Application Effect of Unilateral Cochlear Implantation Combined with Contralateral Hearing Aids on the Hearing and Speech Rehabilitation in Prelingual Deafness Children

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Abstract. Objective. The purpose of the study was to investigate the application effect of unilateral cochlear implantation combined with contralateral hearing aids on the hearing and speech rehabilitation in prelingual deafness children. Methods. In this study, a total of 78 children with severe or extremely severe sensorineural prelingual deafness admitted to our hospital from January 2015 to December 2017 were selected and divided into control group (n=39) and experimental group (n=39), according to the random number table. Among them, the children patients in the control group received dominant training after unilateral cochlear implantation, while the children patients in the experimental group received cochlear implantation combined with contralateral hearing aids; after that, the hearing and speech rehabilitation outcomes of the prelingual deafness children in both groups were compared and analyzed. Results. There were no statistically significant differences in the auditory thresholds of the children patients undergoing cochlear implantation between the two groups, while the auditory thresholds of contralateral ears of the children patients in the experimental group were significantly lower than those in the control group. The recognition rates of the initials, finals, tones and disyllables of the children patients in the experimental group were significantly higher than those in the control group, and the CPA and SIR scores of the children patients in the experimental group were significantly higher than those in the control group, with statistical significance ($P < 0.05$). Conclusions. Unilateral cochlear implantation combined with contralateral hearing aids can promote the hearing and speech rehabilitation in prelingual deafness children, with better clinical effect than the single unilateral cochlear implantation, and cochlear implantation have no interference in the work of contralateral hearing aids; therefore, this joint treatment method is worthy of wide application and promotion.

Keywords: Cochlear Implantation; Hearing Aids; Prelingual Deafness Children; Hearing And Speech Rehabilitation
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The children aging from 1-3 years old are in a critical developmental phase for the formation of language function, which is firstly premised on hearing. Similarly, due to no access to the sound stimulation from the outside, prelingual deafness children are easily subject to language disorders [1-4]. With more and more emphasis on early intervention of hearing-impaired children, the clinical examination of neonatal hearing has been gradually intensified in the way that infants with hearing impairment will be diagnosed within three months and intervention will be implemented within six months. At present, cochlear implantation is an effective treatment for

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severe or extremely severe hearing impairment, and many children have recovered unilateral hearing through unilateral cochlear implantation. It has been shown in relevant studies that the bilateral intervention (unilateral cochlear implantation combined with contralateral hearing aids) for children with severe or extremely severe sensorineural prelingual deafness can beneficially facilitate the hearing and speech rehabilitation [5-8]. Based on this, in this study, in order to investigate the application effect of unilateral cochlear implantation combined with contralateral hearing aids on the hearing and speech rehabilitation in prelingual deafness children, a total of 78 children with severe or extremely severe sensorineural prelingual deafness admitted to our hospital were selected and their data were retrospectively analyzed. The study is reported as follows. Materials and Methods

General Information

A total of 78 children with severe or extremely severe sensorineural prelingual deafness admitted to our hospital from January 2015 to December 2017 were selected and divided into control group (n=39) and experimental group (n=39), according to the random number table. Among them, in the control group, there were 21 males and 18 females, aging from 1.3 to 5.6 years old, with the average age of (3.1±0.2) years old, while in the experimental group, there were 22 males and 17 females, aging from 1.2 to 5.7 years old, with the average age of (3.2±0.3) years old. There were no significant differences in the general data of the children patients in both groups, with comparability (P > 0.05), as shown in Table 1

Table 1
Comparison of the general data between the two groups

	Control group (n=39)	Experimental group (n=39)	t/X^2	P
Age	(3.1±0.2)	(3.2±0.3)	1.7321	0.0873
Gender			0.0518	0.820
Male	21 (53.85)	22 (56.41)		
Female	18 (46.15)	17 (43.59)		
Contralateral uncorrected hearing	(94.13±8.59)	(93.16±8.57)	0.7067	0.4819

Inclusion Criteria

① Patients met the clinical diagnostic criteria for severe or extremely severe sensorineural prelingual deafness. ② Patients had no inner ear malformations. ③ Patients had the history of wearing hearing aids for more than one year. ④ Patients received unilateral cochlear implantation. ⑤ This study was approved by the Hospital Ethics Committee, and patients and their families were informed of the purpose and process of the study, received the treatment protocols and signed the informed consent.

Exclusion Criteria

① Patients had retrocochlear pathology related to auditory nerves. ② Patients had incomplete clinical data.

