Hearing Improvement after Resection of Cerebellopontine Angle Meningioma: Case Study of the Preoperative Role of Transient Evoked Otoacoustic Emissions

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Abstract
In a retrospective case study of a patient with a right-sided cerebellopontine angle mass lesion, transient evoked otoacoustic emissions were robustly present despite a severe to profound sensorineural hearing loss and abnormal auditory brainstem response. These results were interpreted as suggestive of a neural site of lesion, and the potential for planned, preserved, or improved hearing by a suboccipital surgical craniotomy was considered. A gross total resection was successful. Three years postoperatively, the patient has normal hearing sensitivity and word recognition ability.

Key Words: Meningioma, postoperative hearing recovery, sensorineural hearing loss, transient evoked otoacoustic emissions

Abbreviations: ABR = auditory brainstem response, CPA = cerebellopontine angle, ECOG = electrocochleography, IAC = internal auditory canal, MRI = magnetic resonance imaging, SNHL = sensorineural hearing loss, TEOAEs = transient evoked otoacoustic emissions

It is generally accepted that otoacoustic emissions enable one to obtain valuable information about the motility of outer hair cells in the cochlea (Dallos, 1997). These low-amplitude acoustic signals can be recorded from a sealed, intact ear canal and are particularly useful in differentially demonstrating cochlear function. In combination with electrocochleography (ECOG) and the auditory brainstem response (ABR), otoacoustic emissions can provide powerful diagnostic information about discrete portions of the hearing mechanism from the hearing end organ to the brain stem.

The following case study illustrates the role of transient evoked otoacoustic emissions (TEOAEs) in a complete preoperative neurodiagnostic assessment of a patient with a moderate-sized right cerebellopontine angle (CPA) mass.

CASE STUDY

A 43-year-old female experienced a sudden onset, right-sided hearing loss 15 weeks into her second normal pregnancy. Her primary care physician obtained audiologic assessments that revealed a mild mid-frequency sensorineural hearing loss (SNHL) with very poor word recognition ability in her right ear and normal hearing in her left ear (Fig. 1). ABR testing at the time revealed a right ear response characterized by poor morphology and interpeak latencies prolonged well beyond two standard deviations. Left ear absolute and interpeak latencies were within normal limits with good morphology. Diagnostic imaging was delayed until the successful delivery of a healthy term infant.
Figure 1 Initial audiologic assessment demonstrated a mild SNHL in the right ear with poorer word recognition scores than expected based upon the degree of hearing loss. The left ear hearing remained within normal limits.

Shortly after the delivery, magnetic resonance imaging (MRI) revealed a 2.5-cm enhancing mass lesion in the right CPA (Fig. 2). Its widespread attachment with brain, dural tail, and isodensity on T1-weighted images was suggestive of a meningioma (Lalwani and Jackler, 1993; Glasscock et al, 1994). Extension of tumor into the internal auditory canal (IAC) was noted.

Figure 2 Gadolinium-enhanced MRI revealed a right 2.5-cm cerebellopontine mass (arrow) with IAC extension and a dural tail.

Figure 3a Right ear hearing assessment demonstrated a progressive, mild to profound, right-sided SNHL with no measurable word recognition score.

Three weeks later, the patient was seen in our clinic, where the audiologic evaluation revealed a mild sloping to profound SNHL with no measurable word recognition ability in the right ear (Fig. 3a). Immittance measures were compatible with the audiometric results. The right ear ABR consisted of a wave I peak with no repeatable components thereafter (Fig. 3b). Pure-tone thresholds, word recognition, and the ABR in the left ear continued to be within normal limits. Clinical rating of facial function and electroneuronography were normal bilaterally. The preoperative work-up was completed by
obtaining TEOAEs and an essentially normal response was obtained from each ear. Notably, the right ear response was obtained at a stimulus level of 75.9 dB SPL and resulted in a strong evoked emission with an overall level of 20.5 dB (Fig. 3c). Whole wave reproducibility was excellent (97%). Likewise, individual band reproducibility and signal-to-noise ratios were robust.

Until this point in the patient's preoperative work-up, planned hearing preservation had not been considered a viable surgical option given the degree of her hearing loss, poor word recognition scores, and the poor quality ABR. The presence of TEOAEs in this patient's right ear was interpreted as indicating that the nature of her hearing loss was neural and likely the result of compression of the VIIIth cranial nerve in the IAC and/or the CPA. The presence of robust INTRAOP ABR

![INTRAOP ABR](image)

**Figure 4**  Intracoperative ABR monitoring; wave V was initially absent but appeared toward the end of the surgical procedure.

TEOAEs suggested normal outer hair cell function, implying good cochlear blood supply. Tumor resection with preservation of the auditory nerve was therefore planned via a suboccipital approach in an attempt to preserve hearing.

![FREQUENCY IN HERTZ (Hz)](image)

**Figure 5**  Audiologic assessment showed significantly improved higher frequency hearing sensitivity 3 days postoperatively.

