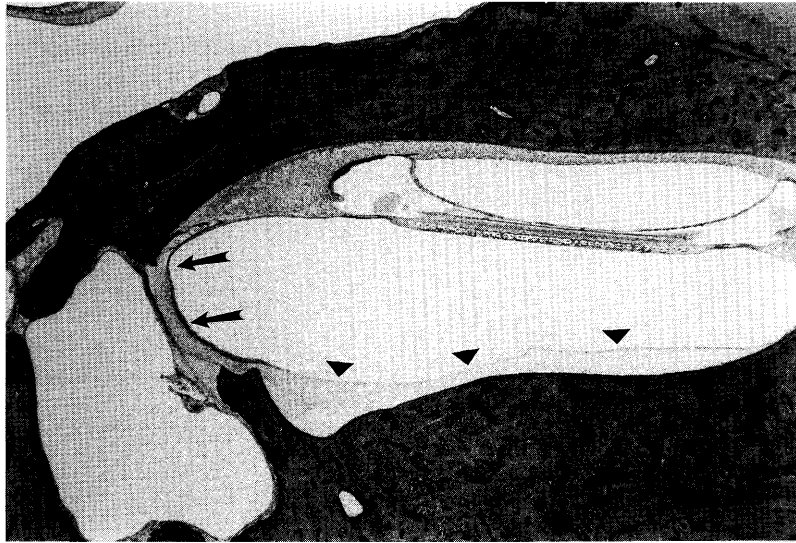


Figure 3. Proliferation of mesothelial cells in the scala tympani of the lower basal turn in the left ear (arrow head). Proliferating mesothelial cells cover the inside of the round window membrane (arrow). (hematoxylin and eosin. original magnification $\times 20$.)

with a proliferation of mesothelial cells in the inner layer. The epithelial layer had granulation on its outer surface, but no thickening was observed in the middle ear.

The superior ampullary wall had collapsed, and there was a proliferation of mesothelial tissue. Collapsed walls were also detected in the lateral ampulla and posterior ampulla, with mesothelial tissue bridging across the collapsed walls. The saccule was normally shaped, and the saccular duct was open. The utricular wall had not collapsed, but some infoldings were detected on the wall. The endolymphatic sinus and duct were open and the silastic tube remained in the sac as evidence of the previous surgery.

(Right ear)

The external auditory canal and the tympanic membrane appeared normal. The middle ear appeared normal except for granulation tissue in the round window niche. The fissure connecting the round window niche and ampulla of the posterior canal was closed by bone or loose connective tissue. The organ of Corti and ganglion cells appeared normal, and there was no endolymphatic hydrops. The round window membrane was of almost normal thickness.

Histopathologic findings in the vestibule were not evaluated due to an artifact caused by an air bubble in the superior and lateral ampullae. The posterior ampullae, the saccule, the utricle, and the endolymphatic duct and sac appeared normal.

DISCUSSION

Ruptures of the labyrinthine window have been suggested as a cause of profound, sudden hearing loss, and explosive and implosive routes were proposed by Goodhill.¹⁾ He presented a case with a history of intermittent vertigo for five years following an acute onset of tinnitus, a

MESOTHELIAL CELL IN THE SCALA TYMPANI

feeling of blockage in the ear, and hearing loss. An exploratory tympanotomy showed perilymphatic fistula in both oval and round windows, suggesting the presence of a persistent fistula. Although perilymphatic fistulas have been described clinically, information regarding their pathophysiology is lacking due to the paucity of studies of this condition in human temporal bones.

Differential diagnosis of perilymphatic fistula from findings of Meniere's disease may be difficult in some cases, due to the common clinical features of these two diseases, and because perilymphatic fistula and Meniere's disease may occur in the same patient. An exploratory operation can only be an examination which differentiates these diseases, especially in cases with long-standing disequilibrium. Interpretation of the histopathologic findings in the left ear in this study was complicated not only due to the possibility of coexistent Meniere's disease, but also in consideration of the two surgeries for its treatment. Similar histopathological findings (collapse of the membranous labyrinth of the pars superior) have been described in animals with experimentally induced perilymphatic fistula.⁵⁻⁷⁾ The first clinical diagnosis of our patient had been atypical Meniere's disease because of intermittent disequilibrium without hearing loss. But, perilymphatic fistula may have existed in the left ear at the onset of vestibular symptoms. Generally, final diagnosis of perilymphatic fistula can be confirmed by an exploratory tympanotomy.

