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Original Article

Evaluation of the Reading and Writing Skills of Children with Cochlear Implants

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OBJECTIVES: This study aims to evaluate the reading and writing abilities of students with cochlear implants and compare their results with those of their normal-hearing peers. The effect of age at implantation and duration of cochlear implant use were analyzed in relation to the subjects' reading and writing skills development.

MATERIALS and METHODS: The study included 20 students who underwent cochlear implantation and 20 students with normal hearing, who were enrolled during their 6th to 8th grades. The age of the subjects ranged between 12 and 14 years. Their reading and writing skills were evaluated by using the Written Expression Proficiency Assessment Tool and Informal Reading Inventory.

RESULTS: The reading and writing skills of students with cochlear implants were significantly lower than those of their peers with normal hearing. Positive correlations were identified between the reading and writing abilities of students with cochlear implants. Moreover, both the age of implantation and the total time of cochlear implant use had no statistically significant effects on the reading and writing skills of students with implants.

CONCLUSION: Early implantation has positive effects on speech and language skills development, but significant differences in the reading and writing skills of children with implants compared with those of their normal-hearing peers are observed in higher grades.

KEYWORDS: Cochlear implant, reading skills, writing abilities

INTRODUCTION

Hearing-impaired children follow the same semantic process when acquiring the same set of skills compared with their normal-hearing peers when their reading and writing skills are examined. However, owing to the insufficiency of the sound stimuli reaching the brain during the speech and language development, hearing loss can negatively affect both the reading and writing skills of hearing-impaired individuals [1, 2]. Meanwhile, the communication skills of children with hearing loss can be developed with the use of cochlear implants. Such implants have become popular among children with profound hearing loss, particularly those who do not benefit from conventional hearing aids. In primary school, both normal and hearing-impaired children are taught to read and write at the same time under the same educational curriculum. In such a system, hearing-impaired children are included in the same educational program within the same classrooms as their normal-hearing peers. However, when examining the classroom skills of hearing-impaired children, several differences in their reading and written expression skills can be found compared with their normal-hearing peers. For example, in comparison with their normal-hearing peers, hearing-impaired children use fewer words in their written narratives [3].

Cochlear implantation alone is not sufficient to facilitate the development of language and communication skills among hearing-impaired children. Rather, many other factors affect these skills. Some of these include diagnosis time of hearing loss, age upon first usage of hearing aids, history of special education/rehabilitation, training before and after using the device, family education, child's intelligence and memory levels, implantation age, and total usage time of the cochlear implant [4-6]. Furthermore, family income, maternal engagement, and residual hearing before implantation are important factors for accelerated language comprehension of students with cochlear implant [7]. In the literature, the reading and writing skills of hearing-impaired students have

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been separately assessed, and only a few studies have examined the reading and writing skills of children together. Therefore, written language and paragraph reading comprehension ability for Mandarin-speaking children with cochlear implants were evaluated and compared with their normal-hearing peers [8, 9]. In addition, while past studies have assessed the reading and writing skills of hearing-impaired students using hearing aids, only few studies have evaluated the reading and writing skills of children using cochlear implants.

The aim of the present study is to evaluate the reading and writing skills of children using cochlear implants, particularly secondary school children of the 6th, 7th, and 8th grades, and to compare the reading and writing performances of children with implants and their normal-hearing peers. The second aim of the study is to examine the characteristics of students with cochlear implants, particularly those that have a significant impact on the reading and writing skills of students.

MATERIALS and METHODS

The research population comprised 20 students with normal-hearing ability and 20 hearing impaired students using cochlear implants. The students who participated in the research were 12-14 years old and enrolled during their 6th, 7th, and 8th grades. Hearing impaired students had prelingual bilateral severe to profound sensorineural hearing loss and have been using a unilateral cochlear implant for at least two years. All students with implants used hearing aids before implantation except for one. Students with hearing impairment have no additional physical/psychological disabilities other than being hearing-impaired.

The control group of the study comprised children with normal hearing in the same age group who have been going to the same classes (6th, 7th, and 8th grades) in normal primary schools. These children passed the Distortion Product Otoacoustic Emission test with no additional psychological/physiological disabilities.

The present study was approved by the institutional review board. A written informed consent form was obtained from the parents of the patients who participated in this study.

