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Real Ear to Coupler Difference (RECD) Corrected Thresholds in Children: How Accurate is the Standard Audiogram Results?

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Background

The standard audiogram is considered the “gold standard” in clinical care to characterize hearing function. Subsequently, interventions are recommended based on the results of these audiograms. There is increased recognition, however, that the standard audiogram is not always the most accurate method of measuring true levels of hearing.[1]

Audiograms usually provide Decibel Hearing Level (dB HL), which is a threshold result referenced to the Decibel Sound Pressure Level (dB SPL) measured at the tympanic membranes of normal-hearing individuals. This measurement is based on a standard cylindrical coupler mold referenced to the average ear acoustic characteristics but significant variability can exist in external and middle ear anatomy and physiology between individuals.[2] Real Ear to Coupler Difference (RECD) is a frequency-specific difference between SPL at the tympanic membrane and SPL in a control hard-walled

coupler and is used routinely in hearing aid fitting. RECD is unique to an individual's external and middle ear acoustic properties, which can be used to provide more accurate hearing level results. This could certainly be an important factor to consider when assessing children's hearing since their ear structures are growing and changing over time. RECD measurements are usually straightforward to perform and are widely available; as well, they have been shown to have high test-retest reliability.[3]

Although the use of RECD in hearing aid calibration has been broadly studied, its use in routine hearing evaluation in children has not been reported. As there can be great heterogeneity among children's external and middle ear acoustic properties, we have been using individual RECD values to generate a Real Ear-Corrected Hearing Level (RECHL) results in children presenting to our pediatric audiology clinic (Nova Scotia Hearing and Speech Centre) at the IWK Health Centre in Halifax, Nova Scotia.

Our Findings

A total of 166 children (mean age 12 years; 55% boys) had both standard audiogram and RECHL results available for analysis. In this population, 14% had normal hearing, 52% had conductive hearing loss and 27% had sensorineural hearing loss. Overall, the hearing level was overestimated (dB HL > RECHL) by the standard audiogram when compared to RECHL at all tested frequencies (250–6000Hz). In the lower frequencies (250–1000Hz) and at 6000Hz, about half of the children were overestimated, with a threshold difference up to 25dB. Between 1500–4000Hz, about 1/3 were overestimated, with a similar threshold difference.

When the differences between standard audiogram thresholds and the RECD corrected thresholds were analyzed in children with middle ear dysfunction, similar results were found. In comparison, a much smaller proportion of pediatric patients with normal hearing (i.e., no middle ear pathologies) had substantial threshold differences between dB HL and RECHL. Interestingly, in patients with sensorineural hearing loss, the threshold differences between standard audiogram and RECD corrected results showed an underestimation of hearing levels in the mid-frequencies (1500-3000Hz).

Implications

We have been using RCED values to provide RECHLs in children undergoing routine hearing assessments. Overall, our data indicate that the standard pure-tone threshold evaluation may overestimate hearing levels in children, particularly in the low and high frequencies, and in children with middle ear dysfunction or conductive hearing loss. This could lead to over-diagnosis and/or over-treatment of hearing loss in some children.

The dB HL scale may not always accurately reflect ear canal dB SPL in children, as this scale is defined by the average normal adult hearing population. The growth of a child's external and middle ear adds to the imprecision to this method. It has been suggested that the average difference between dB HL and dB SPL in the adult ear will undervalue that of the child's ear canal, due to the standardization of measurement to a 2 mL coupler.[4] This may explain why we found such threshold errors in our cohort.

As mentioned above, RECD is a widely available tool with extensive use in calibrating the output of hearing aids in adults and children. It is encouraged that RECD measurements be repeated with every ear mold change, which can be very frequent in young children since their external and middle ear anatomy and dimensions are constantly changing. This helps provide real ear measurements for proper titration of hearing aid outputs.[5] However, the use of RECD in routine hearing assessments in children has not been previously reported to our knowledge.

We believe that RECHL may provide a more accurate representation of hearing ability. This is by accounting for the differences in individual external and middle ear characteristics, which are constantly changing in the early years of life and are susceptible to fluctuation with certain middle and external ear pathology.[6] The concern regarding standard audiogram results in children is that hearing levels could be overestimated, which could lead to over-treatment. As the identification and proper amplification of hearing deficits, particularly at a young age, has been linked to improved speech development in children,[7] we believe the accurate hearing assessment is important.

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