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Spoken language development in children with cochlear implants exposed to Sign Language: a scoping review

Desenvolvimento de linguagem falada em crianças com implantes cocleares expostas à Língua de Sinais: uma revisão de escopo

Desarrollo del lenguaje hablado em niños con implantes cocleares expuestos a la lengua de señas: una revisión exploratória

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Abstract

Introduction: Following a diagnosis of deafness, professionals involved in early intervention must inform families about all habilitation options. For this, it is essential that they are familiar with scientific evidence. **Objective:** To map the scientific evidence available in the literature regarding the acquisition and development of spoken language in children with cochlear implants (CIs) who are exposed to Sign Language (SL). **Methods:** This is a scoping review. The databases Embase, LILACS, PubMed, Scopus, Web of Science, and ASHA were consulted. For gray literature, searches were conducted in Google Scholar and ProQuest. Studies that assessed spoken language development in children with CIs exposed to SL were included. **Results:** Seven studies were included in this review. Sample sizes ranged from 1 to 181 participants. **Discussion:** The studies included in this review showed mixed results. Some studies

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report advantages, while others point to disadvantages in the development of various aspects of spoken language in children with CIs who are exposed to SL. Deaf children present diverse and comprehensive characteristics that will directly influence skill development. The findings should be interpreted with caution, considering the methodological limitations observed in the studies, such as small sample sizes and the predominance of observational designs and case studies. **Conclusion:** Based on the evidence found, it is not possible to definitively state whether exposure to SL represents an advantage or disadvantage in the development of spoken language in children with CIs. The available studies are limited in terms of sample size and methodological robustness.

Keywords: Deafness; Cochlear implantation; Sign language; Child.

Resumo

Introdução: Frente ao diagnóstico da surdez, os profissionais envolvidos na intervenção precoce devem informar a família sobre todas as opções de habilitação. Para isso, é fundamental que estejam familiarizados com as evidências científicas. **Objetivo:** Mapear as evidências científicas disponíveis na literatura sobre a aquisição e o desenvolvimento da linguagem falada em crianças com implante coclear (IC) expostas à Língua de Sinais (LS). **Métodos:** Trata-se de uma revisão de escopo. As bases de dados Embase, LILACS, PubMed, Scopus, Web of Science e Asha foram consultadas. Para a literatura cinzenta, buscou-se no Google Scholar e ProQuest. Foram incluídos estudos que avaliaram o desenvolvimento da linguagem falada em crianças com IC expostas à LS. **Resultado:** Sete estudos foram incluídos nesta revisão. O tamanho das amostras variou de 1 a 181 participantes. **Discussão:** Os estudos incluídos nesta revisão apresentaram resultados divergentes. Alguns estudos apontam vantagens, enquanto outros indicam desvantagens no desenvolvimento de diferentes aspectos da linguagem falada em crianças usuárias de IC expostas à LS. Crianças surdas apresentam características diversas e abrangentes que influenciarão diretamente o desenvolvimento das habilidades. Os achados devem ser interpretados com cautela, considerando as limitações metodológicas observadas nos estudos, como o reduzido tamanho amostral e o predomínio de delineamentos observacionais e estudos de caso. **Conclusão:** Com as evidências encontradas, não é possível afirmar de forma definitiva se a exposição à LS representa uma vantagem ou desvantagem no desenvolvimento da linguagem falada em crianças usuárias de IC. Destaca-se a limitação dos estudos disponíveis quanto ao tamanho amostral e à robustez metodológica.

Palavras-chave: Surdez; Implante Coclear; Língua de Sinais; Criança.

