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Effect of digital wireless technology on the language development of children with cochlear implants

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Effect of digital wireless technology on the language development of children with cochlear implants

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Original Article

Effect of digital wireless technology on the language development of children with cochlear implants

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Abstract

Introduction

Hearing is the principal sensory modality by which language and speech are acquired. For that reason, a child with hearing loss whose family chooses an auditory approach for learning language must have as much exposure to high-quality auditory stimulation as possible. Both hearing aids and cochlear implants (CI) are best in quiet and close places, but not so good at a distance, in noise or when sounds bounce around. Children with CI have significant difficulty in hearing conversational speech in the presence of background noise. They may have difficulty understanding soft speech signals due to distance and reverberation. Assistive listening technology is impressive and can be a big help for CI children. So, if CI children have unique needs that are not addressed by his CI, assistive listening devices (ALDs) can be the answer. Using the Roger inspiro system as a wireless communication accessory provides a significant increase in speech understanding in high levels of noise, by its wireless remote microphone.

Aim

The aim of the study is to monitor the effect of digital wireless technology (Roger inspiro) on the language development of children with cochlear implants.

Participants and methods

The present randomized case–control study included 20 children with CI using Roger inspiro during rehabilitation sessions as an ALD (11 boys and nine girls) with ages range from 5.3 to 11.6 years with a mean age of 5.9 years as well as 20 age- and sex-matched CI controls without ALD (10 boys and 10 girls). All children in the study or the control groups had bilateral severe to profound sensory neural hearing loss and they used advanced Bionics CI. Phoniatrics and Audiological assessment was done before auditory and language therapy for both groups. Reassessment was done after 6 months of therapy.

Results

Results show that there is a statistically significant improvement in The Word Intelligibility by Picture Identification (WIPI) scores after rehabilitation and with Roger. However, there is no significant difference between study and control groups as regards receptive, expressive, and total language. Highly significant correlation between WIPI results and expressive language results after therapy with Roger was found.

Conclusion

Coupling of wireless technology to CIs might help children improving their auditory access. The study supports the use Roger inspiro in enhancing speech perception for children with CI. The preliminary results also show the usefulness of wireless technology in the development of language skills in these children.

Keywords: Cochlear implant, Roger inspiro, WIPI test, wireless technology

Introduction

Hearing is the principal sensory modality by which language and speech are acquired. For that reason, the child with hearing loss whose family chooses an auditory approach for learning

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language must have as much exposure to high-quality auditory stimulation as possible [1]. The technological development of communication aids for children and adults with hearing loss has progressed rapidly over the last decades. Quality has improved and the number of different types of aids has increased. However, few studies have examined the prevalence of technology use and interpreting services use among hearing impaired children with hearing aids or cochlear implants (CIs) [2]. Both hearing aids and CI are best in quiet and close places, but not so good at a distance, in noise or when sounds bounce around (reverberation) which are the big three problems for all listeners, but they are especially difficult for children with CI [3]. CI users report problems in understanding speech in noise even with the latest technology; speech recognition is more susceptible to background noise than that of normal hearing children [4]. Children with CI also have significant difficulty in hearing conversational speech in the presence of background noise [3], which can be solved by using frequency-modulated (FM) systems. Use of an FM system combats the deleterious effects of noise and reverberation in the classroom by improving the Signal-to-noise ratio (SNR) at the child's ear. The SNR improvements are achieved when the teacher uses an FM transmitter, which sends the signal to an FM receiver. Once the FM receiver detects the speech signal from the transmitter, the information is sent through a receiver electrically coupled to the child's CI speech processor [5]. FM systems transmit sound using radio waves from a microphone that is worn or used by a teacher, parent, or any other communication partner directly to the child. This system is often called remote microphone hearing assistance technology (RM-HAT). When a teacher, parent, or conversational partner wears an RM-HAT system, the microphone on the RM-HAT picks up the speaker's voice and transmits that signal directly to the child's hearing aid or CI [6]. This direct transmission avoids the interference from background noise or reverberation. Sound received from an RM-HAT system is then processed through the child's hearing aid or CI. The most frequent place where RM-HAT systems are used by children is in the classroom, as the large group listening environment typically has interfering background noise and the teacher and students speak from more than a few feet away [6]. Roger inspiro is a digital wireless communication accessory providing a significant increase in speech understanding in high levels of noise, by its wireless remote microphone [7,8]. Roger reduces sound distortion, reduces listening fatigue, improves voice clarity and understanding, and improves hearing at a distance from the speaker. These benefits are reflected to the performance of the children with CI [8]. By using Roger systems the child becomes: more attentive to sound, increases searching for sound, increases verbal input to the child, increases interaction in noisy places, dancing to music, and following direction better [9].