Data Collection

The Written Expression Proficiency Assessment Tool was used to evaluate the participants' writing skills [10], and the Informal Reading Inventory [11] was employed to assess reading skills as well. These tests have been verified in terms of their reliability and validity for research [10, 11].

First, for the evaluation of the writing ability of students, the Written Expression Proficiency Assessment Tool was used. Details about the aim of the study and its estimated duration were given to the students. To evaluate their writing skills, a picture about a traffic jam that was caused by a car with a flat tire in the traffic lights was shown to the students, and they were asked to write a story that was relevant to what they saw in this picture. Then, questions about the picture were asked, and the answers given were evaluated. They were allowed to take their time, that is, no time constraint was applied at this stage.

Later on, the students' written narratives were evaluated over 100 points using the Written Expression Skill Evaluation Form. According to this form, the title is expressed in 3 points, the expression level in 51 points, the narrative richness in 24 points, and the writing rules in 22 points.

In the second part, the Informal Reading Inventory was used for the evaluation of the reading ability of students. The inventory contains stories and informative texts appropriate for students from each grade level. It evaluates the reading ability by using two forms: Reading Assessment Form and Response Forms to Questions.

When the reading was finished, the student was asked talk about the story read to the researcher. Three main criteria were taken into consideration for evaluating the Reading Assessment Form: characters, main events, and details. The researcher evaluated this narration by giving 25 points for the characters, 50 points for the main events, and 25 points for the details of the story. Then, the students were asked to answer questions about the text through the Response Forms to Questions. There were 10 questions in the form and each question was scored with 10 points. The scores of the reading assessment and the Response Forms to Questions related to the text were added and averaged, and the total reading score was calculated.

Statistical Analysis

Results for both the students with normal hearing and those with cochlear implants showed homogeneous distributions of total reading and writing scores. The independent samples *t*-test was used to obtain these results. The relationship between the reading and writing performances of students with normal hearing and cochlear implant was analyzed using the simple correlation method. The effects of implantation age and total time of implant use, which were thought to influence the levels of reading and writing performances, were analyzed by regression analysis. Statistical for Social Sciences version 15 (SPSS Inc.; Chicago, IL, USA) was used for the statistical analysis in the present study.

RESULTS

Table 1 shows the descriptive statistics for the total reading and writing scores of normal-hearing and students with implants. A significant relationship can be found between implanted and normal-hearing stu-

Table 1. Total reading and writing scores of students with normal-hearing and those with implants

	Students with cochlear implants (n = 20)			Normal-hearing students (n = 20)				
Variables	Ave.±SD	Min.	Max.	Ave.±SD	Min.	Max.	t	Cohen's d
Total reading scores	46.40±29.76	0.00	92.00	83.85±5.61	71.00	94.00	-5.23*	1.75
Total writing scores	49.05±22.49	0.00	86.00	82.60±6.68	69.00	95.00	-6.39*	2.02

Ave.: average; SD: standard deviation; Min.: minimum; Max.: maximum

*p<0.001.

Table 1 shows the total reading and writing scores of students with normal-hearing and those with implants. A significant relationship was observed between implanted and normal-hearing students in terms of their total reading scores [t (20.35) = -5.23, p<0.001, Cohen's d=1.75] and total writing scores [t (22.33) = -6.39, p<0.001, Cohen's d=2.02]. In addition, students using cochlear implants received scores lower than those with normal-hearing in both areas.

Table 2. Correlations of total reading and total writing scores of students with cochlear implant

	Age of implantation	Duration of CI use	Total reading score	Total writing score
1. Age of implantation	1			
2. Duration of CI use	-0.61	1		
3. Total reading score	-0.16	-0.15	1	
4. Total writing score	-0.20	0.03	0.86**	1

CI: Cochlear Implantation
**p =.0000001
Table 2 shows the correlations of total reading score and total writing scores of students with cochlear implants. A positive correlation (r=0.86) can be found between the total writing and reading scores students with cochlear implants

Table 3. The effects of cochlear implantation age and the total time of cochlear implant use on writing and reading scores