Resúmen

Introducción: Ante el diagnóstico de sordera, es fundamental que losprofesionalesorienten a lasfamilias sobre todas lasposibilidades de habilitación. Para ello, deben estar familiarizados conlaevidencia científica disponible. **Objetivo:** Mapear laevidencia científica sobre laadquisición y eldesarrollodellenguaje oral enniñoscon implante coclear (IC) expuestos a laLengua de Signos (LS). **Métodos:** Se realizó una revisiónenlas bases de datos Embase, LILACS, PubMed, Scopus, Web of Science y ASHA. Además, se consultóla literatura gris en Google Scholar y ProQuest. Se incluyeronestudios que evaluaroneldesarrollodellenguaje oral enniñoscon IC que estuvieranexpuestos a la LS. **Resultados:** Se incluyeronsieteestudiosconmuestras que variaron entre 1 y 181 participantes. **Discusión:** Los resultados encontrados fueron divergentes. Algunosestudiosreportaronbeneficios, mientras que otrosindicaronposiblesdesventajasen aspectos específicos dellenguaje oral enniñoscon IC expuestos a la LS. Esta heterogeneidadpuedeexplicarse por ladiversidad de características presentes enlapoblación sorda, que impactandirectamenteeneldesarrollo de habilidades comunicativas. Laslimitaciones metodológicas de losestudios, como eltamañoreducido de lasmuestras y elpredominio de diseñosobservacionales y estudios de caso, requieren una interpretación cautelosa de los resultados. **Conclusión:** La evidencia disponible no permite establecer de maneraconcluyente si laexposición a la LS favorece o perjudicaeldesarrollodellenguaje oral enniñoscon IC. Se destacalanecesidad de estudiosconmayor rigor metodológico y muestras más amplias.

Palabras clave: Sordera; Implantación Coclear; Lengua de Signos; Niño.

Introduction

The use of cochlear implant (CI) is recognized worldwide as the gold standard treatment in cases of severe to profound sensorineural hearing loss (SNHL), mainly bilaterally, among the pediatric population. Its ultimate advantage is the development of hearing skills, which facilitates the acquisition of oral language[1]. Moreover, the CI promotes significant improvement in cognitive performance and in the quality of life as a whole[2].

Several factors are associated with the variability of the spoken language among children with SNHL, such as age, type of hearing loss, presence of additional impairments[3], length of time using the CI, age at the time of the surgery, and performance in the auditory speech perception[4]. In that context, long-term results in the spoken language after the cochlear implantation are the outcome of the combination of communicative, cognitive and environmental factors[5]. However, specific influences, such as the diversity of the linguistic environment have still been scarcely understood[3].

Historically, the debate on the ideal outcomes for hearing-impaired children led to the development of two main approaches of intervention, each one representing distinct philosophies: the oral approach, which stresses the acquisition and development of the spoken language, and the visual-manual approach, which emphasizes the use of the Sign Language (SL).There are still significant knowledge gaps on the effectiveness of the bilingual intervention, ultimately when compared to the exclusively oral intervention for hearing-impaired children when the goal is the spoken language[6].

The use of the CI may enable children to learn the spoken language. Surgery at an early age and family engagement in caring are associated with favorable outcomes, while the presence of additional impairments may delay language development. In that sense, learning the SL before undergoing cochlear implantation may help prevent language deprivation[7]. Thus, ideally, families of children who were referred to the use of the CI should be informed about the actual technological limitations and about the available evidence of bilingualism (exposure to the SL and parallel exposure to the spoken language)[8].

There are scarce studies in literature that effectively prove if the exposure to SL combined with the oral language is the most effective in order to promote the development of the spoken language in that population[6]. However, experts claim that the exposure to SL along with the spoken language may reduce the possibility of hindering communication and losing learning opportunities, especially in situations when the child, for any reasons, has no CI speech processors[9].

Professionals involved in the early intervention must impartially inform the families of the available rehabilitation options. Moreover, such information or recommendations must be grounded in scientific evidence[10].

Therefore, the objective of this review was to map the available scientific evidence in literature on the acquisition and development of the spoken language in children with CI exposed to the SL.

Methods

Type of study

This is a scoping review under the recommendations of the *Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews – PRISMA-ScR*[11] registered in the OSF under DOI 10.17605/OSF.IO/2TPFW. No approval was required from the Research Ethics Board as it is a review of literature.

Search strategy

Search was carried out on August 29th, 2022, and updated on August 22nd, 2024, in Embase, LILACS, PubMed, Scopus, *Web of Science and* Asha databases. As for grey literature, search was conducted in the *Google Scholar* and in the ProQuest, no date restriction. Search strategies were developed for each database or electronic repository, regardless of the year of publication, using descriptors in Portuguese selected in the Health Sciences Descriptors (Descritores em Ciências da Saúde- DeCS), and descriptors in English selected in the Medical Subject Headings (MeSH) (Chart1).

