Effect of Articulation Disorders on Interpretation of Word Recognition Scores in Hearing Impaired Children with Cochlear Implant

Original Article

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ABSTRACT

Objectives: Speech recognition tests are used to explain the accuracy of patient auditory reception and processing of speech material. There will be a problem when testing children because their speech recognition scores are affected by their level of language development and their auditory capabilities. This prospective study was designed to compare word recognition test scores -Arabic version- before and after phoniatric evaluation and application of Arabic articulation test in children using cochlear implant aiming at evaluating effect of articulation disorders on interpretation of word recognition scores.

Methods: Forty-six children enrolled in Med El cochlear implant program divided into 4 groups according to language assessment. Aided word recognition test was performed before and after application of Arabic articulation test that detects speech and articulation errors including substitution, phonological processes, right words and wrong words.

Results: Scores of word recognition test of study groups were improved after phoniatric evaluation and application of articulation test and reflected the importance of duration of language rehabilitation and use of cochlear implant.

Conclusion: Speech production errors could contaminate the results of open-set speech perception tests and the application of standardized articulation test aids in real estimation of word recognition in children with cochlear implant.

Key Words: Auditory perception; cochlear implant; hearing impairment; speech articulation; word recognition.

Received: 06 January 2021, **Accepted:** 07 April 2021

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ISSN: 2090-0740, 2022

INTRODUCTION

Today, Cochlear implant (CI) is considered the solution of severe to profound hearing-impaired adults and children. CI is performed for a wide variety of causes leads to hearing loss[1]. Auditory stimulation from a CI early in life should be expected to influence most cognitive functions as a consequence of the plasticity of the brain in a young child[2].

Language as an outcome measure for assessment of a medical/surgical intervention was a new concept which was rapidly assimilated into the care of the prelingually deafened child. Children with hearing impairment show delays in verbal semantic ability throughout the developmental period. They show difficulty in using concept words, figurative and multiple meanings. In addition to troubles in understanding connected discourse in both spoken and written modes[3]. In addition, they always have element of delayed language development in all parameters (semantics, syntax, pragmatics & phonology), with decreased vocabulary size at word level together with decreased ability to utter complete sentences with complete phrase at sentence formulation level (sentence simplification)[4].

Speech perception and production are the main goals for CI. Previous studies showed a large variability in speech perception abilities in users of CI because of many factors[5,6,7]. In the first years after the advent of CI, may authors have assessed speech perception skills in CI users many frequently. Today, the used speech assessment batteries of hearing in adults and children using CI consist of monosyllabic words and sentences presented either in quiet and noisy situations[8,9]. The Phonetically Balanced Kindergarten (PBKG) Word Test[10] is still one of the most commonly used tests to assess speech perception abilities in hearing impaired children. An Arabic version of PBKG word lists was developed in 1984[11].

 DOI: 10.21608/ejentas.2021.56874.1302

Speech recognition tests are used to explain the accuracy of patient auditory reception and processing of speech material. There will be a problem when testing children because their speech recognition scores are affected by their level of language development and their auditory capabilities[12]. There is currently considerable discussion about the difficulties seen in speech recognition tests whether they are due to a low-level deficit affecting auditory discrimination, or they reflect impairment of a specialized language processing system[13].

Speech production disorders affects interpretation of word recognition (WR) test that may affect scores in either over or under estimation way. Accordingly, this prospective study was designed to compare WR test scores -Arabic version- before and after phoniatric evaluation in children using CI. Phoniatric evaluation detected speech production disorders that may affect percent correct scores of WR test.

PATIENTS AND METHODS

Patients

The study group consisted of 46 children with profound SNHL enrolled in Med El CI program. The study was conducted in Audiology unit at Otorhinolaryngology Department. They were programmed initially using behavioral programs.

Inclusion criteria included children 4 to 6 years old using CI with satisfactory aided response, average and above average IQ and receiving aural and oral rehabilitation.

Hearing impaired children with other causes of velopharyngeal insufficiency was excluded from the study including children with cleft palate, post-adenotonsillectomy and neurologically affected children.

This study was performed after fulfilling the requirements of the ethical committee at the ENT Department and the approval of the Institutional Research Board of the Faculty of Medicine in our University. Written informed consent was also obtained from all the patients who participated in this study. All patients presented written informed consent in accordance with the Declaration of Helsinki.

Equipment

1. Computer based programming Software and a programming unit for MED-EL (MAESTRO) cochlear implant device
2. Two channel pure tone diagnostic audiometer model (Madsen Itera II)
3. Sound treated room (locally made).