Aim

To monitor the effect of digital wireless technology (Roger inspiro) on language development of children with CI.

Participants and methods

The present randomized case–control study included 20 children with CI using Roger during rehabilitation sessions as an assistive listening device (ALD) (11 boys and nine girls) with ages range from 5.3 to 11.6 years with a mean age of 5.9 years as well as 20 age- and sex-matched CI controls without Roger use (10 boys and 10 girls), with the same age range, for comparison. All children in the study or the control groups had bilateral severe to profound sensory neural hearing loss. They used an advanced Bionics CI harmony processor and as wireless communication, Roger inspiro transmitter was used in combination with Roger X receiver. The patients were recruited from the Phoniatrics and Audiology Departments of the Hearing and Speech Institute. The approval of the local ethics cochlear implant committee in Hearing and Speech Institute as well as a fully informed consent from each of the parent of the participating patients was obtained.

Inclusion criteria

(1) All children wearing CI for at least 1 year.
(2) All children with prelingual hearing impaired, and using verbal communications.
(3) Regular programming of all children with CI performed at the Audiology Department at Hearing and Speech Institute.
(4) All children were regularly having auditory language therapy sessions at the Phoniatrics Department.
(5) All children with average mental abilities.

Exclusion criteria

(1) Children with below average mental abilities.
(2) Children who did not regularly use CI or ALD.
(3) Children who did not regularly follow up the auditory and language therapy sessions.

The therapy program was applied from October 2017 until March 2018 for 6 months continuously (three times per week). All children had regularly auditory and language therapy sessions at the Phoniatrics Department, at the Hearing and Speech Institute with a Roger system for one group of children for 6 months continuously, while the other group had therapy without the Roger system.

The first assessment was done before therapy for both groups. The assessment was done in the presence of their mother to reassure the children. Then the second assessment was done after 6 months of auditory and language therapy sessions. The assessments included the following:

(1) Language assessment using modified preschool language scale-4 (Arabic edition). This test measures receptive, expressive, and total language age [10]. The language improvement quotient [10] was used to compare between the rates of progress in language and was determined by calculating the difference between the language age in a period divided by the period of time. For example, language improvement quotient after 6 months=(language age in months after 6 months of therapy − language age in months before the therapy)/6 months.

(2) The intelligence quotient using Stanford–Binet Intelligence Scale (1986) [11].
(3) Audiological assessment which included the following:
    (a) Aided free-field response performed for children with CI on beginning of assessment and at the end of 6 months for both cases and control groups.
    (b) The Arabic WIPI (word intelligibility by picture identification) test was done at 1 month and after 6 months of rehabilitation using Roger Inspiro in noise with live voice. Test presented via loudspeaker at sensational level (40 dBSL) according to their aided threshold with embedded narrow band noise at a signal to noise ratio + 10 with the aid of two examiners, one to administer test items via a loudspeaker, the other turning on the page for the child after selecting the test item. This test was developed by Ross and Lerman [12] and remains among the most widely used tools for pediatric word recognition assessment [13]. The speech material is within the vocabulary of the child and it is sometimes necessary to use reinforcement such as a smile or hand clapping to keep children interested in the task [14]. All test items were presented with a carrier phrase (show me….). A practice item was presented prior to testing to be sure that the child understands the idea of test, the child responds to the item by pointing to one of the six pictures on a page. A recorded version of the test is available, but live voice is preferred by most clinicians [15]. The examiner scored each item by marking down the number associated with the right selection; the number of correct responses and the number of errors are calculated.

Statistical analysis

The statistical analysis was performed using 'SPSS 20 for windows' software statistics version (SPSS Inc., Chicago, Illinois, USA). The obtained data were tabulated and statistically analyzed to evaluate the differences within and between the groups under study. Correlations between the essential studied parameters were determined. The statistical analysis included the arithmetic mean, SD, hypothesis Student's '*t*' and Pearson's correlation tests. *P* values less than 0.05 were chosen as the level of significance. All results are presented as mean ± SD.