Chart 1. Search strategy

DATABASE	SEARCH
Embase	'cochlear implants'/exp OR 'cochlear implants' OR 'cochlear implant'/exp OR 'cochlear implant' OR 'cochlear prosthesis'/exp OR 'cochlear prosthesis' OR 'cochlear prostheses'/exp OR 'cochlear prostheses' OR 'auditory prosthesis'/exp OR 'auditory prosthesis' OR 'auditory prostheses'/exp OR 'auditory prostheses' OR 'cochlear implantation'/exp OR 'cochlear implantation' OR 'cochlear implantations' OR 'cochlear prosthesis implantation' OR 'cochlear prosthesis implantations' 'sign language' OR 'sign languages' OR 'multilingualism' OR 'bilingualism' OR 'language development' OR 'language acquisition' 'child' OR 'children' OR 'child, preschool' OR 'preschool child' OR 'preschool children' #1 AND #2 AND #3
LILACS	("CochlearImplants" OR "CochlearImplant" OR "CochlearProsthesis" OR "CochlearProstheses" OR "AuditoryProsthesis" OR "AuditoryProstheses" OR "CochlearImplantation" OR "CochlearImplantations" OR "CochlearProsthesisImplantation" OR "CochlearProsthesisImplantations" OR "Implantes cocleares" OR "Implante coclear" OR "Próteses cocleares" OR "Prótese coclear" OR "Próteses auditivas" OR "Prótese auditive" OR "Prótesis cocleares" OR "Prótesis coclear" OR "Prótesis auditivas" OR "Prótesisauditive" OR "Implantscochléaires" OR "Implantcochléaire" OR "Prothèsecochléaire" OR "Prothèsescochléaires" OR "Appareilsauditifs" OR "Protheseauditive" OR "Prothèsesauditives" OR "Implantação Coclear" OR "Implantações, Coclear" OR "Implantações Cocleares" OR "Implantação de prótese coclear" OR "Implantação de próteses cocleares" OR "Implantação, Prótese coclear" OR "Implantação, próteses cocleares" OR "Implantação de próteses, coclear" OR "Implante de Prótese Coclear" OR "Implantación Coclear" OR "Implantaciones coclear" OR "Implantación, Protesis coclear" OR "Implantación de prótesis coclear" OR "Implantationcochléaire" OR "Implantationscochléaires" OR "Implantation, prothèsecochléaire" OR "Pose d'implantscochléaires") AND ("SignLanguage" OR "SignLanguages" OR "Multilingualism" OR "Bilingualism" OR "LanguageDevelopment" OR "LanguageAcquisition" OR "Línguas de Sinais" OR "Língua, sinais" OR "Línguas, sinais" OR "Libras" OR "Linguagem de Sinais" OR "Língua Brasileira de Sinais" OR "Língua Gestual" OR "Lengua de Signos" OR "Lenguaje, signo" OR "Lenguaje, signos" OR "Lengua de señas" OR "Lenguaje de señas" OR "Lenguaje de signos" OR "Lenguas de señas" OR "Lenguas de signos" OR "Langue dessignes" OR "Langue, signe" OR "Langues, signe" OR "Multilinguismo" OR "Multilingüismo" OR "Multilinguisme" OR "Bilinguismo" OR "Bilingüismo" OR "Bilinguisme" OR "Desenvolvimento da Linguagem" OR "Desenvolvimento, Linguagem" OR "Aquisição, Linguagem" OR "Aquisição da Linguagem" OR "DesarrollodelLenguaje" OR "Desarrollo, Lenguaje" OR "Adquisición, Lenguaje" OR "Adquisicióndel linguaje" OR "Développementdulangage oral" OR "Développement, Langue" OR "Acquisition de la langue" OR "Acquisition, Langage" OR "Développement verbal") AND ("Child" OR "Children" OR "Child, Preschool" OR "PreschoolChild" OR "PreschoolChildren" OR "Criança" OR "Crianças" OR "Niño" OR "Niños" OR "Enfant" OR "Enfant de 6 à 12 ans" OR "Pré-escolar" OR "Crianças, Pré-Escolar" OR "Criança Pré-Escolar" OR "Crianças Pré-Escolares" OR "Preescolar" OR "Niñoenedadpreescolar" OR "Niños, Preescolar" OR "Pré-Escolares" OR "Niñosenedadpreescolar" or" Enfant d'âgepréscolaire" OR "Enfants, Pré-scolaire" OR "Enfant d'âgepré-scolaire" OR "Enfant de 2 à 5 ans")
