Clinical Application of the Cochlea Scan for Hearing Threshold Estimation in Children

Arne Knief, Claus-Michael Schmidt, Dirk Deuster, Antoinette am Zehnhoff-Dinnesen

Department of Phoniatrics and Pediatric Audiology
University Hospital Münster, Westphalian Wilhelms-University Münster

Introduction

The growth function of distortion product otoacoustic emissions offers the possibility to estimate ear and frequency specific hearing thresholds in children (Boege and Janssen, 2002). With the Cochlea Scan (Fischer-Zoth/Natus) a portable device for clinical measurements is commercially available. The device measures the amplitude of the distortion product otoacoustic emissions at three intensities above threshold and extrapolates the threshold from that. Its application was tested in a group of newborns, infants and children. We compared the cochlea scan thresholds with thresholds from sound-field or air conduction audiometry.

Methods

95 children (63 male, 32 female) with a mean age of 5 y ± 4 m, age range from 7 days to 11;7 years, were examined. We performed Cochlea Scan (module CS) measurements in the frequencies 1.5 kHz, 2 kHz, 3 kHz, 4 kHz, and 6 kHz and, dependent on age and individual development, sound-field or air conduction audiometry. Thresholds of Cochlea Scan and behavioural audiometry were compared with the Wilcoxon signed rank test. Furthermore, we tested if frequency was a factor influencing the estimated thresholds by using analysis of variance (ANOVA) followed by a multiple comparison procedure with Bonferroni adjustment. To evaluate if thresholds were age-related a correlation analysis was performed for each method

Results

Compared to sound-field audiometry, Cochlea Scan estimated significantly better thresholds at 2 kHz, 3 kHz, 4 kHz, and 6 kHz At 1.5 kHz not enough data could be collected. The differences ranged from 28 dB at 1.5 kHz to 42 dB at 6 kHz (28/ 29/ 38/ 38/ 42 dB). The air conduction audiometry provided significantly better thresholds than Cochlea Scan at 1.5 kHz, 2 kHz, and 3 kHz and significantly worse thresholds at 6 kHz. At 4 kHz the difference was not significant. The differences were smaller compared to sound field and ranged from 11 dB at 2 kHz to -6 dB at 6 kHz (7/ 11/ 4/ 1/ -6 dB). Frequency dependence was tested with an ANOVA. Only Cochlea Scan thresholds showed frequency-dependency (ANOVA, $F(4,706)=42.86$, $p<0.001$): The significantly highest mean Cochlea Scan threshold of 22 dB ($p<0.001$) was found at 2 kHz, the significantly lowest mean threshold of 6 dB was found at 6 kHz ($p<0.001$). Frequency was no significant factor in air conduction audiometry ($F(5,687)=1.84$, $p=0.10$) and in sound field audiometry ($F(5,120)=0.29$, $p=0.92$).

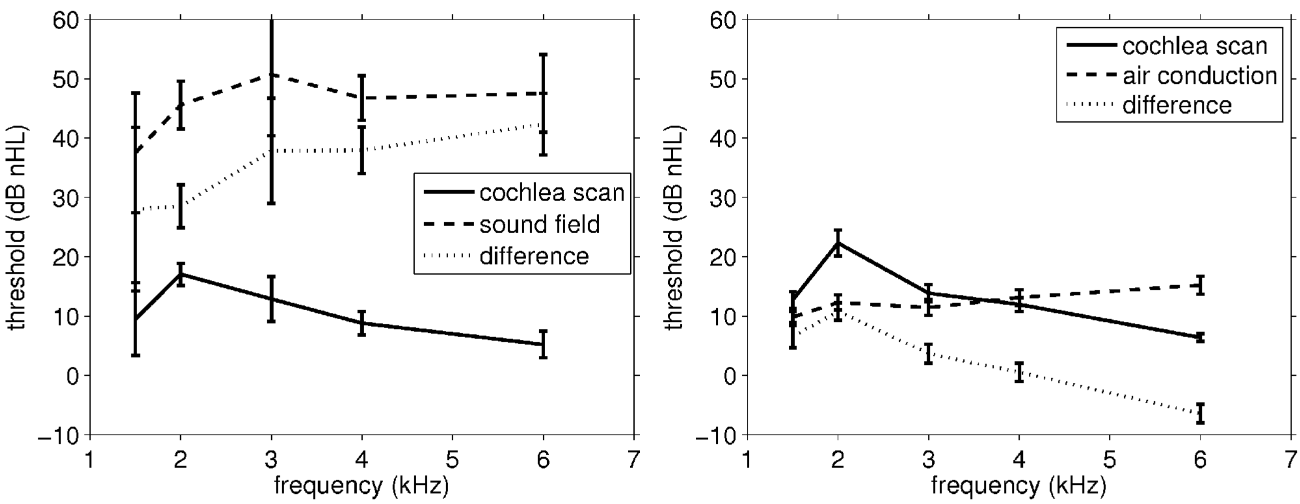

Figure 1: Threshold estimations with cochlea scan (straight line) and sound field audiometry on left (dashed line) as well air conduction audiometry on right (dashed line) and their differences (dotted lines) are shown. Errorbars display standard errors of mean.