Method

1. Full medical and otologic history.
2. Otologic examination.
3. Aided audiological evaluation: using warble tones in a sound field at 0.5,1,2 and 4kHz. presented via loudspeakers placed at a 45 degrees azimuth at a distance of one meter from the child. The child response to sound was obtained using visual reinforcement audiometry or conditioned play audiometry. According to the aided thresholds, satisfactory aided response was considered using pure tone threshold better than 40dB at each tested frequency.
4. Aided WR test: using Arabic version of PBKG word lists (Soliman and Elmahalawi, 1984) delivered via a sound field of 55 dB HL. Arabic version of PBKG word lists was used to assess percent correct score for word recognition. It is an open set test composed of 8 lists. Each list is composed of 25 CVC or CVCC monosyllabic words. Items of each list are phonetically balanced.
5. Complete phoniatric evaluation.

Language assessment using the Preschool Language Scale-4 "Arabic Version"[14] for determination of language age. Language ability of the children were classified into 4 groups:

- Group 1: CI children uttering single words.
- Group 2: CI children uttering simple sentences (2 words sentence)
- Group 3: CI children uttering complete sentences (3-4 words sentence)
- Group 4: CI children uttering long sentences.

Mansoura Arabic Articulation Test [M.A.A.T.][15] for detection any speech disorders (fixed disorder and phonological processes). A 106 pictures–naming test was designed to elicit spontaneous single word responses representing all possible initial, middle, final and double positions of consonants and vowels. For facilitation of articulation test results, speech disorders divided into 4 categories: substitution, phonological processes, right words and wrong words.

Aided WR test after phoniatric evaluation: corrections of scoring of WR after correlating speech disorders obtained by M.A.A.T with the Arabic version of PBKG word list. The results of M.A.A.T test included wrong words, substitution, phonological processes and right words. Speech disorders including substitution, phonological processes and right words was considered correct and included in percent correct scores of WR test.

RESULTS

There was no statistical significance difference among all groups as regards sex, age, duration of implantation and language rehabilitation (Table 1).

Descriptive analysis of Articulation test of each group as regards (wrong words, Substitution, phonological Process and Right words) was mentioned in (Table 2).

When scores of WR in each group before and after phoniatric evaluation were compared, there was

statistically significant difference as shown in (Table 3). (Table 4) showed significant correlation between WR scores after phoniatric evaluation and duration of language rehabilitation and implantation.

Before phoniatric evaluation, there was statistically significant difference among all groups in WR scores. By pairwise comparison using Man Whitney test, there was statistically significant difference between all groups except between group (1) and group (2) (Table 5). After phoniatric evaluation, there was statistically significant difference among all groups in WR scores. By pairwise comparison using Man Whitney test, there was significant difference between group (1) and group (3), group (1) and group (4) and group (2) and (4).

Table 1: Comparison among all groups according patient's characteristics

	Group (1) (N=10)		Group (2) (N=14)		Group (3) (N=11)		Group (4) (N=11)		Test of significance (p)
	%	No.	%	No.	%	No.	%	No.	
Sex									
Male	2	20	5	35.7	4	36.4	7	63.6	(MCP=.5)
Female	8	80	9	64.3	7	63.6	4	36.4	
Age (years)	Median (Min-Max)								
	5 (4.5 - 6)		4.5 (4 - 6)		5.5 (4 – 6)		6 (5 - 6)		(H=3.3, P=.189)
Duration of CI use (years)	1 (2m - 1.5)		1.5 (.5 - 3)		2 (1- 2)		2 (.5 - 3)		(H=3.4, P=.189)
Duration of language rehabilitation (years)	1 (1m - 1.5)		1.5 (.5 - 2.5)		2 (1- 2)		2 (.5 - 2.5)		(H=5.8, P=.12)

MCP: Monte Carlo Exact *p value* - H; Kruskal Wallis test - N: number - M: month

Table 2: Descriptive analysis of M.A.A.T results of each study group

	Group (1) (N=10)	Group (2) (N=14)	Group (3) (N=11)	Group (4) (N=11)
Wrong words Median (Min -Max)	18 (8-20)	12.5(5-17)	7 (4 -14)	5(1 -8)
Substitution Median (Min -Max)	3(1 -5)	3(0-5)	2 (1 -7)	2 (0 -3)
Phonological Process Median (Min -Max)	1.5 (0 -3)	7(3 -8)	3(1 -10)	4(2 -7)
Right Words Median (Min -Max)	3(2 -9)	3 (3- 7)	10 (3 -16)	15 (10 -18)

Table 3: Comparison between WR scores before and after M.A.A.T test in each study group

	Percent correct scores of WR before M.A.A.T test	Percent correct scores of WR after M.A.A.T test	Test of significance (p)
Group (1) Median (Min -Max)	12(8 -36)	28(20 -68)	(z = -2.8, P=.005*)
Group (2) Median (Min -Max)	12(12 -28)	50(32 -80)	(z = - 3.3, P=.001*)
Group (3) Median (Min -Max)	40(12 -64)	72(44 -84)	(z = -2.9, P=.003*)
Group (4) Median (Min -Max)	60 (40 -72)	80 (68 -96)	(z = -2.9, P=.003*)

Z; Wilcoxon Test - *: statistically significant.

