Original Article
International Journal of Basic and Clinical Studies (IJBCS)
2015; 4(2): 11-20, Yalcinkaya F

Why the Left Ear Must Be Chosen for Implant in Children to Learn the Mother Language

Fulya Yalcinkaya*

***Biruni University, Audiology Department. Topkapi/ Istanbul-TURKEY**

Abstract

Implant in one ear, if there is hearing loss in the other ear, signal transmission between hemispheres is not possible. Because, fibers of the corpus callosum is not connected between the left and right sides of the brain (uncrossed). In that case, if the right ear is implanted the right hemisphere; and if the left ear is implanted, the left hemisphere have function. In children, if both ears are available for implant, generally the right ear is implanted. In this case, the stimulus heard by the implanted right ear are transmitted to right hemisphere (the left hemisphere is non-functional). Children whose right ears are implanted and observed for a long time show great success in speech perception and simple language tests. However, they are seen to be late in advanced reading and writing skills. As a result, it is seen that in cases where right ear was chosen for implant, the right hemisphere becomes efficient for several years, but in following years it loses its effect; because the right hemisphere cannot undertake the liabilities of the left hemisphere. The effect of the right ear selection is that long-term cortical auditory development is delayed in children using cochlear implants relative to their normal hearing peers. According to my hypothesis, in children learning the mother tongue (not in grown-ups), left ear must be chosen for implant in order to activate the functions of left hemisphere, since the left hemisphere can undertake the liabilities of the right hemisphere. In this way, active processing may be possible in advanced language use, pragmatic language, and reading and writing functions. Hearing of left ear (effects of side of stimulation) possibly causes permanent reorganization.

Key words: Cochlear implantation, Right ear, Left ear, Right-hemispheres, Left-hemispheres, Language,

Introduction

Hearing and learning the language is a process beginning just after being born and it is mostly completed around fourth and fifth years in a normal child. In other words, neuroplastic activity in this period is in maximum level and stimulations are transmitted, placed, and coded to related centers very fast and correctly by all neurons. Integration starts in centers related to learning and language. This activity of audial cortex begins and continues increasingly after birth. Scarcity or lack of stimulation hinders or annihilates cortical activity according to its level. Every passing day without stimulation causes the cortical activation to decrease. Inactivation acrophilia develops in related centers. So, with this purpose, it must be provided to stimulate residual senses as soon as possible. In people with severe hearing loss, these stimulations can be provided with cochlear implant.

Responses from cochlear implant users remain different from those of their normal hearing peers. These differences decreased over time, but were not eliminated even after 10 years of time-in-sound. Specifically, the P(1)-N(1)-P(2)-N(2) complex, typical of a normally mature response, began to emerge by 10 years of time-in-sound experience, but the amplitudes of peaks P(2) and N(2) became abnormally large. Mature-like cortical responses emerge in children after long-term unilateral cochlear implant use (1,2).

In this paper it is stated that children learning the first language, whose both right and left ear are available for implant but the right ear is implanted, experience latency in cortical-aural language processing in long term.

- Ear selection for implant must be different in children learning the first language and the ones who already uses the language.
- In children who experience hearing loss after having acquired language the right ear can be chosen. But in children to learn language for the first time, right ear must not be chosen for implant; instead, left ear must be chosen.

If there is similar hearing loss in both ears of a child, generally right ear is chosen for implant. In children learning the mother tongue, according to my hypothesis, left ear is to be chosen for implant. This hypothesis is only applicable for babies and children learning their first language; it does not include children whose ears were implanted after learning the first language. In researches, it is pointed out that right ear results (the right hemisphere is capable of speech sound processing in the intact brain) are goof and it created recovery in those having used it for a long time. This is true; however, in researches, right ear results in researches are related to noticing speech sounds. Regardless of CI side and age at implantation, all children exhibited improvement in speech perception with continuous use. My hypothesis is that right ear selection is not convenient in real language processing.

W. House applied cochlear implant to children in 1980 (3), and in Turkey it was first done in 1987 (4). In many studies made until today, mostly the right ear has been implemented (5,6,7,8,9). In these researches it is normal that there was not any difference between right and left ear results. Because the ages of children who are learning the first language and whose ears are implanted are different and that they cannot be observed until they learn reading and writing at school, the real effect of left ear cannot become clear.