Results

The sample composed of 20 children with CI trained with Roger inspiro as an ALD (11 boys and nine girls) with age-matched and sex-matched CI controls not trained with Roger inspiro (10 boys and 10 girls). The percentage of males to females is shown in Fig 1.

All children in the study or the control groups had bilateral severe to profound sensory neural hearing loss; they used advanced Bionics CI. Their aided postoperative response was done initially at the beginning of the study and after 6 months

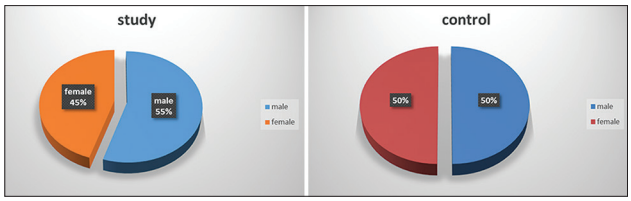

Figure 1: The percentage of males to females.

which showed no statistically significant difference between both groups.

Table 1 shows that there is statistically significant difference between WIPI test results in children with Roger during language and auditory therapy and children without Roger in both prerehabilitation and postrehabilitation conditions regarding speech recognition. The table shows that there are higher scores of speech recognition in the group of children with Roger postrehabilitation. The statistically significant difference between WIPI results with and without Roger under prerehabilitation and postrehabilitation conditions is represented in the right column. However, the highly significant difference in speech recognition between results of prerehabilitation and postrehabilitation conditions with and without Roger is clarified in the bottom last row.

Comparison between study group (children trained with Roger) and control group (children trained without Roger) regarding receptive, expressive, and total language quotient (language improvement after therapy) showed no significant difference (Table 2). However, there were increased rates of language domains. Receptive language showed an increase by 12% ($P = 0.363$); expressive language also showed an increase by 28.5% ($P = 0.267$); and total language showed an increase by 25.3% ($P = 0.104$). The highest increase was in the expressive language domain.

There is no significant correlation between WIPI results and receptive, expressive, and total language results before therapy with Roger. However, there is highly significant correlation between WIPI results and expressive language results after therapy with Roger as shown in Table 3.

Discussion

Sensorineural hearing loss can have a significant impact on a child's ability to perceive speech in noise and in quiet conditions. As a result, remediation is necessary to facilitate language development. The use of amplification has generally been the first step in this process. Advances in hearing instrument technologies over the last decade have provided people with hearing loss benefits of comfort and enhanced speech recognition and language development. Particularly, the use of FM systems has been shown to enhance speech perception in children [16].

In this study, the sample composed of 20 children with CI using Roger during therapy as an ALD as well as 20 age- and sex-matched CI controls not using Roger; there is no statistical

Table 1: Mean and SD of WIPI test score in prerehabilitation and postrehabilitation conditions with and without Roger

Condition	Without Roger (mean±SD)	With Roger (mean±SD)	*P*
Prerehabilitation	50.66±5.09	57.333±4.96	0.000
Postrehabilitation	76.66±5.97	84.333±4.57	0.034
P	0.000	0.000	

Table 2: Comparison between the study group (with roger) and control group (without roger) as regards receptive, expressive, and total language

	Mean±SD	*t*	Significance
Receptive language quotient			
With Roger	1.182±0.382	0.972	0.363
Without Roger	1.037±0.145		
Expressive language quotient			
With Roger	0.816±0.487	1.205	0.267
Without Roger	0.582±0.283		
Total language quotient			
With Roger	1.001±0.336	1.870	0.104
Without Roger	0.747±0.529		

Table 3: Correlation between WIPI and language results with Roger before and after therapy in the study group

	Pre-therapy (mean±SD)	*P*	Post-therapy (mean±SD)	*P*
WIPI	58.5±12.08	0.686	81.00±11.4	0.246
Receptive language	1.03±0.14		1.20±0.85	
WIPI	58.5±12.08	0.667	81.00±11.4	0.000
Expressive language	0.58±0.283		0.63±0.287	
WIPI	58.5±12.08	0.957	81.00±11.4	0.061
Total language	0.747±0.53		0.955±0.21	

difference as regards age between the study and control groups ($P = 0.785$).

