Tinnitus in the Courtroom

By Dennis Colucci, AuD, MA

The advent of the functional magnetic resonance imaging (fMRI) has advanced tinnitus research to go beyond the gross identification of tinnitus cohorts to a more refined evaluation of the brain networks that constitute tinnitus symptoms. This is especially useful in the medical-legal arena, where establishing the existence of tinnitus can be difficult because of the absence of a known objective test to identify tinnitus, resulting in potential compensation and malingering for a defendant or plaintiff.

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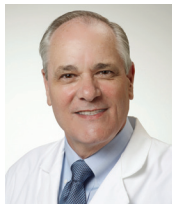
CHALLENGES IN OBJECTIVE DIAGNOSIS

In patients not in litigation, proof of tinnitus and comorbid hyperacusis is built upon establishing an incidental or medical causation, specific complaints and patterns, responses to questionnaires and ratings, medical and environmental histories, interview, and behavioral observations. In additional replicable and complimentary audiological test findings, an absence of malingering or feigning, and an assessment of the patient's psychological profile complete the examination. From this information, a constellation of findings reveals the onset, causation, medical complications, course of the disease process, and the severity and annoyance levels. Furthermore, impingements on the patient's quality of life and degree of impairment can be used to develop a treatment plan and prognosis.

Determining tinnitus claims can be challenging in the medical-legal arena. For the most part, a forensic evaluation would show if findings significantly conclude the likely presence of tinnitus and, if so, if the purported incident and case merits are consistent with known causations (i.e., physical trauma, chemical exposure, acoustic trauma, aging, etc.). Expert witnesses make these determinations based on current technology and scientific knowledge. However, legal professionals remain in the position to sort out claims. Because of the subjective nature of tinnitus, a more objective approach would be desired.



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fMRI FOR PRECISION

In patients with bothersome or debilitating tinnitus, the brainstem and cortex can become involved as abnormal, functionally connected networks and subnetworks develop. These large-scale networks involve auditory and non-auditory structures associated with attention, audition, and emotion (Husain. *Hear Res* 2016;334:37). In their work on aging and cognitive decline, Febo and Foster have shown the meaning of fMRI signals in terms of neuroplasticity and the types of neural activity that generate the signals (*Front Aging Neurosci* 2016; 8:1588).

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fMRI uses two very strong magnets and radio frequencies to measure subatomic particles within the hydrogen atom of the water molecule. These particles (protons and neutrons) are made up of quarks, the building blocks of matter. As a result of the quark configuration, protons are positively charged and neutrons have no charge. When magnetic fields are engaged in combination with an intermittent exposure to radio waves, the resulting alterations (the flip) in proton position are

used to develop the resonating image. However, instead of measuring the structures themselves (as in CT scanning or standard MRI), fMRI looks at resonance changes in regional blood flow based on the contrast between oxygen rich and oxygen poor blood. Activity in the brain receives more oxygenated blood levels.

ABNORMAL FUNCTIONALLY CONNECTED NETWORKS

Ueyama and colleagues recently developed an fMRI method for tinnitus that uses resting-state measures of functional connectivity, cross-correlated for area strength and auto-correlated to identify repeating patterns in time (*PLoS One* 2013;8[6]:e67778). This protocol allows for the parsing out of functionally connected regions within networks that correlate to patient symptoms such as distress, depression, and loudness.

Tinnitus Handicapped Inventory (THI) and the Hamilton Depression Rating Scale (HAM-D) were used to correlate the findings between tinnitus and non-tinnitus patients. The ability to mathematically compute activity within a region and all regions yields an objective measure of the existence of tinnitus as a network; however, it does not describe or objectify the depth of the condition.

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The findings of this study suggest that different brain regions are responsible for tinnitus symptoms. Depression symptoms are shown to be related to network regions for distress and depressive state. Brain regions involved in tinnitus loudness, however, are not correlated to those involved in depression, but a relationship between the default mode network (active non-engaged state) and the integration of multi-sensory information is present.

Although patients readily identify tinnitus and hyperacusis, establishing these in the medical-legal arena can be challenging for legal professionals. While forensic specialists may be able to establish causations, the fMRI approach is quickly becoming the preferable tool. However, it comes with limitations. For example, fMRI can only demonstrate correlations between tinnitus symptoms and brain region activation; it cannot be used as an objective biomarker for compensation. Furthermore, brain networks involved in tinnitus and hyperacusis cannot be assumed to be the same. But with the continuous advancements in fMRI and related technology, an objective approach to tinnitus diagnosis could be possible in the near future.