	Total reading scores				Total writing scores			
	β	t	p	sr	β	t	p	sr
Age of CI	-0.41	-1.43	0.172	-0.323	-0.30	-1.01	0.327	-0.238
Total time of CI use	-0.40	-1.39	0.182	-0.315	-0.16	-0.53	0.603	-0.125
	R2=0.13, F(2,17) = 1.23, p = 0.317				R2 = 0.06, F(2,17)=0.52, p=0.607			

sr: semipartial coefficient; β: standardized regression coefficient; CI: cochlear implantation
Table 3 shows the effects of cochlear implantation age and the total time of cochlear implant use on writing and reading scores. No significant relationship was found between the variables tested. On the other hand, the relationships between the age of implantation and the total time of cochlear implant use and the variables of total reading score and total writing score were examined. No significant relationship was found between the variables being tested and the age of implantation and duration of implant use.

Table 4. Effects of implantation surgery time (36 months and before and after 36 months) on the reading and writing scores of students with implants

	36 months and before	After 36 months	
Variables	Ave.±SD	Ave.±SD	t
Total reading scores	54.25±26.29	34.62±32.49	1.49
Total writing scores	53.58±21.92	42.25±23.02	1.11

SD: standard deviation; Ave.: average score
Table 4 shows the division of students with implants according to implantation surgery time: 36 months and before and after 36 months. No significant relationship was found between the variables tested

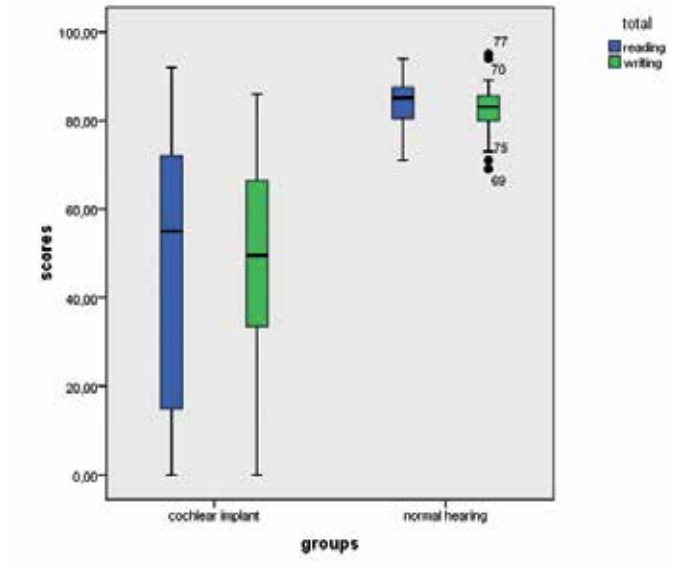

Figure 1. Reading and writing scores of normal hearing and implanted students.

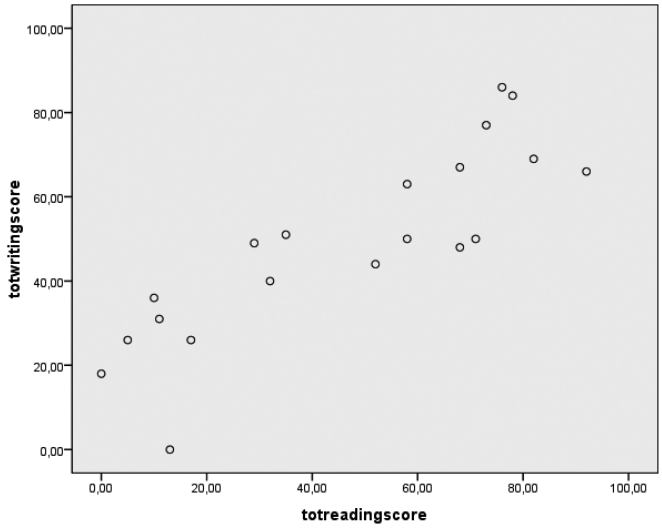

Figure 2. Relationship between total reading and writing scores of implanted students.

dents in terms of their total reading scores [t (20.35) = -5.23, p<0.001, Cohen's d=1.75] and total writing scores [t (22.33) = -6.39, p<0.001, Cohen's d=2.02]. In addition, students using cochlear implants received scores lower than normal-hearing students in both areas (Figure 1).