![FREQUENCY IN HERTZ (Hz)](image)

**Figure 6a**  Hearing sensitivity was normal in the right ear at 3 months postoperatively.
Facial nerve function and ABR/ECOG monitoring were carried out during the suboccipital resection of this CPA mass. The tumor was separated from the VIIth and VIIIth cranial nerve complex, and the extension into the IAC was removed. Frozen pathology reports were consistent with meningioma. The initial, intraoperative ABR response consisted of a wave I and possibly wave II with no other identifiable components (Fig. 4). These early ABR components were repeatable throughout the surgical procedure. After completing the IAC drill-out and removing the IAC tumor extension, the amplitude of wave I increased and what appeared to be wave V of the ABR emerged with a latency of 8.3 msec. This ABR configuration persisted until monitoring was completed at the close of the case. Gross total resection of the meningioma was successful.

Three days postoperatively, the patient demonstrated significantly improved higher frequency pure-tone thresholds (Fig. 5). Three months postoperatively, normal pure-tone thresholds were present in the right ear from 250 to 8000 Hz, and the patient's speech recognition score had improved to 96 percent (Fig. 6a). Facial function was entirely normal. Her postoperative ABRs, which, while continuing to demonstrate prolonged interpeak latencies, were nevertheless characterized by a well-defined and replicated wave V component with a latency of 7.6 msec (Fig. 6b). Three months postoperatively, the TEOAEs of the operated ear were characterized as having a strong response with excellent reproducibility (Fig. 6c). Three years after surgery, the patient's hearing continues to be within normal limits.

DISCUSSION

This case study demonstrates the role of otoacoustic emissions in the preoperative decision making and assessment of patients with CPA lesions by helping to differentiate sensory (cochlear) from neural (auditory nerve) components in SNHL. The presence of strong and reproducible TEOAEs in an ear with heretofore “nonserviceable” hearing led to a reconsideration of the surgical approach with a view toward possible hearing preservation. In particular, TEOAEs results in this case made a compelling case for attempted hearing preservation despite tumor extension into the IAC that gave the appearance of a possible acoustic neuroma. The patient’s preoperative ABR on the affected side consisted of wave I only, indicating activation of the distal-most segment of the auditory nerve. It is believed that in certain cases of lesions in the CPA, the associated hearing loss originates from VIIIth nerve compression by the tumor mass (Glasscock et al, 1994). In this case, cochlear outer hair cell function was likely preserved because the IAC extension of the meningioma had not affected cochlear blood supply. Intraoperatively, the previously absent ABR wave V appeared following successful dissection of the tumor extension in the porus. We surmise that this was the result of release of the nerve block.

Generally, TEOAEs are expected to occur when hearing is normal and are absent when hearing levels exceed 30 to 40 dB HL without “complicating etiological factors” (Harris and Probst, 1997). Obviously, the patient in this case study was known to have a significant
etologic factor, namely, a moderate-sized CPA mass lesion. However, as Robinette and Durrant (1997) have observed, “...findings of (evoked) otoacoustic emissions in an ear with moderate or greater sensorineural hearing impairment are highly specific. They provide strong evidence of good outer hair cell function and indicate a retrocochlear lesion...” The very presence of TEOAEs in this patient with a severe SNHL led her audiologists and neurotologists to consider the potential for improved postoperative hearing abilities via a planned hearing preservation surgical procedure.

There have been reports of patients with intracranial tumors, associated severe hearing loss, and unexpected otoacoustic emissions. For example, Bonfils and Uziel (1988) describe a subset of patients with unilateral acoustic neuromas who had measurable TEOAEs bilaterally. Their patient 2 had click evoked responses despite a mean audiometric threshold of 80 dB HL. Robinette et al (1992) described in detail the findings of 30 patients with acoustic neuromas who received TEOAEs, ABR, and acoustic reflex measures. Patients 7 and 8 had average hearing losses of 43 and 62 dB HL, respectively, with recordable TEOAEs. Similarly, Proschel et al (1994) reported that three patients (N = 34) had emissions despite the presence of moderate or greater hearing loss. Recently, Filipo et al (1997) have observed, “…findings of (evoked) otoacoustic emissions in an ear with moderate or greater sensorineural hearing loss are often nonspecific even when paired with ECOG. We suggest that TEOAEs may play an important, specific role in the neurodiagnostic work-up of such patients. We have initiated a review of patients fitting this clinical profile who have received a complete preoperative work-up including TEOAEs, and hope to report our results in the near future.

CONCLUSION

The presence of TEOAEs in a patient with mild to profound SNHL, 0 percent word recognition, and abnormal ABR was a satisfactory if unexpected clinical finding. The initially planned surgical resection that did not call for hearing preservation was changed, the result being a normal hearing outcome. We suggest that it would be prudent to measure TEOAEs in all patients with CPA mass lesions, particularly those suspected to be meningiomas, to help differentiate the sensory and neural components in the sensorineural hearing impairment. We are presently evaluating the clinical utility of evoked OAE measurements in all patients with posterior fossa tumors in order to determine if the addition of this sensitive test of cochlear function could be a helpful adjunct to surgical planning.

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REFERENCES