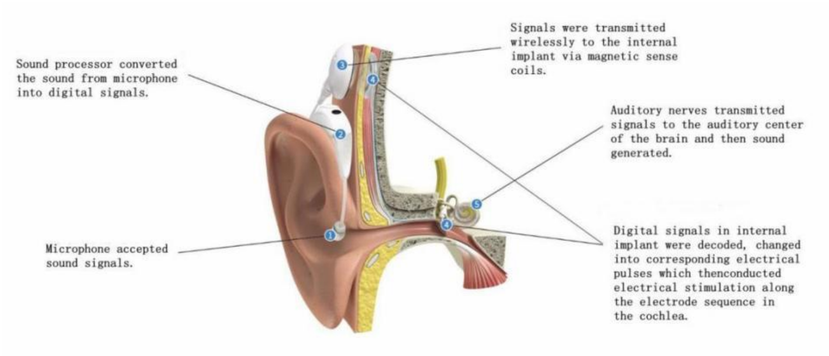
Methods

The children patients in the control group received dominant training after unilateral cochlear implantation (Cochlear implant: Cochlear C1422\CP802, CP810, MEDEL SONATA, 0PUS2), while the children patients in the experimental group wore hearing aids with the type of WIDEXME5-SP (AE) after cochlear implantation. In addition, the cochlear implants were all adjusted by the same medical staff, and the cochlear profiles were shown in Figure 1.

All the children patients' hearing was tested by up-and-down method in standard isolation booths, with ambient noise of no more than 35 dB(A), and the tested ears were the ones without cochlear implantation, with the test frequency of 0.5 kHz, 1 kHz, 2 kHz and 4 kHz. Besides, for younger children, the hearing test could be conducted by play audiometry [9-12]. Before the test, the medical staff should calibrate the sound field in advance, check the test signals by using warble tones and test the hearing thresholds of the hearing aids and cochlear implants at the frequency of 0.5 kHz, lkhz, 2KHz and 4kHz, respectively. After that, the test was started in isolation booths, with the given sound intensity for the patients controlled by sound level meters. Most importantly, the visual impact of the patients should be avoided. During the test, the test material should be selected from the Criteria and Methods for Evaluating Auditory and

Linguistic Ability of Hearing Impaired Children, the sound intensity of the patients should be kept at about 70 dBSPL by using an AC40 sonometer and the sound was given orally by medical staff [13-14]. For younger groups, the test was carried out by the methods of listening to sound signals and recognizing pictures.

Figure 1 Profile of the cochlear implant



Observation Indexes

The follow-up of patients' rehabilitation training in both groups was conducted for two years and the recognition abilities of initials, finals, tones and disyllables in the two groups at two years after cochlear implantation were tested.

Two years after rehabilitation training, the categories of auditory performance (CAP) and speech intelligibility rating (SIR) of the patients in both groups were evaluated, and higher scores indicated better auditory behavior and speech intelligibility.

Statistical Treatment

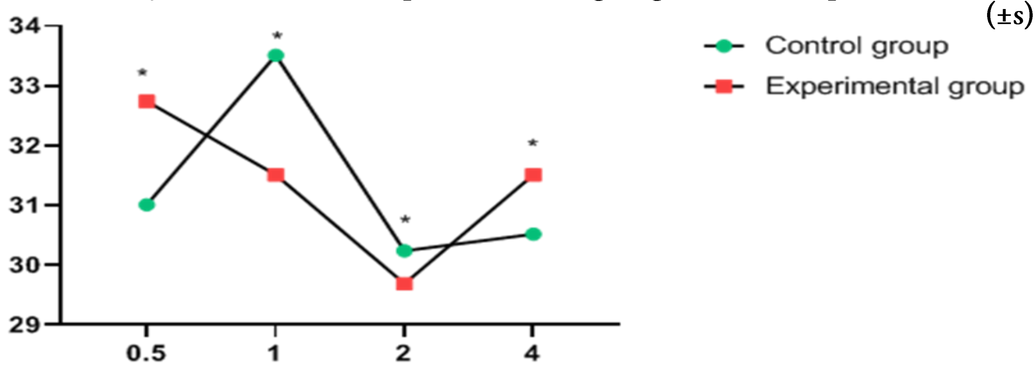
The selected data processing software for this study was SPSS20.0, and GraphPad Prism 7 (GraphPad Software, San Diego, USA) was used to draw the pictures of the data. Measurement data were tested by t-test and enumeration data were tested by X2 test and normality test. The differences had statistical significance when $P < 0.05$.