According to my hypothesis, as the first years (1-3) just include getting the audio, processing, coding and identifying it, the difference of choosing between right and left ear for implantation cannot be seen, as in the very first years the right hrmisphere is dominant for processing and it enables that children whose ears were applied implant in a young age gains language development fast; however, in future years left hemisphere is recessive in this process for language performances.

After children who are applied implantation complete their language development period, the language performance period starts. In this period, audial processes such as dichotic listening, getting signals of continuing spreeches by listening, getting rapid stimulations (rapid process) start to be active after 3 years. Input entry of left hemisphere and myelin intertwining increase after this time. As input entry will increase for both dichotic listening and temporal processing maturation, there happens significant increase in the myelin of left hemisphere processing functions. For this reason, the first 1-3 years following implantation right ear selection seems to be an effective decision whereas it is not effective in daily life and in learning language by listening in school education period. In daily life and school, stimulations come rapidly, continuously, as long sentences, and mostly dichonically. For these processes the left hemisphere functions actively. This time, the right hemisphere is recessive and the left hemisphere becomes active in language processing dominantly. As a result, considering language learning in daily life and processing it in school education period, left ear must be chosen for implant.

On the other hand, in many researches, because of the reasons I have mentioned above, the reasons behind right ear selection and the differences between ears are seen as advantages and statistically, results are interpreted mistakenly. This is an example of the interpretations mentioned: “In the analysis of *Listening Progress Profile (*LiP) test data, when compared preoperative values, significant increase was detected in the 1st month of coclear use. ($p<0,01$). In the analysis of *Monosyllable–Trochee-Polysyllable Test (*MTP) data, when compared to preoperative values, significant increase was found to be in the 1st and 3rd months following the first fitting ($p<0,01$)". This is because most of the testd used in these researches are auditory perception tests evaluating right ear (LiP, MTP) and *Meaningful Auditory Integration Scale* (MAIS) tests etc). So, the real left ear effect cannot be seen. For that reason, in researches the difference between ears cannot be foun statistically. For example, in a research made in Turkey, 28 childen (21 right ear: 60-72-46-103-101-69-45-43-30-85-63-60-60-30-26-160-60-24-115-180-66 month); (7 left ear (100-117-78-24-53-60-51 month), with ≤ 60 months and > 60 months operation ages who developed hearing loss in congenital and prelingual periods and who were observed at least for 18 months after implantation were tested and it was detected that there is a negative correlation between operation age and performance development.

In the group whose operation age is low, test scores were found to show a rapid increase. It was observed that children whose ears were implanted at a young age gained speed in language development and in the future they became more successful in educational skills like reading and writing. Apart from the operation age of the patient, in our data related to LiP, MTP ve MAIS tests we used in the reasearch, it has been detected that genders of patients, the direction of the ear implanted (21 right ears-7 left ears), the model of the applied cochlear implant do not statistically have a significant effect to audial performances of patients (10).

A cross-sectional study to assess the speech intelligibility of right and left cochlear-implanted patients. The study included 50 cochlear-implanted patients (24 male and 26 female): 25 of the patients were pre-lingual and 25 were post-lingual. Twenty-six of the patients were implanted on the right ear and 24 were implanted on the left ear. Speech intelligibility assessment was conducted using the Arabic Speech Intelligibility test. This Arabic Speech Intelligibility test is meant to be an objective measure as the examiner does not have to evaluate how a word was said. Right-ear cochlear implantation has an advantage over left-ear implantation regarding the speech intelligibility. Hence, in case of bilateral profound deafness of the same degree with no anatomical complications in either of the ears, it is recommended to choose the right ear for cochlear implantation (11).

Henkin et al (2008) recently completed a retrospective cohort analysis of 71 pre-lingually deafened children, all of whom were implanted prior to age 48 months. Patients were divided into 2 groups according to ear of implant (right, n = 30; left, n = 41) and matched in age at implantation and preoperative audiological results. The performance of children implanted at 24 months or younger was significantly higher than that of children implanted between 25 and 48 months. A small yet significant "right CI advantage" was evident throughout the study follow-up and was independent of age at implantation (12).

