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Higher frequency variability in external ear resonance – why so much and can we improve poor functioning ears?

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Proposal: The external ear, composed of the pinna and external auditory canal (EAC) is well known to provide amplification of sound passing from the air around the head to the tympanic membrane (TM). The amount of gain in an adult ear is typically 15 to 25 dB SPL peaking near 2.7 kHz due primarily to the quarter-wave length resonance of the EAC. A secondary peak near 5.0 kHz of around 10 dB is also present thought due to conchal resonance. Considerable variation in gain exists at the higher frequencies above 2 to 3 kHz.; this variability can be as much as 20dB SPL.

The reasons for this variability are unclear in many cases but obviously contribute to the higher frequency hearing thresholds, particularly in sound field testing. Some external ears, like middle ears, are clearly better than others and their identification may not be possible by inspection, including otoscopy.

When hearing thresholds are normal with a normal cochlea and middle ear, these variations are of little significance; in cases of mild hearing loss, an improvement of 10 dB SPL or greater in the frequency range above 2 kHz could be beneficial. This could be particularly useful and convenient in patients scheduled for surgical correction of a middle ear conductive hearing loss, who are found on real ear sound pressure measurements to have poor external ear resonance. Correction of that deficiency, if possible, at the same time would have real value.

This paper will discuss causes of the variability as well as the potential for surgical or prosthetic correction once the cause(s) is identified.

Material and Methods: Review of the literature plus computer model experiments and real ear sound pressure measurements in normal and abnormal external ears (REUG).

Results: While the majority of normal appearing external ears resonate within a range of +5 to -5 dB SPL from mean values, some 10 to 20 % can be considered outliers over a relatively broad higher frequency range above 2.0 kHz. As a general rule, the presence of a large and deep concha, a large pinna, and a large EAC opening correlate with higher gains and the opposite with lesser. If the latter can be partially converted to the former with a conchoplasty, improvement occurs. Passive in the ear prostheses also can provide improvement.

Conclusion: Assessment of external ear resonance in normal appearing ears may on occasion be helpful to the otologist in providing improved hearing thresholds.