Table 2 shows the correlation of total reading scores and total writing scores of students with cochlear implants. A positive correlation (r=0.86) can be found between the total writing and reading scores of students with cochlear implants (Figure 2). On the other hand, there was no significant relationship between the reading and writing scores of the normal-hearing group. Both sets of scores are independent of each other.

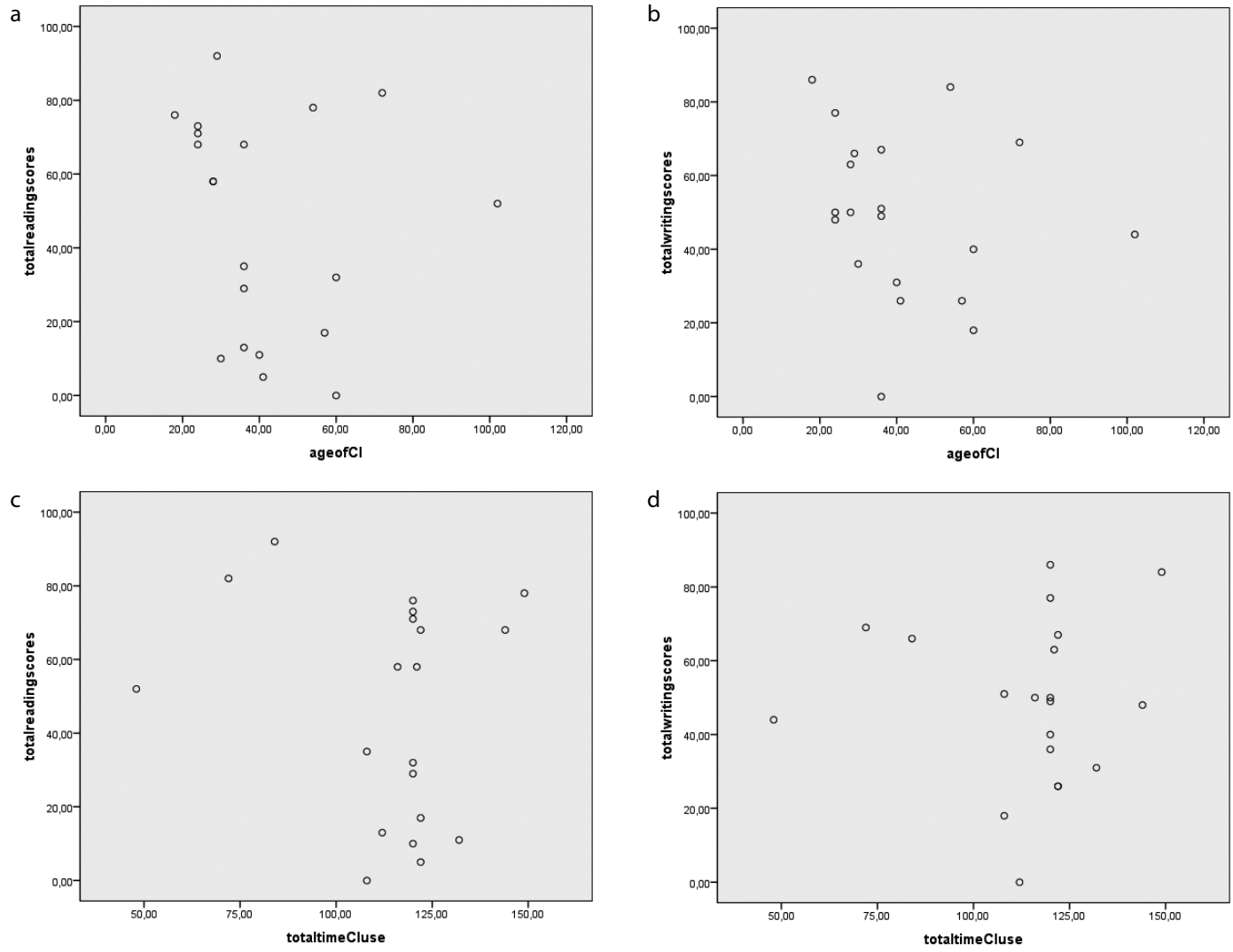

Figure 3, a-d. (a) Effects of age of cochlear implantation on the total reading and (b) writing scores of implanted students. (c) Effects of age of the duration of cochlear implant use on the total reading, (d) and writing (d) scores of implanted students.