RESULTS

Comparison of The Auditory Thresholds of The Patients Undergoing Cochlear Implantation between The Two Groups

There were no statistically significant differences in the auditory thresholds of the patients undergoing cochlear implantation between the two groups, as shown in Figure 2, and the auditory thresholds of the contralateral ears in the patients undergoing cochlear implantation in the experimental group were significantly lower than those in the control group, as shown in Figure 3.

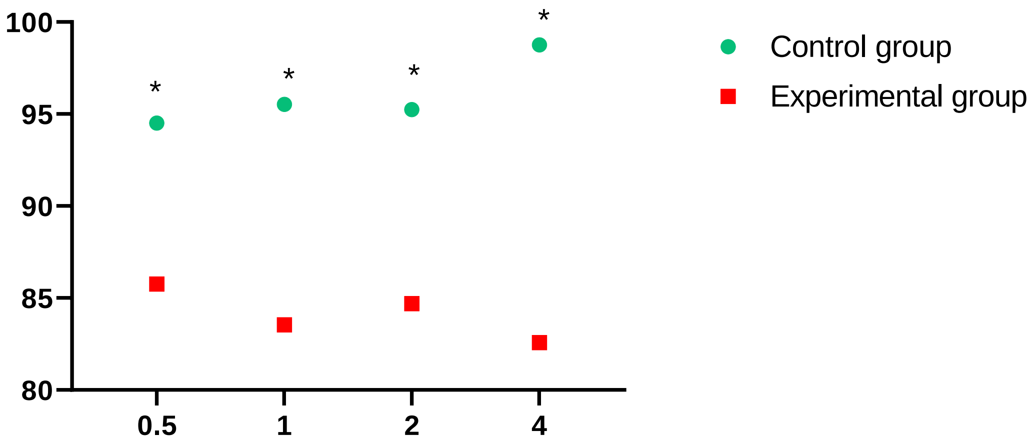
Figure 2
Comparison of the auditory thresholds of the patients undergoing cochlear implantation between the two groups (±s)



Note: The abscissa represented frequency, while

the ordinate represented auditory threshold.
In the control group, the auditory thresholds of the patients undergoing cochlear implantation combined with hearing aids at the frequencies of 0.5, 1, 2 and 4 kHz were (31.01±8.69), (33.51±7.93), (30.24±8.11) and (30.52±7.22), respectively.
In the experimental group, the auditory thresholds of the patients undergoing cochlear implantation combined with hearing aids at the frequencies of 0.5, 1, 2 and 4 kHz were (32.74±6.51), (31.51±5.41), (29.69±5.44) and (31.51±6.82), respectively.
* indicated that there were no significant differences in the auditory thresholds of the patients undergoing cochlear implantation combined with hearing aids at the frequencies of 0.5, 1, 2 and 4 kHz (all $P > 0.05$).

Figure 3
Comparison of the auditory thresholds of the contralateral ears in the patients undergoing cochlear implantation between the two groups (±s)

