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Original article

Factors impacting hearing aid performance outcomes for Egyptian hearing impaired children

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ABSTRACT

Despite recent technological advances in the audiologic assessment of children, their hearing aid fitting remains a daunting task.

Aims of study: To assess effectiveness of amplification in children using aided sound field tests and Auditory Behavior in Everyday Life (ABEL) questionnaire and to elucidate factors contributing to poor outcomes.

Methods

Detailed medical history, otoscopic examination, basic audiological evaluation, aided sound field tests and ABEL questionnaire for 114 hearing impaired children aged 4–16 years.

Results

Congenital HL considered the commonest cause of HL (55.3%), 36% had unknown cause and 8.8% of HI had acquired cause. Profound loss in 67.5%, severe in 17% and 54.4% of them (54.4%) were fitted around the age of 3 years. Binaural HA in 88.6% and digital type for 61.4%. There were statistically significant differences between unaided and aided values in sound field tests for HI children.

Poor performance in direct measures and ABEl in children with congenital and profound degree of hearing loss, better response when they were fitted earlier with digital aids. ABEL scores showed negative correlations with aided tonal sound field test and positive with aided speech discrimination score.

Conclusions

Inappropriate amplification, late age of fitting with no speech therapy were clinical red flags for poor outcomes. ABEL questionnaire was a valid procedure to assess the hearing aids appropriateness.

1. Introduction

Hearing loss in children, independently from degree, can take to a series of perceptual impairments, and causes secondary deficiencies involving the cognitive, emotional, social and educational aspects. To minimize these long term negative consequences, the diagnosis and the efficient early intervention are necessary.[1]

Despite recent technological advances in the audiologic assessment of infants and children, hearing aid fitting in this population remains a daunting task and the adaptation of such devices in the pediatric population is a quite difficult task. Even those who routinely assess very young children seek further validation of the fitting selected for a particular child.[2]

The wide variability of fittings among hearing instrument manufacturers, whether programmed based on a validated fitting prescription such as NAL-NL1 or DSL 5, or the manufacturer's own proprietary algorithm underscores the need for verification of fittings.[3,4] One of the primary reasons for utilizing Probe Microphone Measurement PMM is that several studies have confirmed that the manufacturer's initial-fit algorithm often is an inadequate amplification prescription, sometimes providing less-than-prescribed gain in the high frequencies by as much as 20 dB.[5–8] Also, Leavitt and Flexer, Munro et al., reported that software predicted prescriptive gain persistently fall short of real ear targets by clinically significant amounts.[9,10]

To know what the actual hearing aid is doing on the patient who is going to be wearing it, *in situ* validation measurement is needed such as functional gain, but there are clear limitations in its use. Probe microphone measurements provide an excellent option for verifying real-ear performance on a specific patient

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and to ensure the amplification provided by the hearing aid is appropriate for the patient's hearing loss.[81,112]

When probe microphone measures of the child's individual ear canal acoustics cannot be obtained, an average RECD based on the child's age has been found to be more accurate than using manufacturer's proprietary algorithms, but less accurate than measuring real-ear or RECD.[13]

Audiologists can evaluate HA benefits and limitations from using hearing aids for hearing impaired children with number of clinical tests that assess auditory skills in hearing impaired (HI) children he can quantify the behavioral responses of these children in response to the amplified signal provided by the hearing aid, by means of functional gain (direct measures) that is defined as the difference in dB between aided and unaided sound-field thresholds as a function of frequency.[11] Aided speech skills tests in a structured environment are routinely used as a clinical assessment tool; however, there is some evidence that assessment of hearing by audiometry does not always adequately reflect child behavior in daily life.[14]

Ears with significant sensorineural deficit also show greater noise effects than do normally hearing subjects for reasons thought to be related to a loss of precision in cochlear level processing.[15] Speech perception in noise for children with AN/AD and SN type hearing loss was broadly similar and both groups were more affected by noise than their normally hearing peers.

Muñoz et al.,[16] concluded that evidence-based protocols would enhance the audiologists' ability to use aided speech perception testing to estimate real-world listening skills, to guide decisions about habilitative interventions and to monitor and evaluate the success of that intervention.[17] Speech perception in noise tests, to assess hearing aid performance in every day listening situations.