By comparing between the study group (with Roger) and the control group (without Roger) a statistically significant difference between WIPI results with and without Roger under both prerehabilitation and postrehabilitation conditions regarding speech recognition was observed. However, there was a highly significant difference in speech recognition between WIPI results of prerehabilitation and postrehabilitation conditions with and without Roger. This agreed with a study done by Thibodeau [7] at the Callier Center for Communication Disorders, and revealed that the use of Roger systems in combination with hearing instruments resulted in significant improvements in speech understanding in noise at 65–80 dB(A) noise levels over traditional and dynamic FM technologies. The average improvement in speech recognition afforded by Roger over dynamic FM at the 80 dB(A) level was 35%. At 75 dB(A), there was an improvement of 54% over traditional FM. Roger was also the preferred technology of most listeners in the study in real-world listening situations.

By comparing between the study group (with roger) and control group (without roger) as regards receptive, expressive, and total language, the language measures did not result in significant differences between the groups, but there were increased rates of language domains. Receptive language showed an increase by 12% ($P = 0.363$); expressive language also showed an increase by 28.5% ($P = 0.267$); and total language showed an increase by 25.3% ($P = 0.104$). So the expressive language showed the best improvement which indicates that the Roger system has an important role in language development.

A study by Moeller *et al*. [17] used the formal language measures to compare two groups of 2–4-year-old children. One group was encouraged to use FM as much as possible at home and the other group used hearing aids alone. While the language measures did not result in significant differences between the groups, some participants had increased rates of language acquisition which suggested they received benefit from the use of FM. Moeller *et al.* [17] also discussed the impact of FM systems on speech intelligibility. Differences were noted when comparing parental records of the children's performances. The parents in the FM group reported that their children asked for repetitions or clarification less often than others not using FM systems. The FM group parents reported higher comprehension in their children's understanding and participation in conversations. However, the FM group was found to have higher reports of pragmatic skills, language complexity, and speech intelligibility.

As regards the correlation between WIPI results and language age results with Roger before and after therapy in the study group, there is no significant correlation between WIPI results and receptive, expressive, and total language results before therapy with Roger *P* values of 0.686, 0.667, and 0.957, respectively. Otherwise, there is highly significant correlation between WIPI results and expressive language results after therapy with a Roger *P* value of 0.000**, while both receptive and total language showed no significant correlation with a *P* value of 0.246 and 0.061, respectively. These results indicate the effect of using Roger in the development of expressive language. The results of this study agreed with Gabbard [18] who noted that FM systems help by improving the listening environment by eliminating the speaker-to-listener distance, increasing signal to noise ratio, and improving room reverberation conditions for adults and children. Another study by Madell [19] compared hearing aid usage to the use of FM systems with an active environmental microphone with three participants between the ages of 3 and 5 years. He noticed a significant advantage with the FM system in speech recognition results; the participants showed an improvement of 5–20 dB, particularly greater gains in the frequency regions needed for speech.

A further study by Wolfe *et al.* [20] looked at the latest technology in the area of digital transmission of the signal

between the transmitter and the receiver. This system no longer uses FM, and therefore technically speaking can no longer be referred to as an FM system. The Phonak Roger system, the new wireless technology standard, features an adaptive gain adjustment. The participants were 16 CI recipients fitted with an Advanced Bionics Harmony speech processor and 21 recipients fitted with a Cochlear CP810 processor. The Phonak Roger inspiro transmitter was used, and the FM receivers were coupled to the CI speech processors using the iConnect FM earhook and the Europlug adaptor, respectively. Speech perception results were significantly better in all the FM conditions compared with the no-FM conditions. At the highest noise levels, the Roger system provided significantly better speech perception. This additional advantage over the analog adaptive gain system may be due to the wider bandwidth provided by the digital system or due to clearer signal transmission.

Conclusion

Coupling wireless technology to CIs might help children improve their auditory access. The study supports the use of Roger inspiro in enhancing speech perception for children with CI. The preliminary results also reveal the usefulness of wireless technology in the development of language skills in these children. However, a longer period of time is needed to evaluate the participants using Roger systems that would allow researchers to interpret meaningful changes to language development. The current researches are insufficient and further research needs to be conducted on this subject.

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Conflicts of interest

There are no conflicts of interest.

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