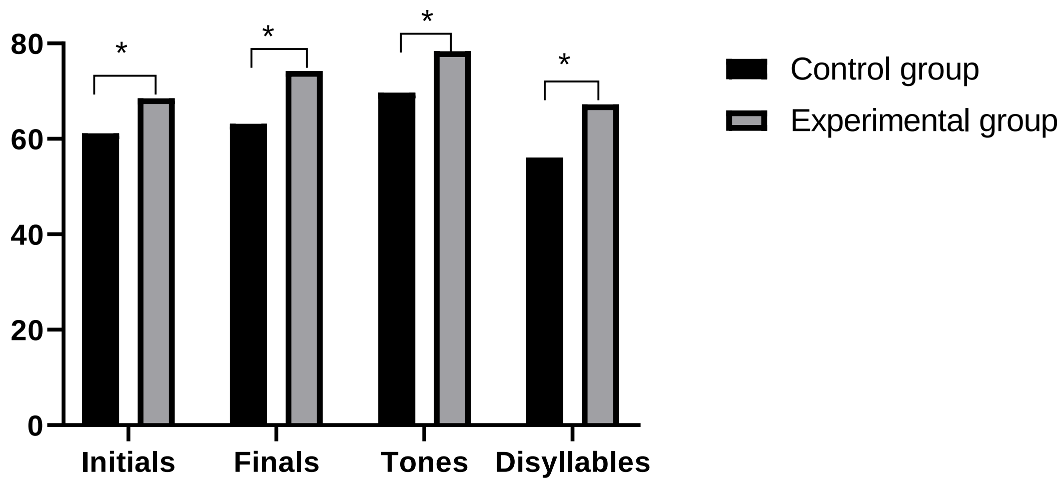


Note: The abscissa represented frequency, while the ordinate represented auditory threshold.
In the control group, the auditory thresholds of the contralateral ears in the patients undergoing cochlear implantation at the frequencies of 0.5, 1, 2 and 4 kHz were (94.51±8.68), (95.52±8.78), (95.24±10.31) and (98.76±7.22), respectively.
In the experimental group, the auditory thresholds of the contralateral ears in the patients undergoing cochlear implantation at the frequencies of 0.5, 1, 2 and 4 kHz were (85.75±6.51), (83.54±7.41), (84.69±8.44) and (82.57±7.46), respectively.
* indicated that there were significant differences in the auditory thresholds of the contralateral ears in the patients undergoing cochlear implantation at the frequencies of 0.5, 1, 2 and 4 kHz (t = 5.0420, 6.5119, 4.9448, 9.7389; all $P < 0.05$).

Comparison of The Speech Recognition Rate between The Two Groups

The recognition rate of the initials, finals, tones as well as disyllables of the children patients in the experimental group was significantly higher than that in the control group, with statistically significant differences between the two groups, as shown in Figure 4.

Figure 4
Comparison of the speech recognition rate between the two groups (±s)



Notes: The abscissa represented initials, finals, tones and disyllables, while the ordinate represented recognition rate (%).
The recognition rates of the initials, finals, tones and disyllables in the control group were (61.17±11.82), (63.18±12.50), (69.71±13.58) and (56.12±7.64), respectively.
The recognition rates of the initials, finals, tones and disyllables in the experimental group were (68.53±11.91), (74.25±12.48), (78.39±13.71) and (67.22±8.43), respectively.
* indicated that there were significant differences in the recognition rates of the initials, finals, tones and disyllables between the two groups (t = 2.7392, 3.9138, 2.8090, 6.0930; all P < 0.05).

Comparison of the CPA and SIR Scores between The Two Groups

The CPA and SIR scores of the children patients in the experimental group were significantly higher than those in the control group (P < 0.05), with statistically significant differences between the two groups, as shown in Table 2.

Table 2
Comparison of the CPA and SIR scores between the two groups (±s)

Group	Cases	CPA score	SIR score
Control group	39	(1.91±0.87)	(1.11±0.49)
Experimental group	39	(2.41±0.86)	(1.47±0.83)
t		2.5525	2.3325
P		0.0127	0.0223

DISCUSSION

Some studies on the clinical treatment for prelingual deafness children have found that many patients only receive unilateral cochlear implantation and then conduct the dominant training only for the affected ears, because they mainly concern about the effect of the hearing aids in the contralateral ears on the recovery of the affected ears [15-18]. Clinical studies have revealed that unilateral cochlear implantation combined with contralateral hearing aids can recover the hearing lost at high frequency in patients and can improve the abilities in sound source localization, musicianship and speech recognition of the patients with severe or extremely severe sensorineural prelingual deafness who still have residual hearing, which is greatly relying on the advantages of hearing aids in amplifying low-frequency sound and making full use of residual low-frequency hearing through the head shadow effect, etc. [19-22]. Our study concluded that there were no statistically significant differences in the auditory thresholds of the patients undergoing cochlear implantation between the two groups, and the auditory thresholds of the children patients in the experimental group were significantly lower than those in the control group. It also pointed out that the recognition rates of initials, finals, tones and disyllables in the experimental group were significantly higher than those in the control group, and the CPA and SIR scores in the experimental group were significantly higher than those in the control group (P < 0.05, with statistical significance.

All these results indicate that hearing aids embody the input of acoustic signals, and cochlear implantation can promote the auditory rehabilitation of the children with good tolerance of cochlear implants. In addition, unilateral cochlear implantation combined with contralateral hearing aids can form binaural hearing, and unilateral cochlear implantation alone will lead to the lateralized development of auditory system, thus unilateral cochlear implantation combined with contralateral hearing aids has better effect on hearing and speech rehabilitation. Our study results are in line with those of Bentler [23] et al., who have stated in their study that after unilateral cochlear implantation, for the patients who still have residual hearing, contralateral hearing aids should be positively adopted, so as to protect binaural hearing, improve hearing quality and promote hearing and speech rehabilitation, suggesting that unilateral cochlear implantation combined with contralateral hearing aids can enhance the hearing and speech rehabilitation outcomes in prelingual deafness children.

In conclusion, unilateral cochlear implantation combined with contralateral hearing aids can promote the hearing and speech rehabilitation in prelingual deafness children, with better clinical effect than the single treatment of unilateral cochlear implantation, and cochlear implantation have no interference in the work of contralateral hearing aids; therefore, this joint treatment method is worthy of wide application and promotion.

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