When the right ear is implanted:

- It becomes efficient in getting and understanding voices. In the period after the implantation is done. In the very first years this recovery may seem effective. Right ear selection (prolonged cochlear-implant usage) loses its efficiency in future years. After the skills of getting and differentiating sounds, the implanted right ear loses its effect. The right hemisphere cannot undertake the liabilities of the left hemisphere and, as a result, the skills of learning-using the language, and also reading-writing skills delay.

Why the Left Ear Must Be Chosen for Implant:

- Left hemisphere undertakes the liability of the right hemisphere. The audial perception skills of those with implanted left ear, until hemispheric adaptation becomes available, may delay in the very first periods, but then they learn the language in a fast way.

Long-term cortical auditory development is altered or increase in children using cochlear implants relative to their normal hearing peers. In some researches, it is seen that right ear selection for implantation is not an effective choice for future periods (1).

Right-ear implanted subjects showed cerebral activation contralateral to implanted ear more frequently than left-ear implanted ones. Previous research supports the team's new findings. For example, earlier research shows that children with impairment in the right ear encounter more trouble learning in school than children with hearing loss in the left ear (13)

In people whose right ears were implanted, signal transmission is required

between hemispheres with corpus callosium in order for the left ear to activate (via contralateral pathways). There is no signal transmission between hemispheres (uncrossed) due to the hearing loss in opposite ear (Fig.1.).

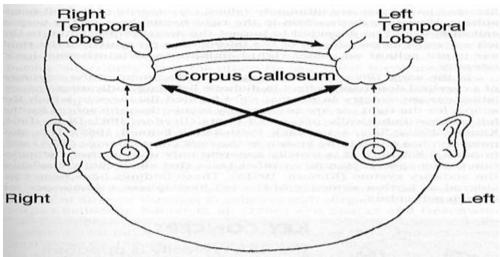

Fig.1. Crossed- normal auditory processing: right and left ear (via contralateral pathways). (http://www.courses.audiospeech.ubc.ca/navid/Imported%20Files/Central%20Auditory%20Processing%20Disorder.pdf)

The Corpus Callosum is not the bundle of fibers that connects the left and right sides of the brain. So, only hemisphere of the implanted ear (right and left) takes charge in processing sounds. For example,

if the right ear was implanted, only the right hemisphere;

if the left ear was implanted, only the left hemisphere is supposed to function. On the other hand, it is to have a different function in children having cochlear implant and learning the first language (Fig.2.).

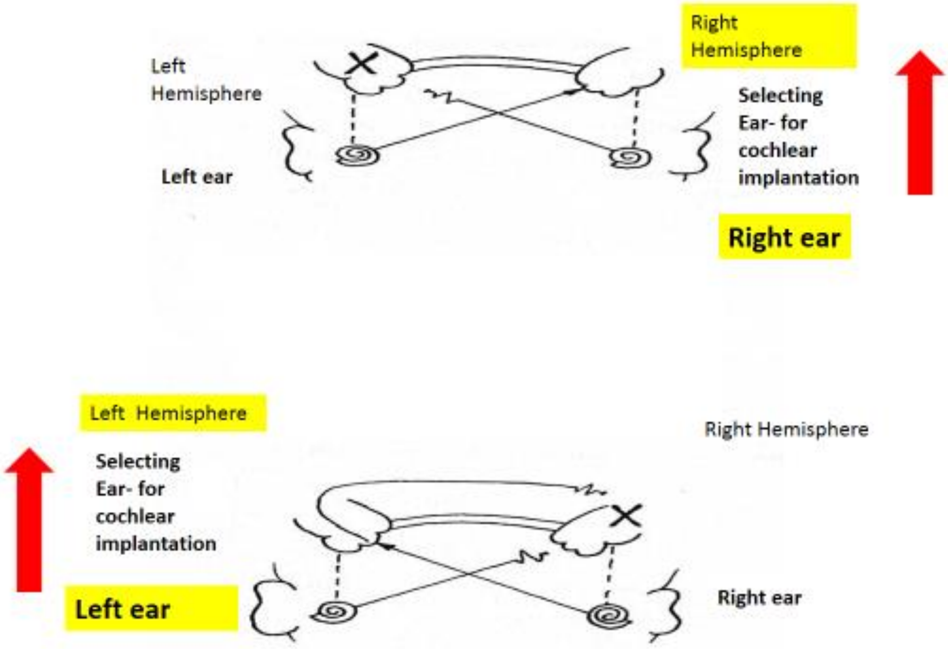

Fig.2. Uncrossed- selecting left ear- for cochlear implantation, selecting right ear- for cochlear implantation.