Table 4: Correlation of percent correct scores of WR before and after M.A.A.T test with age, duration of language therapy and duration of implantation

		WR scores before M.A.A.T test	Age	Duration of language therapy	Duration of CI use
WR scores before M.A.A.T test	(r)	1	.249	.156	.169
	P		.096	.301	.26
WR scores after M.A.A.T test	(r)	1	.16	.277	.296
	P		.28	.06*	.046*

r: Spearman Correlation. - *: statistically significant.

Table 5: Comparison of WR scores among all groups before and after M.A.A.T test

	Group (1)	Group (2)	Group (3)	Group (4)	Test of significance (p)
Percent correct scores of WR before M.A.A.T test: Median (Min -Max)	12 (8 -36)	12 (12 -28)	40 (12 -64)	60 (40 -72)	(H=31.6, P=.0001*)
P1	1				
P2			.007*		
P3				.0001*	
P4		.023*			
P5		.0001*			
P6			.08		
Percent correct scores of WR after M.A.A.T test: Median (Min -Max)	28 (20 -68)	50 (32 -80)	72 (44 -84)	80 (68 -96)	(H=30.99, P=.0001*)
P1	.273				
P2			.002*		
P3				.0001*	
P4		.336			
P5		.002*			
P6			.64		

H; Kruskal Wallis test
P: Significance among all groups assessed by Man Whitney test; p1 Significance between group 1 and group 2, P2: Significance between group1 and group 3, p3: Significance between group1 and group 4, p4: Significance between group2 and group3,
p5: Significance between group2 and group4, p 6: Significance between group3 and group 4.
. *: statistically significant.

DISCUSSION

The present study was a prospective cross-sectional study conducted on 46 hearing impaired children fitted with MED El CI Opus 2. Although study groups did not show significant difference in age, duration of implantation and language therapy (Table 1), WR scores differed significantly before and after phoniatric evaluation and application of articulation test (Table 3&5). In Table (5) before application of articulation test, the statistically significant difference between all groups except between group (1) and group (2) in WR scores could be explained by the percentage of wrong word that are the least in group (4) as shown in Table (2). The significant difference and accordingly improved scores of word recognition after application of articulation test was our hypothesis the present study (Table 3). Hearing impaired children can develop speech but still have many articulation errors in their speech and the examiner cannot precisely detect these errors than can lead to either over or under estimation of word recognition scores. The application of articulation test by phonetician can help in avoiding word recognition scores errors.

Many authors reported that word scores vary widely in the majority of children with CI. Several trials have been made to explain such difference in order to predict performance after CI. Age at onset and duration of hearing loss, residual hearing, course of hearing loss and the regular use of hearing aids are considerable factors that affects speech performance in CI users. In addition, the etiology of hearing loss and its relation to speech performance is questionable[16,17,18].

The WR test performed by PBKJ words is an open-set test in which the child repeats the perceived words and examiner marked it as right or wrong word. This process can be contaminated by speech errors of the child and the sores of WR test can be over or underestimated- according to the present study, Table (2) described speech errors in study groups- this idea was obvious in the present study after application of articulation test and corrections of WR scores obtained before phoniatric evaluation (Table 3). In Table (3), each group showed statistically significant difference regarding the speech discrimination score before and after phoniatric evaluation(p>0.05 for all). But to our best knowledge, no papers discussed this issue until now.

Correlation of scores of WR before and after phoniatric evaluation with age, duration of CI and language therapy showed that scores of WR after phoniatric evaluation were related to duration of CI and language therapy (Table 4). Rönnberg *et al.*[19] concluded that the age of identification and amplification, the amount and type of habilitation are from the weighting factors that contributed significantly to speech perception, speech production, and language outcomes. Accordingly, the scores of WR obtained after application of articultion test is the correct scores that reflectes real speech perception performance in CI users.

CONCLUSION

Speech perception abilities varies considerably in CI users because of many factors. Speech production errors could contaminate the results of open-set speech perception tests and the application of standardized articulation test aids in real estimation of word recognition in children with CI.

It is important to mention the sample sizes for this study were small that affects the generalization of findings. The current study only evaluated few factors that might influence speech discrimination skills. To perform a

more thorough assessment, it may be helpful to obtain information on other potential factors that might have an impact on speech discrimination abilities.

CONFILICT OF INTERESTS

There are no confilicts of interest.

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