Although collapse of the vestibular labyrinth was a frequent finding in the experimentally induced perilymphatic fistula, loss of hair cells was also observed.⁵⁾ In our study, loss of hair cells and a decrease in ganglion cells was observed, especially in the basal turn of the left ear. This decrease could have been due to the ototoxic effect of cis-platinum, which produces a high-frequency sensorineural hearing loss, but the almost normal appearance of the organ of Corti and ganglion cells in the right ear do not support this theory.

A detailed study of the healing process of RWM perforations was carried out by Choo⁹⁾ using chinchillas. The study showed that healing began around the edges of the perforation, primarily by a growth of middle ear epithelial cells that surfaced on the inner ear edges. As epithelial cells grew across the perforation, an adjacent reaction occurred in the scala tympani, which included a "clot" formation of erythrocytes and serofibrinous precipitate, and a mesothelial cell reaction. This mesothelial cell reaction in the scala tympani was suggested to be an active defense and healing mechanism of the lesion. In a study of human temporal bones with a round window labyrinthotomy, proliferated mesothelial cells were seen in the inner layer of the RWM, and the rupture appeared to be reinforced from inside by these proliferated mesothelial cells.¹⁰⁾ Considering these studies, the proliferation of mesothelial cells in the scala tympani of the left ear of the present case can be interpreted as a reaction to the perilymphatic fistula in the RWM, rather than as a reaction to the sac surgeries.

The differences in the pathological findings noted in the scala tympani of the right and left ears of the present case may have been due to the severity of the perilymphatic fistula. In the left ear, this assumption could be supported by the audiogram, severe hair cell loss, and the decrease in ganglion cells of the lower turns which was considered to be an effect of the perilymphatic fistula rather than an ototoxic effect of cis-platinum. In a case where the rupture is severe and damage to the inner ear is serious, like that seen in the left ear of the present case, the mesothelial cell reaction may occur in the scala tympani.

REFERENCES

- 1) Goodhill, V.: Sudden deafness and round window rupture. *Laryngoscope*, 81, 1462-1474 (1971).
- 2) Kohut, R.I., Waldorf, R.A., Haenel, J.L. and Thompson, J.N.: Minute perilymph fistulas: vertigo and Hennebert's sign without hearing loss. *Ann. Otol. Rhinol. Laryngol.*, 88, 153-159 (1979).

- 3) Seltzer, S. and McCabe, B.F.: Perilymph fistula: the Iowa experience. *Laryngoscope*, 94, 37–49 (1986).
- 4) Shelton, C. and Simmons, F.B.: Perilymph fistula: the Stanford experience. *Ann. Otol. Rhinol. Laryngol.*, 97, 105–108 (1988).
- 5) Nomura, Y. and Hara, M.: Experimental perilymphatic fistula. *Am. J. Otolaryngol.*, 7, 267–275 (1986).
- 6) Nomura, Y., Hara, M., Funai, H. and Okuno, T.: Endolymphatic hydrops in perilymphatic fistula. *Acta Otolaryngol. (Stockh.)*, 103, 469–476 (1987).
- 7) Nomura, Y., Okuno, T., Hara, M. and Young, Y.H.: “Floating” labyrinth: pathophysiology and treatment of perilymph fistula. *Acta Otolaryngol. (Stockh.)*, 112, 186–191 (1992).
- 8) Kohut, R.I., Hinojosa, R., Thompson, J.N. and Ryu, J.H.: Idiopathic perilymphatic fistulas: a temporal bone histopathologic study with clinical, surgical, and histopathologic correlations. *Arch. Otolaryngol. Head Neck Surg.*, 121, 412–420 (1995).
- 9) Choo, Y.B.: Microscopic characteristics of round window problems in otology. *Laryngoscope*, 94, 1–9 (1984).
- 10) Sone, M.: Pathological features of healing of a ruptured human round window membrane. *ORL*, 60, 55–57 (1998).