In researches made, the number of cases that had hearing loss in both ears in early childhood and pre-school periods and only the left ear was implanted is very few. Research results where both right and left ears were chosen are generally tests of speech discrimination-intelligibility, word identification (Peabody picture vocabulary test) etc. These test results do not reveal real results, instead they give misleading findings. The truth of the hypothesis is that the left ear selection would give better results compared to right ear selection in in the long term. It can be found out by observing the children, until they are 7-8, whose left ears were implanted and who were also learning mother tongue.

In researches made, mostly the advantages of right ear are emphasized. This is a developmental process and it is normal. It does not show the superiority of the right to the left. The topic to focus on must be that the right hemisphere cannot undertake the liabilities of the left hemisphere.

Language activation was contralateral to the side of implanted ear in 70% of our participants, in accordance with the normal hearing population, in which auditory signals from one ear reach both auditory cortices, but contralateral projections are stronger and more preponderant than ipsilateral ones. However, the proportion of patients with prevalent activation of the contralateral pathway varied in relation to the side of implanted ear. Almost 80% of right-, but only 60% of left-ear implanted children showed normal left-hemispheric activation; thus, 40% of left-ear implanted children atypically activated the right hemisphere. These findings show that most deaf children in the group keep the inborn i.e. biologically constrained left-hemispheric language preference. Activation of the contralateral right hemisphere in the presence of left-ear CI occurred in 3 out of 5 subjects implanted within 4 years of age, whereas the two children who received left-ear CI at a much later age (8 years) showed ipsilateral activation of the left hemisphere (14).

The right ear advantage (REA) has been reported in the auditory processing literature for more than 50 years. The essence of the REA discussion says that the left hemisphere is dominant for speech and language processing and the contralateral auditory pathways are stronger. Therefore, when sounds from the right ear are sent to the left hemisphere (via contralateral pathways) a right ear advantage is often apparent regarding speech, language, and dichotic presentations of language-based sounds, particularly in younger people (15). Emerging evidence in auditory neuroscience suggests that central auditory pathways process speech asymmetrically. In concert with left cortical specialization for speech, a "right-ear advantage" in speech perception has been identified. This study determined: central asymmetry in speech processing, implications for selecting the ear for cochlear implantation. There were no differences between left-ear- and right-ear-implanted patients in improvement on speech recognition tests (16).

Van den Broek and Dunnebier (2009) examined surgical, medical, and audiological factors that impact the selection as to which ear to implant. They note that in the “early years” the ear with the worst hearing was most often chosen for implantation. In the late 1990s, the deciding factor was often based on which ear had better hearing (more residual hearing) as that would usually indicate better preservation of neural pathways and a higher likelihood of a better outcome. More recently, it has been shown similar results were obtained even when implanting the poorer ear, and most recently, ear selection has been weighted via duration of deafness and extent of residual hearing (17).

Tadros et al (2005) recently addressed REA as a normal function in young people with regard to a peripheral (increased sensitivity) and central (speech processing) advantage. Yoshinaga-Itano and colleagues (2008) noted that Oyler et al (1988) reported children with unilateral hearing loss in the right ear were at greater risk for academic difficulties (18,19,20).

Chilosi et al (2014) recently addressed; cerebral lateralization for language in deaf children with cochlear implantation. Functional Transcranial Doppler ultrasonography (fTCD) was used to investigate the effects of early acoustic deprivation and subsequent reafferentation on cerebral dominance for language in deaf children provided with Cochlear Implantation (CI). Twenty children with CI (13 in right ear and 7 in left ear) and 20 controls matched for age, sex and handedness were administered a fTCD animation description task. Left hemisphere dominance for language with comparable mean Laterality Indexes (LIs) was found in children with CI and controls; right-ear implanted subjects showed cerebral activation controlateral to implanted ear more frequently than left-ear implanted ones. Linguistic proficiency of CI recipients was below age expectation in comparison to controls; language scores did not significantly differ between children with left and right LI, whereas both age and side of implantation were significantly related to language outcome (14).