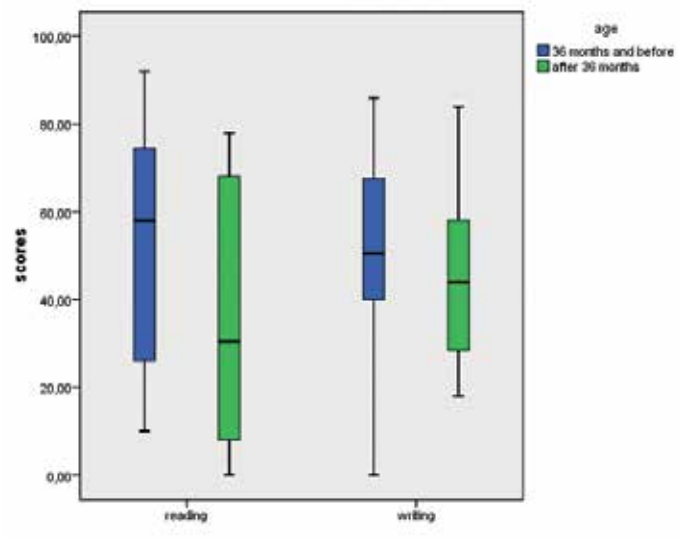

Figure 4. Difference between implanted students according to implantation surgery time on the reading and writing scores.

Table 3 shows the effects of age of cochlear implantation and the durationof cochlear implant use on the total reading and writing skills of students (Figure 3). No significant relationship was found between the variables tested.

Table 4 shows the division of students implanted according to implantation surgery time: 36 months and before, and after 36 months. On the other hand, the relationships between the age of implantation and the duration of cochlear implant use and the variables of total reading score and total writing score were examined. No significant relationship was found between the variables being tested and the age of implantation and duration of implant use (Figure 4).

DISCUSSION

A statistically significant difference was found between students with implants and their normal-hearing peers in terms of both reading and writing skills. This difference indicated that students who use cochlear implants scored significantly lower in reading and writing skill levels than their normal-hearing peers. When the standard deviations of participants' scores were examined, we found that the

standard deviations of students using implants were high. According to this finding, which showed high intra-group variance, there were low and medium as well as high reading and writing performances among students using cochlear implants. The intra-group variance low the normal-hearing group, and the reading and writing skill levels of normal-hearing students were close to each other. Similarly, in another study, when the literacy skills of hearing-impaired children were significantly behind the level of their normal-hearing peer, and only 30% can functionally develop literacy skills [2, 12-15]. Karasu et al. [11] evaluated the reading skills of cochlear-implanted and normal-hearing students. Similar to the findings of the present study, they found that students using cochlear implants can develop certain reading skills, but that such skills are far behind than those of their normal-hearing peers.

For the age of implantation, there was no statistically significant effect on the means of reading and writing scores being tested for students implanted. The age of implantation did not have a statistically significant effect on the total reading and writing scores of students implanted, owing to the heterogeneous distribution and the high variance of the group. If the intra-group variance was lower and the number of participants was higher, the age of implantation would significantly affect the total reading and writing scores of students with implants. When participants were divided into two groups, those who had an implant at 36 months and before (as an early group) and those who had an implant at 36 months (as the late group), we found that the implantation age did not have a significant effect on the variables. According to this, no statistically significant difference was found between the reading and writing scores of students with implants between 36 months and before, and at 36 months after implantation surgery. Furthermore, the standard deviation values obtained in the reading and writing scores indicated that the intra-group variance was high, suggesting a heterogeneous group distribution. Students in the implanted group (36 months and before/at 36 months after the surgery) both had low and high reading and writing scores. The time of implant use had no statistically significant effect on the variables being tested (reading and writing scores). According to the findings, if a sufficient number of participants were included, the time of implant usage would suggest a significant effect on the reading skill. However, the opposite was found in terms of the written expression skills of students with implants. The intra-group variance of cochlear implant users for writing scores was not high, suggesting that implant users provided similar written narrative points. This finding supports the fact that the duration of implant use is not a significant influence on the writing score.