Vidas et al.[14] concluded that formal tests didn't provide a complete picture of the child's auditory progress. One way to overcome this problem is to use a range of tools including interview or questionnaire data (indirect measures) based on reports of observations from parents, caregivers and/or educators that are valuable in assessing full range of child's listening and communicative behavior as they occur in real-world settings.[18–22]

Accurate description of an individual child's auditory behavior is important for a number of rehabilitative decisions, such decision include choosing suitable hearing instrument, identifying areas requiring greatest auditory training efforts, determining effectiveness of current rehabilitation program and or device and evaluating the appropriateness of educational placement.[2]

The commonly used functional assessment tools for infants and children are Auditory Behavior in Everyday Life (ABEL), Early Listening Function (ELF), Infant Toddler Meaningful Auditory Integration Scale (IT-MAIS), Meaningful Auditory Integration Scale (MAIS). ABEL is an appropriate, simple and quick tool for parents to rate children's auditory skills in everyday life aged 4–14 years with bilateral sensorineural hearing loss (SNHL) from mild to profound. ABEL questionnaire consisting of 24 questions, divided into three factors: Oral-Aural, hearing awareness and social skills and speaking, plus the total score.[23]

1.1. Aims of this study

1. To assess the effectiveness of amplification in HI children using direct aided sound field (tonal & speech discrimination in quiet and in noise) and indirect measures (ABEL).
2. To elucidate the factors contributing to poor outcomes.

2. Material and methods

One hundred and fourteen children who were complaining of hearing loss were examined. They were recruited from the Audiology unit, Faculty of Medicine, Assiut University Hospital during their routine follow-up post hearing aid fitting. They were 55 (48.2%) girls and 59 boys (52.7%) aged at participation from 4 to 16 years with normal intelligence (a score of 80 or higher on a standard Stanford Binet test of intelligence).

The participants had bilateral SNHL of varying degree (moderate – profound) according to the arithmetic average of thresholds obtained at 500, 1000 and 2000 Hz)[24] and various etiologies.[25,26] All of them were fitted with hearing aids for at least 3 months and they were classified based on degree, duration of hearing loss and age of fitting.

Any evident health problems that prevented observation of the activities listed in the questionnaire (such as mental retardation and/or other serious neurological damage) were considered exclusion criteria.

Parents or caregivers of these children were interviewed aged (20–55 years).

Informed consent was obtained from all parents of the participants and the study was approved by the Ethics Committee of Assiut Medical University. The study was carried out in the period from September 2015 to March 2016.

2.1. Methods

Each child was submitted to careful systematic history-taking procedure from their parents or caregivers with focus on their hearing complaints (onset, duration). A detailed medical history was taken to define conditions causing acquired deafness; social evaluation was also included as family size, parents' education and HA fitting data.

Otoscopic examination: The ear canals were examined to see any external ear abnormality, foreign body, impacted cerumen or perforated tympanic membrane (T.M).

They also underwent a basic audiological evaluation. Behavioral (pure tone or play) audiometry, recent audiograms were made available for all children with hearing impairment that included air and bone conduction thresholds (pure-tone average at the frequencies of 0.5, 1, 2 and 4 kHz in each ear), speech audiometry [speech recognition threshold (SRT) using Arabic spondee words[27] and speech discrimination score (SDS) using Arabic phonetically balanced words[28] were performed using a calibrated pure-tone audiometer (Dual Channel clinical audiometer-Madsen OB 922 GN Otometrics, Cobenhagen, Denmark) with TDH-39 earphones in a sound-treated booth (industrial acoustic company IAC model 1602-A-t, USA) and tympanometry (Interacoustics AZ 26, Denmark).

Speech perception in noise (SPIN) test for children using Arabic version[29] using Panasonic Stereo CD player SA-AK 240,) was connected to the audiometer and adjusted to deliver recorded speech stimuli. This test reflects the selective auditory attention ability. It consisted of 20 Arabic meaningful sentences within the vocabulary of children. The length of these sentences ranged from 4 to 8 words. These sentences were recorded with background speech noise at S/N = 0dB. They were presented monaurally at 40 dB SL (ref. SRT) or at most comfortable level (this test could be done only for children with hearing loss up to moderately severe due to limit of the equipment). Scoring was calculated by counting the number of correctly identified sentences (repeating meaning of sentence with errors in some words was considered a correct response), 5% correct score was given to each correctly identified sentence. The percent scores were calculated for each ear.

Auditory brainstem response (ABR) Nicolit Spirit equipment (USA) was also used when deemed necessary to establish or confirm hearing loss threshold The accuracy of predicting the actual hearing threshold using ABR is quite good, generally within 10 dB.[30,31]