"We were intrigued to discover that the clicks triggered more amplification in the baby's right ear, while the tones induced more amplification in the baby's left ear," said Sininger previous research supports the team's new findings (21).

The first 3-5 years right and left ear functions are not equal in processing sounds. Whereas the first 3-5 years are seen proper for the selection of right ear for implantation (speech intelligibility, speech discrimination, the latency time of the P1), this selection is not proper for the following periods. It is true that in the first years right ear selection is successful, but it is deceptive for the following years. For example, earlier research shows that children with impairment in the right ear encounter more trouble learning in school than children with hearing loss in the left ear (22).

It shows that unilateral deafness results in an asymmetric brain, with different hemispheres showing differential responses for both the deaf and the hearing ear. The results suggest a specific adaptation process at the hemisphere ipsilateral to the hearing ear, involving specific (down-regulated inhibitory) mechanisms not found in the contralateral hemisphere (23)

In accordance with the reports on Western language-speaking children (12 and 24 months after implantation), showed cochlear implants increasingly benefit Mandarin-speaking congenitally deaf children over a 2-year post-implantation period (24). Implantation before 3 years of age promotes the development of open-set speech perception abilities in congenitally deafened children. The present investigation demonstrated that age at implantation influences open-set speech perception of cochlear implanted children 4-5 years after device connection (25).

Getting the continuous fast speeches and language processing (sentence comprehension, semantic processes) is carried out by the left hemisphere. According to the dynamic dual pathway model of auditory language comprehension syntactic and semantic information are primarily processed in a left hemispheric temporo-frontal pathway including separate circuits for syntactic and semantic information whereas sentence level prosody is processed in a right hemispheric temporo-frontal pathway (26). In bilateral listeners, children with long periods of unilateral cochlear implant use prior to bilateral implantation showed a reduction in normal dominance of contralateral input in the auditory cortex ipsilateral to the stimulated ear, further confirming an abnormal strengthening of pathways from the stimulated ear. By contrast, cortical activity in children using bilateral cochlear implants after limited or no unilateral cochlear implant exposure normally lateralized to the hemisphere contralateral to side of stimulation and retained normal contralateral dominance of auditory input in both hemispheres (27).

The right hemisphere cannot carry out language learning functions of continuous fast speeches without the left hemisphere (for instance: in daily life teaching of an instructor, television, radio, continuous conversations). Persistent differences from normal could reflect an increase in attention or multi-sensory processing during listening. Because of that reason, considering advanced language processing and use, left ear must be chosen in ear selection for implant.

References

1	Jiwani S, Papsin BC, Gordon KA. (2013). Central auditory development after long-term cochlear implant use. *Clin Neurophysiol*, 124 (9):1868-80.
2	Varela-Hall, C; Martinez, A; Halty, L; Santos, JM; Ortiz, T. (2012). Cortical organization of different languages with different proficiency levels. *Rev Neurol*, 29;54 (1)137-45.
3	House W.(1976). Cochlear implants. *Ann Otol Rhinol Laryngol*, 85(suppl 27):1.
4	Altay B, Konrot A. (2006).Koklear İmplantın Tarihçesi ve Ülkemizdeki Gelişimi. *Türkiye Klinikleri Cerrahi Tıp Bilimleri Dergisi*. 2(10):1-6.
5	Sennaroğlu L. Koklear İmplantasyon. Koç C (ed): *Kulak Burun Boğaz Hastalıkları ve Baş Boyun Cerrahisi.* Ankara: Turgut Yayıncılık, *2004*: 403-414)
6	Sennaroğlu L, Sennaroğlu G, Yücel Esra. Koklear İmplantasyon. Çelik O. Kulak Burun Boğaz Hastalıkları ve Baş Boyun Cerrahisi. İstanbul: Turgut Yayıncılık, *2002*: 326-338.)
7	Totan S. Koklear implantasyonda hasta seçim kriterleri ve klinik uygulamalarımızın sonuçları. Uzmanlık tezi, Ege Üniversitesi Tıp Fakültesi KBB Hastalıkları, İzmir, 2002.
8	Bülent Agüloğlu. Koklear implant uygulanan hastaların cerrahi ve işitsel yönden retrospektif analizi. T.C. Dicle Üniversitesi Tıp Fakültesi Kulak Burun Boğaz Anabilim Dalı.Tez Danışmanı Doç. Dr. A. Ediz Yorgancılar. Diyarbakır-2014.
9	De flippo CL, Scott BL. A method for training and evaluating the reception of on going speech. J Acoustic Soc Am, *1978*; 63(11):86–92.
10	Süleyman Özdemir. Koklear implant uygulanan hastaların işitsel performans analizleri. T.C. Çukurova Üniversitesi Tıp fakültesi Kulak Burun Boğaz Dalı. Uzmanlık Tezi. Tez Danışmanı Prof. Dr. Mete Kıroğlu. Adana -2006.
11	Mohammed AA, Sarwat SA. (2014). The side of cochlear implantation and speech intelligibility in pediatric and adult cochlear implantees. *The Egyptian Journal of Otolaryngology*. 30, (4)362-366.
12	Henkin Y, Taitelbaum-Swead R, Hildesheimer M, Migirov L, Kronenberg J, Kishon-Rabin L. (2008). Is there a right cochlear implant advantage?.*Otol Neurotol*. 29(4): 489-94.
13	http://newsroom.ucla.edu/releases/Left-and-Right-Ears-Not-Created-5480?RelNum=5480.