PUBMED	("Cochlear Implants"[Mesh] OR "Cochlear Implants"[Title/Abstract] OR "Cochlear Implant"[Title/Abstract] OR "Cochlear Prosthesis"[Title/Abstract] OR "Cochlear Prostheses"[Title/Abstract] OR "Auditory Prosthesis"[Title/Abstract] OR "Auditory Prostheses"[Title/Abstract] OR "Cochlear Implantation"[Mesh] OR "Cochlear Implantation"[Title/Abstract] OR "Cochlear Implantations"[Title/Abstract] OR "Cochlear Prosthesis Implantation"[Title/Abstract] OR "Cochlear Prosthesis Implantations"[Title/Abstract]) ("Sign Language"[Mesh] OR "Sign Language"[Title/Abstract] OR "Sign Languages"[Title/Abstract] OR "Multilingualism"[Mesh] OR "Multilingualism"[Title/Abstract] OR "Bilingualism"[Title/Abstract] OR "Language Development"[Mesh] OR "Language Development"[Title/Abstract] OR "Language Acquisition"[Title/Abstract]) ("Child"[Mesh] OR "Child"[Title/Abstract] OR "Children"[Title/Abstract] OR "Child, Preschool"[Mesh] OR "Child, Preschool"[Title/Abstract] OR "Preschool Child"[Title/Abstract] OR "Preschool Children"[Title/Abstract]) #1 AND #2 AND #3
SCOPUS	TITLE-ABS-KEY ("Cochlear Implants" OR "Cochlear Implant" OR "Cochlear Prosthesis" OR "Cochlear Prostheses" OR "Auditory Prosthesis" OR "Auditory Prostheses" OR "Cochlear Implantation" OR "Cochlear Implantations" OR "Cochlear Prosthesis Implantation" OR "Cochlear Prosthesis Implantations") AND TITLE-ABS-KEY ("Sign Language" OR "Sign Languages" OR "Multilingualism" OR "Bilingualism" OR "Language Development" OR "Language Acquisition") AND TITLE-ABS-KEY ("Child" OR "Children" OR "Child, Preschool" OR "Preschool Child" OR "Preschool Children")
WEB OF SCIENCE	("Cochlear Implants" OR "Cochlear Implant" OR "Cochlear Prosthesis" OR "Cochlear Prostheses" OR "Auditory Prosthesis" OR "Auditory Prostheses" OR "Cochlear Implantation" OR "Cochlear Implantations" OR "Cochlear Prosthesis Implantation" OR "Cochlear Prosthesis Implantations") ("Sign Language" OR "Sign Languages" OR "Multilingualism" OR "Bilingualism" OR "Language Development" OR "Language Acquisition") ("Child" OR "Children" OR "Child, Preschool" OR "Preschool Child" OR "Preschool Children") #1 AND #2 AND #3
ASHA	("Cochlear Implants" OR "Cochlear Implant" OR "Cochlear Prosthesis" OR "Cochlear Prostheses" OR "Auditory Prosthesis" OR "Auditory Prostheses" OR "Cochlear Implantation" OR "Cochlear Implantations" OR "Cochlear Prosthesis Implantation" OR "Cochlear Prosthesis Implantations") AND ("Sign Language" OR "Sign Languages" OR "Multilingualism" OR "Bilingualism" OR "Language Development" OR "Language Acquisition") AND ("Child" OR "Children" OR "Child, Preschool" OR "Preschool Child" OR "Preschool Children")
GOOGLE SCHOLAR	"Cochlear Implant" AND ("Sign Language" OR "Language Development") AND ("Child" OR "Preschool")
PROQUEST	("Cochlear Implants" OR "Cochlear Implant" OR "Cochlear Prosthesis" OR "Cochlear Prostheses" OR "Auditory Prosthesis" OR "Auditory Prostheses" OR "Cochlear Implantation" OR "Cochlear Implantations" OR "Cochlear Prosthesis Implantation" OR "Cochlear Prosthesis Implantations") AND ("Sign Language" OR "Sign Languages" OR "Multilingualism" OR "Bilingualism" OR "Language Development" OR "Language Acquisition") AND ("Child" OR "Children" OR "Child, Preschool" OR "Preschool Child" OR "Preschool Children")

