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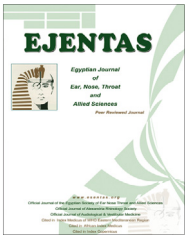

ORIGINAL ARTICLE

The effect of using integrated signal processing hearing aids on the speech recognition abilities of hearing impaired Arabic-speaking children

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KEYWORDS

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Abstract *Background:* Integrated signal processing (ISP) uses a coordinated and concerted approach to signal processing so that both wearer and environmental information, along with the intermediate results of each processing unit, are shared among other signal processing units.

Aim: The aim of this work was to evaluate the benefits of ISP, if any, in pediatric hearing aid (HA) users.

Methods: This study was conducted on 16 Egyptian children with bilateral moderate to severe sensorineural hearing loss. Children's performance was assessed using their own digital HAs and using newly-fitted ISP HAs. Evaluation was repeated at 1 and 6-month post-ISP HA fitting. Evaluation included aided sound field threshold estimation and speech recognition in noise tests. Parents were asked to fill the WILSI self-assessment-questionnaire.

Results and conclusions: Significant improvement in aided sound field threshold levels and speech recognition in noise tests was recorded using ISP HAs over time. As regards consonant manner, glides and stop consonants showed the highest improvement. Though voiced and voiceless consonants were equally transmitted through digital HAs, voiced consonants were easier to perceive using ISP HAs. Middle and back consonants were easier to perceive compared to front consonants using both HAs. Application of WILSI self assessment questionnaire revealed that parents reported better performance in different listening situations. In conclusion, results of the present study support the use of ISP HAs in children with moderate to severe hearing loss due to the significant improvement recorded in both subjective and objective measures.

1. Introduction

Hearing loss in children is a common problem particularly in developing countries. Advances in the identification of infectious diseases at birth, genetic testing and universal hearing screening allow early identification and management of hearing loss.[23] Children with hearing loss usually present with delayed

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language development, scholastic under-achievement, behavioral, psychological, intellectual and social problems.[25,38]

Early application of the suitable amplification devices by the age of 6 months results in the development of speech and language as of normal children.[42] However, hearing aid fitting in young infants presents a unique set of problems, and to some extent, requires a unique set of skills. The selected HAs must be flexible and must be adjusted to account for the acoustic characteristics of a small ear canal. In general, advanced technologies offer the greatest flexibility to meet the challenges of the infant HA fitting.[34] A great number of clinical studies have been conducted to quantify the effectiveness of advanced HA features as adaptive directionality, noise reduction and speech enhancement algorisms dynamic feedback cancelation and frequency transposition in improving speech intelligibility.[29,43,17,6,3,4]

ISP is a relatively new technology incorporated in HAs which uses a coordinated and concerted approach so that both wearer and environmental information, along with the intermediate results of each processing unit, are shared among other signal processing units in order to achieve the best sound quality and intelligibility.[30] In ISP the various processing features are grouped into 3 functional modules: the high definition sound analysis (HDSA) module which characterizes and classifies the nature of the acoustic environment, the high definition sound processing module which includes all processing functions as compression, noise reduction feedback cancelation and finally the high definition system optimizer module which ensures optimal and efficient operation for all components. The dynamic integrator (DI) coordinates the activities of the three modules with references to the wearer characteristics. The aim of this study was to evaluate the benefits of ISP and the impact on speech perception in a group of Arabic-speaking children.

2. Methodology

2.1. Participants

The present study was conducted on 16 children, 10 males and 6 females with an age range between 6 and 12.5 years and a mean age of 9.62 (±2.19 years). Inclusion criteria included children with bilateral symmetrical sensorineural hearing loss with average or above average intelligence as measured by Hiskey-Nebraska test of Learning Aptitude and not suffering from any neurological disorder. Children with neurological disorders or history suggestive of central auditory processing disorder were excluded. Neonatal risk factors (hypoxia, sepsis, neonatal jaundice) were the frequent causes of hearing loss (50%), followed by heredofamilial (25%) and ototoxicity (12.5%) while in 12.5% of children no evident cause of hearing loss was present. Fourteen children had severe hearing loss, one child had moderately severe hearing loss and one child had moderate hearing loss.

All children regularly used different models of binaural digital HAs for at least 6 months with a mean duration of HA use of 2.59 (±2) years and a range of 6 months to 7 years. All children used WDRC in their digital HAs. Sixty-three percent of children used static feedback management while 37% of children used dynamic feedback management in their digital HAs. Neither directionality nor noise management algorithms were used in children's digital HAs. All children were referred to Phoniatric Unit Ain Shams University hospitals for speech and language therapy after hearing aid fitting.

2.1.1. Methods

All children were tested in three sessions, initial evaluation using the child's own hearing aid followed by using Integrated Signal Processor Hearing Aid (ISPHA) 1 and 6 months after fitting.

2.1.2. Initial evaluation session

A formal written consent was obtained from parents of all children participating in this study. Children were submitted to full history taking, basic audiological evaluation, aided sound field hearing threshold, speech recognition-in-noise tests at zero signal to noise ratio (SNR) using the child's digital hearing aid. Parents were asked to fill in the Widex Infant Listing Skills Inventory WILSI self assessment questionnaire in relation to their child's own digital hearing aids.

2.1.3. ISP HA fitting session

Two Widex Flash 19 HAs were fitted to the child and adjusted using the NOAH and Widex Compass programing system with the following features: Dynamic integrator, including the following features 5 bands and 5 channels, speech and noise tracer, sound diary and data logging (with multi-directional dynamic feedback cancelation, adaptive extended dynamic range compression EDRC, fully adaptive directional microphone and classic noise reduction algorithms) were also utilized. with a maximum gain of 114 SPL at an acoustic input of 60 dB at 1600 HZ ANSI S3.22.

2.1.4. Post-fitting evaluation sessions

These were carried out 1 and 6 months post ISP HA fitting, including aided sound field hearing threshold, in double-walled sound-treated booth IAC 1602, using two-channel audiometer GSI 61. Warble tones were used to estimate aided thresholds. Meanwhile speech recognition-in-noise tests were performed at zero degree azimuth at a distance of 1 meter from loudspeaker. Speech materials (word, consonant and sentences) were presented according to the language age in speech in noise tests with speech noise presented at zero SNR.

WILSI questionnaire developed by Anderson and Smaldino[1] was filled out by parents after counseling and was repeated at 1 and 6 month-post ISP HA fitting intervals for all children. It was translated to suit Egyptian children[50] and it consisted of 3 sections. Section 1 consisted of environmental sounds with 5 situations, Section 2 speech sounds with 6 situations and finally Section 3 speech production with 5 situations. Sixteen children completed the initial and 1-month-post fitting evaluation sessions while nine children completed the 6-month-post fitting evaluation session. Seven children did not complete the study either due to lack of motivation and/or unrealistic expectations.

Arabic speech perception tests were used in the evaluation of the outcome of the ISP HA. These included CDs for pediatric speech recognition-in-noise tests.[46,47,14] Table 1 shows the Arabic speech test battery used in this study. *PBKG* is an open-set test composed of 8 lists. Each list is composed of 25 consonant–vowel consonant CVC or CVCC monosyllabic