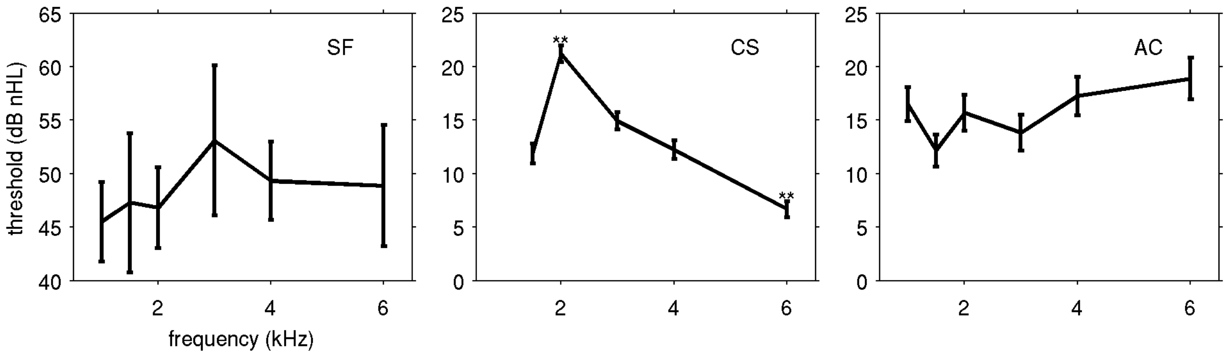

*Figure 2: Dependency between estimated thresholds and frequency is shown. Significant variations are marked by ** (p<0.001) Left: thresholds estimated by sound field audiometry (SF), middle: thresholds estimated by cochlea scan (CS), and right: thresholds estimated by air conduction audiometry (AC)*

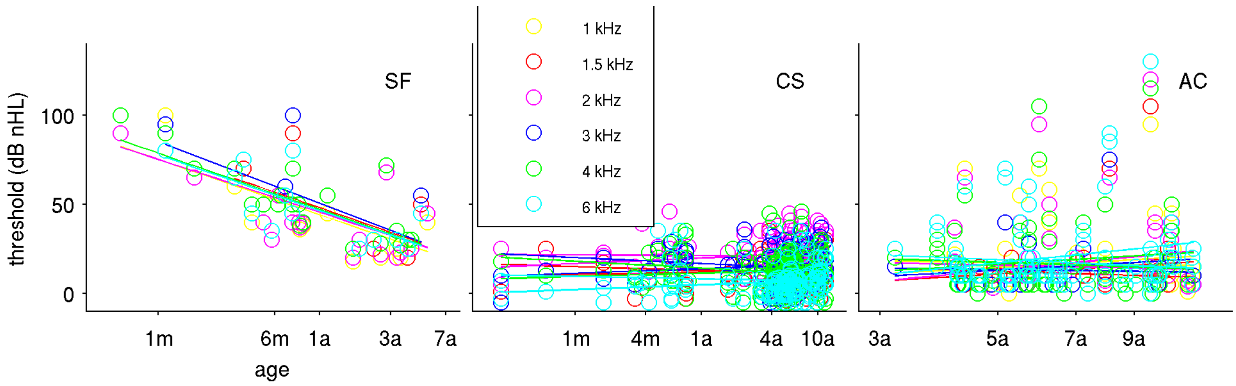

Figure 3: In the left thresholds of sound field audiometry (SF), in the middle thresholds of cochlea scan (CS), and in the right thresholds of air conduction audiometry (AC) are shown against age. The dots mark the single thresholds for each frequency. The straight lines denote a linear fit of the thresholds to the logarithm of age for each frequency.

Correlations between the thresholds and the logarithm of age were calculated for each method. Only sound field audiometry showed a significant correlation (r = 0.71, t-test, p<0.02) to the logarithmic age. The supposed linear correlation did not explain the variance of the thresholds of cochlea scan and air conduction audiometry.

Discussion

Despite the unexpected variation of thresholds with frequency (lowest threshold at highest frequency), Cochlea Scan provides a valuable tool to measure peripheral hearing thresholds in newborns, infants and young children. The threshold variation might be due to standing-wave problems in the ear canal (Whitehead et al., 1995) or due to the algorithm extrapolating the threshold from supra-threshold distortion product measurements.

Using Cochlea Scan to measure the cochlear function independently of age, side specifically and frequency specifically is superior to sound-field audiometry. There was no advantage in comparison to air conduction audiometry. Nevertheless, we have to keep in mind that middle ear pathologies can influence the results, hearing loss can only be estimated up to 50dB, and supracochlear damage cannot be ruled out by otoacoustic emission measurements.

Acknowledgment

This study was supported by the Rolf-Dierichs-Stiftung. We thank Georg Haveresch for technical assistance and the audiometry team for data collection.

References

Boege, P.and Janssen, T. (2002). Pure-tone threshold estimation from extrapolated distortion product otoacoustic emission I/O-functions in normal and cochlear hearing loss ears. *The Journal of the Acoustical Society of America, 111*(4), 1810-1818.

Whitehead, M. L., Stagner, B. B., Lonsbury-Martin, B. L., & Martin, G. K. (1995). Effects of ear-canal standing waves on measurements of distortion-product otoacoustic emissions. *The Journal of the Acoustical Society of America, 98*(6), 3200-3214.