Selection criteria

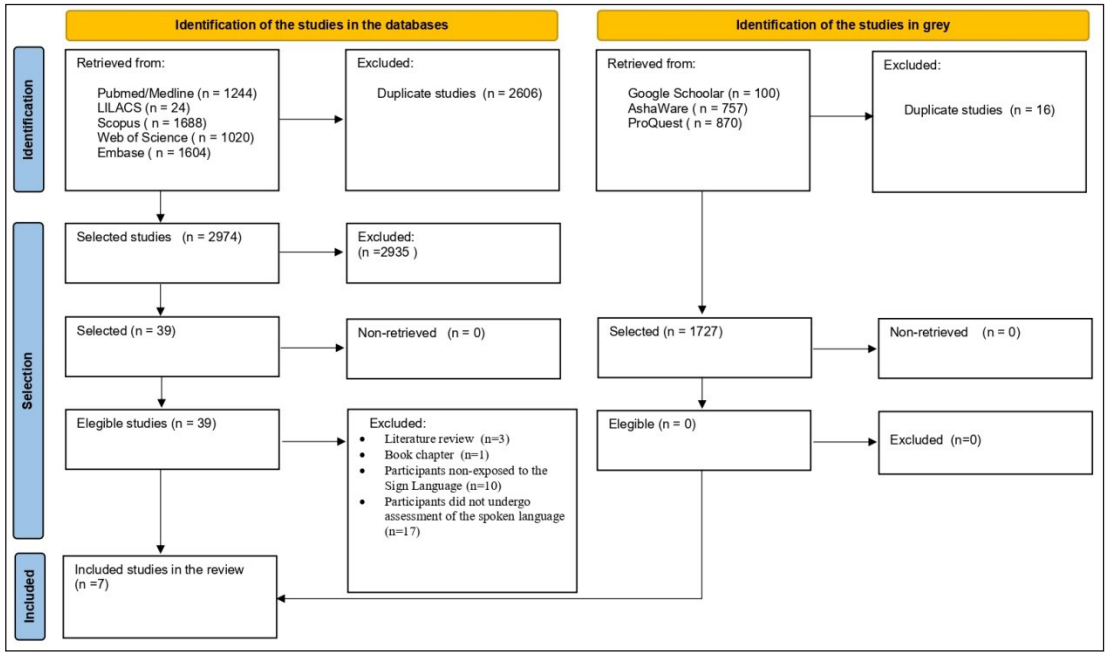
Studies that assessed the development of spoken language in children, users of the CI and exposed to the SL were included. Books, book chapters, proceedings abstracts, and other review studies were excluded.

Selection process and data extraction

Search for articles was inserted in the *Rayyan* software, and duplicate studies were removed. In that process, articles were segmented in three groups: included (for the articles included), excluded (for the excluded articles) or maybe (for the doubtful articles). Triage was conducted by two reviewers in a separated and simultaneous way using the blinding mechanism offered by the program. Initially, the studies were pre-selected by titles and abstracts. Subsequently, full reading of the included studies was carried out. An Excel flowchart was developed to insert data of interest from the included studies, aiming to map the evidence. Information of the selected studies was collected, such as case studies(number of participants, age range, gender and diagnosis), main results and conclusion. Complementary data were identified, as follows: a) year of publication, b) research nationality.

Results

From 6550 records, 2612 were removed as duplicates. Out of the 3938 remaining records, 3899 were excluded after analysis of the title and abstract, with 39 studies being kept for analysis. Seven[12-18]out of the last remaining 39 studies were included in this review (Figure 1).



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffman TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71. For more information, visit: http://prisma-statement.org/

Figure 1. Flow chart of the article selection.

The earliest study included in this review was published in 2003[12], and the latest one in 2017[18]. The location where studies took place varied, with two studies from Italy[13,17], two from the United States of America (USA)[13,18], one from Iran[15], one from Spain[14]and one from Brazil[16].

The main data of the included studies are shown in Table 1. Sample size ranged from 1 to 181 participants, totaling 373 assessed children. Participants' age ranged between 3 and 9 years. