Bizarre "Sawtooth" Tympanogram in a Patient with Otitis Media

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Abstract

A patient evaluated for otitis media had a bizarre tympanogram with a "sawtooth" configuration. Acute otitis media with a pinpoint perforation was diagnosed. After resolution of the acute infection, a 2-mm diameter perforation remained and the presence of a patulous eustachian tube was documented. Tympanoplasty was eventually required, after which a normal tympanogram was recorded. Our interpretation of the tympanogram is discussed and the literature reviewed.

Key Words: Acoustic immittance, eustachian tube, tympanometry

One of the many valuable applications of tympanometry in clinical practice is the confirmation of tympanic membrane perforations. In the presence of a perforation, the typical tympanogram will yield a straight line. Although rarely reported, certain perforations can yield uncharacteristic results (Kobayashi and Okitsu, 1986; Cox and MacDonald, 1995). We report in this case study the presence of an unusual "sawtooth" pattern tympanogram associated with a small perforation of the tympanic membrane, possibly due to a valve-like action of the opening.

CASE REPORT

A 63-year-old male was evaluated for left otitis media and otitis externa. He reported a 15-year history of bilateral tinnitus and intermittent left ear infections with hearing loss.

Microscopic examination of the left ear revealed a pinpoint perforation with minimal pus in the middle ear and on the tympanic membrane. Audiometric data revealed hearing levels that were borderline normal and symmetric (Fig. 1). Speech discrimination was excellent and speech reception threshold results agreed with pure-tone analysis. Multiple tympanometric ear canal volume recordings indicated a normal right ear canal volume and a slightly increased left ear canal volume. Acoustic immittance testing of the right ear using a GSI-1733 Version 2 Middle Ear Analyzer with a pump speed of 50 daPA/sec and probe tone of 226 Hz produced normal results while the left ear

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![Figure 1](image_url) Pure-tone audiometric data of a patient with a pinpoint perforation of the left tympanic membrane. O = right ear air conduction, X = left ear air conduction, < = right ear bone conduction.
revealed a distinctive "sawtooth" pattern during pressure gradients in both positive and negative directions, during which the patient reported hearing clicking sounds (Fig. 2). The "sawtooth" pattern demonstrated reversal from positive to negative pressure directions.

The patient was treated with antibiotics for otitis externa and otitis media. He returned 1 month later with his symptoms resolved. Microscopic examination of the left ear revealed a 2-mm posterior inferior perforation of the tympanic membrane that was dry. At this time, a patulous eustachian tube was documented by the inability to obtain a seal with the tympanometer.

The patient returned 4 months later. Microscopic examination of the ear indicated a small but unchanged perforation of the tympanic membrane and audiologic tests revealed similar hearing loss. Seven months later, a left tympanoplasty was performed to correct the perforation.

The patient has exhibited no problems postoperatively and audiometry revealed normal hearing thresholds on both sides (Fig. 3). Tympanometry of the left ear revealed an intact tympanic membrane and normal volume readings (Fig. 4).

**DISCUSSION**

The present case report has been contributed in order to assist in the understanding and interpretation of tympanic membrane perforations. The case bears clinical relevance to audiologists in analyzing unique presentations such as the sawtooth pattern reported here. While unique tympanograms are rarely reported in
the literature, the clinical occurrence may be more frequent. A single report of this finding has been presented in the literature, described as a nystagmoid pattern (Kobayashi and Okitsu, 1986). We prefer the sawtooth terminology that is commonly used in electronics, since only nystagmus of peripheral or optokinetic origin has this configuration.

The expected tympanometric presentation of a perforated tympanic membrane is a straight line. The perforation couples the external and middle ear canals, producing no differential impedance with pressure changes. In this case, the sawtooth presentation occurred due to the ability of the small valve-like opening to remain sealed until the tympanometer applied a critical pressure. With pressure application, the typical reading of a gradually ascending curve began, indicating an increase in tympanic membrane compliance. During this phase, the pressure gradient was not strong enough to force the perforation open so the reading was comparable to an essentially normal tympanogram. At a certain critical pressure, the gradient increased to a point where the perforation became patent. At this point, the trace abruptly fell back to baseline, as seen in the vertical segment of the tracing, indicating a return to the original compliance of the tympanic membrane before the gradient was induced. Finally, the perforation became sealed again, thereby perpetuating the cycle. This repetitive return to baseline was due to the equilibration of pressure across the tympanic membrane, requiring not only the opening of the perforation but the presence of a patulous eustachian tube that allows the unrestricted movement of air required for middle ear equilibration. The repetitive valvular action of the perforation yielded the sawtooth pattern seen in Figure 2. This step-wise equilibration occurred with pressure gradients induced in both positive and negative directions, with the expected orientation reversal of the sawteeth on the negative sweep. The sawtooth pattern in both positive and negative pressure sweeps demonstrates the ability of the perforation to act as a valve in both directions of air movement across the tympanic membrane.

These findings suggest that unexpected variations from the typical tympanogram, although rarely reported, can and do indeed occur in the presence of rare middle ear anatomical variations. Recognition of these unusual patterns and an understanding of the basic mechanisms of tympanometric analysis will aid in the definitive diagnosis of small tympanic membrane perforations and other sources of middle ear pathology.

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REFERENCES