Geers [16] compared the reading performance of children with implants and their normal-hearing peers in a study, whose findings are similar to those of the present study. She found no significant relationship between the duration of cochlear implant use and reading ability in the implanted group. Similarly, Willsredt-Svenson et al. [17] did not find a direct relationship between reading skills and implant age and duration of implant use. In contrast to the findings of the present study, Trawler [12, 18] reported a statistically significant relationship between the duration of implant use and literacy skills of hearing-impaired children in his normative data.

One of the important variables affecting the reading and writing performances of children is the diagnosis time of hearing loss [19]. In the present study, diagnosis time was at approximately 1 year of age (although these children were already using hearing aids during 18–24 months). According to the literature, the fastest period of language development for babies is during 0–24 months. Speech and language skills of hearing-impaired children who are not adequately exposed to sound stimuli during language development are adversely affected [1,20,21]. For children with hearing loss, beginning to use hearing aid at 1 year of age may be too late because the loss of hearing time also affects the development of reading and writing skills [22]. Similar to the literature, the fact that participants in the present study started to use hearing aids at a later time, this delay may have had a negative effect on their reading and writing development. All participants except for one used hearing aids before implantation. Only eight of the participants used hearing aids before 18 months of age, the rest were prescribed hearing aids after 18 months of age.

According to the literature, children who received cochlear implants before the age of 2 are at the same speech and language development level as their hearing peers when they reach the age of 5. Similarly, the auditory discrimination abilities of children implanted before the age of 2 are closer to those of their normal-hearing peers compared with children who received their implants after the age of 2 [23-26].

In the present study, owing to insufficient number of participants, early and late implants were divided into two groups according to the time of surgery (before 36 months and after 36 months).

When looking at the age of implantation, only four students had implant surgery before the age of 2 years, the rest had their implants after the age of 2 years. The reason for not finding any significant effect of implantation on reading and writing skills could be the later age limit set to separate the early and late groups.

Many factors can influence the reading ability of hearing-impaired children. Geers [22] reported that such factors include onset of hearing loss, diagnosis time, intelligence level, and biological age of babies. The implant fitting software, the number of active electrodes, and the dynamic range are also considered as the implant-dependent properties that can affect the subsequent reading ability of children.

While reading and writing scores of patients with implants were related to each other, there was no relation between the reading and writing scores of normal-hearing students. In this context, the reading and writing scores of normal-hearing students were obtained independently of each other. In a normative data study of children with hearing impairment, Traxler [12] noted that hearing-impaired children do not develop age appropriate reading and writing skills. As a result, a hearing-impaired child who has not developed reading skills cannot improve his writing skills. Supporting our findings, Geers and Hayes [27] argued that hearing-impaired children are less exposed to environmental stimuli than their normal peers, and that this reflects negatively on their speech and language development as well as on their subsequent ability to read and write.

The reading skill development of hearing-impaired individuals, whose language development is slow due to hearing loss, can also

be adversely affected by this process [28]. Similarly, Antia et al. [29] argued that children with hearing impairment, whose language development is slow, find it very difficult to communicate through writing. Hence, according to these findings, while speech and language development is negatively affected by hearing loss, the slow language development process in different studies negatively affects one's reading and writing skills. As a result, the development of reading and writing skills of individuals suffering from slow language development can be negatively affected.

CONCLUSION

In conclusion, children who use cochlear implants develop lower levels of reading and writing skills than their normal-hearing peers, even if they go to normal schools together. Early implantation has positive effects on speech and language skills development, but differences in the reading and writing skills of these children compared with those of their normal-hearing peers are observed in higher grades (6th, 7th, and 8th grades). The age of implantation and the duration of implant use are not the only factors affecting the language development and academic performance in children using implants. The use of these assessment scales in cochlear implant recipients and hearing aids does allow children to be compared with their normal-hearing peers for abilities other than speech and language.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethics Committee from Marmara University (19.01.2016-14).

Informed Consent: Written informed consent was obtained from the patient's parents who participated in this study.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - H.Ç., A.Ç.; Design - H.Ç.; Supervision - A.Ç.; Resource - H.Ç.; Materials - H.Ç.; Data Collection and/or Processing - H.Ç.; Analysis and/or Interpretation - H.Ç., A.Ç.; Literature Search - H.Ç.; Writing - H.Ç., A.Ç.; Critical Reviews - A.Ç.

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