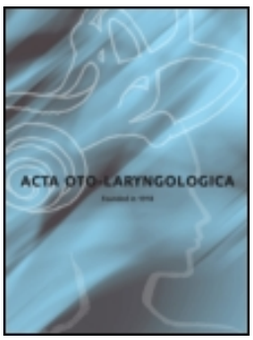

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Investigation of the External Aperture of the Vestibular Aqueduct in Meniere's Disease by Three-dimensional Image Analysis

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The width of the external aperture of the vestibular aqueduct was measured in patients with Meniere's disease using three-dimensional images. The width of the aperture on the affected side was significantly smaller compared with that in normal ears or ears with chronic otitis media. Also, the width of the aperture on the opposite (healthy) side in unilateral Meniere's disease was significantly smaller than in these two other groups. These findings suggest that the aqueduct is incompletely developed in patients with Meniere's disease and that this may be related to the pathogenesis of this condition. Also, in unilateral Meniere's disease the opposite ear runs a high risk of eventually developing the disease. *Key words: Meniere's disease, living individuals, surface reconstruction method, pathogenesis, bilateral involvement.*

INTRODUCTION

Observation of the external aperture of the vestibular aqueduct has so far only been possible in cadavers and dry temporal bones. Now, however, it has become possible to produce three-dimensional images of this structure in living individuals by the surface reconstruction method (1). In this study, we used three-dimensional images obtained by this method to measure the width of the external aperture of the vestibular aqueduct in patients with Meniere's disease. Interesting findings were obtained concerning the pathogenesis and bilateral nature of this disease.

MATERIALS AND METHODS

The material comprised 26 normal ears in subjects aged 14–67 years (39.7 years on average), 39 ears with chronic otitis media in subjects aged 11–70 years (44.1 years on average), and 36 ears affected by Meniere's disease in subjects aged 20–65 years (44.7 years on average). Thus, a total of 101 ears were tested. To prepare three-dimensional images, a surface reconstruction method was used by which two-dimensional CT images could be expressed in a three-dimensional manner (1). First, using a GECT/T9800 apparatus, 15 consecutive CT slices were taken by the overlapping method, with the external aperture of the vestibular aqueduct being at the center of this series of images. Slices were taken parallel to the orbito-meatal line with a thickness of 1.5 mm, and at intervals of 1.0 mm. The data were recorded on magnetic tape, and a three-dimensional image was reconstructed using Quantex 3D imaging software (Yokogawa Medical System). The reconstructed image was rotated until the external aperture could be distinguished most clearly and its width was then measured directly on the image itself (Fig. 1).

RESULTS

The widths of external aperture in 26 normal ears without vertigo or deafness, 36 ears with Meniere's disease, and 39 ears with chronic otitis media are shown in Fig. 2. The width of the

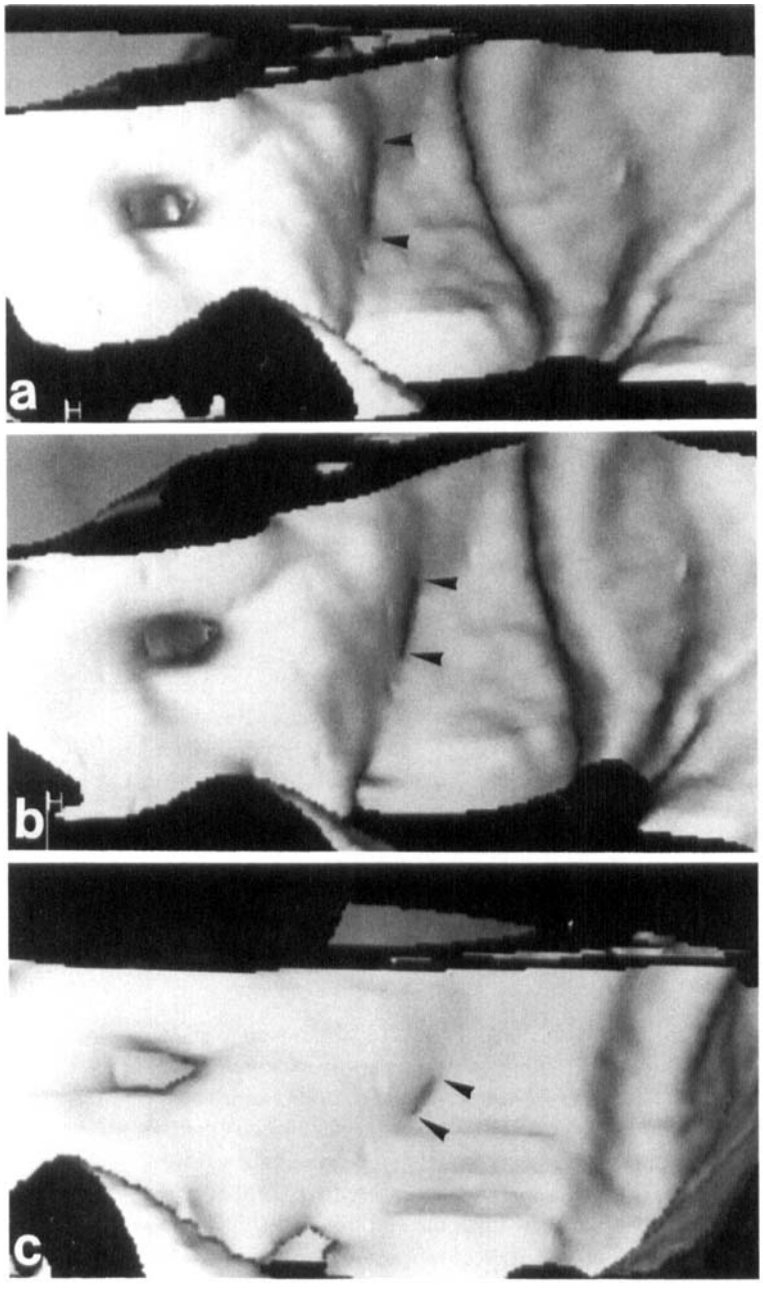

Fig. 1. Representative three-dimensional images of the external aperture of the vestibular aqueduct shown by the arrows. (*a*) normal subjects, (*b*) chronic otitis media, (*c*) Meniere's disease.

aperture was 6.67 mm ±1.73 mm in the normal ears, 4.02±1.42 mm in the ears with Meniere's disease, and 6.44±1.66 mm in the ears with chronic otitis media. Its width in Meniere's disease was significantly smaller than in the normal ears or in those with chronic otitis media ($p<0.01$).

Next, the differences in the width of the external aperture between the right and left sides were studied. In Fig. 3, the vertical axis shows the aperture widths for the right ear and the horizontal axis shows those for the left ear for all the subjects in whom both ears were

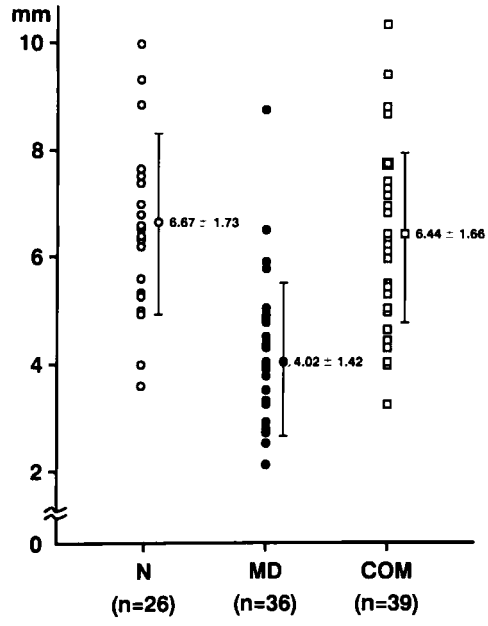

Fig. 2. The width of the aperture of the vestibular aqueduct in the three groups. *N*: normal subjects, *MD*: Meniere's disease, *COM*: chronic otitis media.

measured. In all 3 groups, no marked difference was noted between the right and left sides. The aperture was large on both sides in the normal ears and in those with chronic otitis media, whereas it was small bilaterally in Meniere's disease.

To study bilateral changes in Meniere's disease, the width of the external aperture was compared by dividing the aperture widths in the ears affected initially with the widths in those affected later in the patients with bilateral Meniere's disease. Also, the ears on the affected and healthy sides were compared in patients with unilateral Meniere's disease (Fig. 4.). In bilateral Meniere's disease, the width of the external aperture was significantly smaller ($p<0.01$) on both sides compared with the normal ears and those with chronic otitis media, and it tended to be smaller in the ear affected initially. Among the individual subjects, the aperture width of the ear affected initially was smaller in 5 out of 7 cases (71.4%). Furthermore, in unilateral Meniere's diseases the aperture width was significantly smaller on both the affected and unaffected sides compared with the normal ears and those with chronic otitis media ($p<0.01$). There was also a tendency for it to be smaller on the affected side than on the unaffected side.

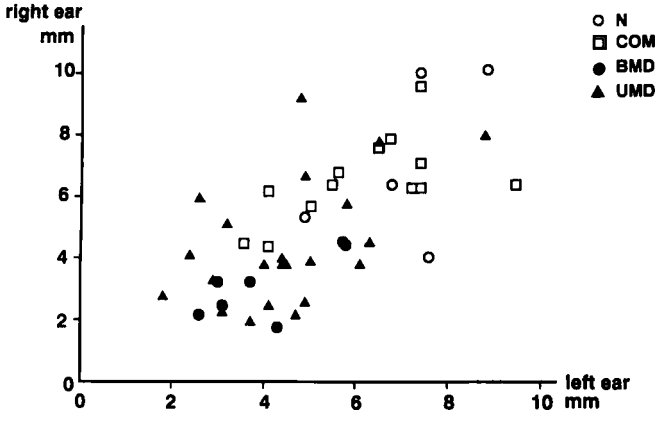

Fig. 3. The width of the aperture of the vestibular aqueduct on the right and left ears *N*: normal subjects, *COM*: chronic otitis media, *BMD*: bilateral Meniere's disease, *UMD*: unilateral Meniere's disease.

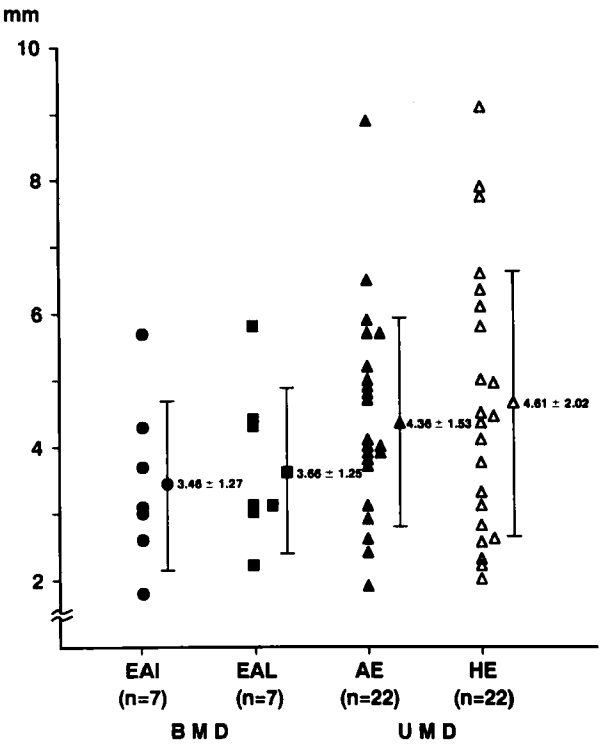

Fig. 4. Comparison of the width of the external aperture of the vestibular aqueduct in Meniere's disease. *BMD*: bilateral Meniere's disease, *EAE*: ear affected initially, *EAL*: ear affected later, *UMD*: unilateral Meniere's disease, *AE*: affected ear, *HE*: healthy ear.

Among the individual subjects, the aperture width on the affected side was smaller in 13 out of 22 cases (59.1 %).

DISCUSSION

Observation of the external aperture of the vestibular aqueduct in Meniere's disease has been performed previously using temporal bone specimens or radiological methods. With temporal bones, detailed investigations are possible but the number of cases is restricted since cadavers are used. Radiological studies are performed in living individuals by tomography or CT, but the rate of visualization is less than 100%. Three-dimensional imaging, as used in this study, could visualize the external aperture in all the subjects. Also, it is the most suitable method for observing the aperture in Meniere's disease, since such an aperture is very small and can scarcely be identified on X-rays.

It has been previously reported (1) that the width of the external aperture of the vestibular aqueduct is significantly smaller in ears with Meniere's disease compared with normal ears and ears with chronic otitis media, and these findings were confirmed in this study in which the number of subjects was larger. The width of the external aperture reflects the volume of the aqueduct, so these findings suggest that incomplete development of the vestibular aqueduct is present in Meniere's disease. Endolymphatic hydrops due to a resultant disturbance of endolymphatic absorption could thus be one factor in the pathogenesis of this disease (1).

In unilateral Meniere's disease, the width of the aperture in the opposite ear was also significantly smaller when compared with normal ears and those with chronic otitis media. In unilateral Meniere's disease, there is a possibility that the opposite ear may also be eventually affected, and the frequency of bilateral involvement increases with the duration of the disease (2, 3, 4). Our findings support these clinical observations.

Furthermore, in bilateral Meniere's disease the width of the aperture was generally smaller in the ears affected initially, and in unilateral Meniere's disease it was also smaller on the affected side. These findings suggest that the disease is more likely to occur in the ear with the greater degree of dysplasia of the aqueduct, but it is necessary to conduct further investigations in a larger number of subjects to confirm this point.

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