14	Chilosi, AM; Comparini, A; Cristofani, P; Turi, M; Berrettini, S; Forli, F; Orlandi,G; Chiti, A; Giannini,N; Cipriani, P; Cioni, G.(2014). Cerebral lateralization for language in deaf children with cochlear implantation. *Brain & Language.*129. 1–6.
15	http://www.audiology.org/news/cochlear-implant-right-ear-advantage
16	Morris LG, Mallur PS, Roland JT Jr, Waltzman SB, Lalwani AK. (2007). Implication of central asymmetry in speech processing on selecting the ear for cochlear implantation. *Otol Neurotol.* 28 (1): 25-30.
17	Van den Broek E, Dennenier EW. (2009). Cochlear Implantation in Post-Lingually Hearing-Impaired Adults: Choosing the Most Appropriate Ear. *International Journal of Audiology.* (48)9: 618-624.
18	Tadros, SF; Frisina, ST; Mapes, F. Kim; SH; Frisina; DR; Frisina, RD. (2005). Loss of Peripheral Right-Ear Advantage in Age-Related Hearing Loss. *Audiology and Neurotology.* Vol 10, No 1.
19	Yoshinaga-Itano, C; DeConde Johnson, C; Carpenter, K; Stredler Brown, A. (2008). Outcomes of Children with Mild Bilateral Hearing Loss and Unilateral Hearing Loss. *Seminars in Hearing.*29, (2)196-211.
20	Oyler, RF., Oyler AL., Matkin, ND. (1988): Unilateral Hearing Loss: Demographics and Educational Impact. *Lang Speech Hear Serv*Sch. 19: 201-210.
21	http://www.eurekalert.org/pub_releases/2004-09/uoc--lar090804.php.
22	http://www.sciencedaily.com/releases/2004/09/040910082553.htm.
23	Kral, A; Heid, S; Hubka, P; Tillein, J.(2013). Unilateral hearing during development: hemispheric specificity in plastic reorganizations. *Front Syst Neurosci.* 2013; 7: 93. doi: 10.3389/fnsys.2013.00093
24	Jiunn Liang Wu, Hui Mei Yang (2003). Speech perception of Mandarin Chinese speaking young children after cochlear implant use: effect of age at implantation. *Int J Pediatr Otorhinolaryngol.* 67(3):247-53.
25	Wu JL, Lin CY, Yang HM, Lin YH. (2006). Effect of age at cochlear implantation on open-set word recognition in Mandarin speaking deaf children. *Int J Pediatr Otorhinolaryngol.* 70(2):207-11.
26	Friederici, A.D. (2011). The Brain Basis of Language Processing: From Structure to Function. *Physiological Reviews.*91. (4), 1357-1392.
27	Gordon KA, Papsin BC, Harrison RV. Activity-dependent developmental plasticity of the auditory brain stem in children who use cochlear implants. Ear Hear, 2003;24:488-500.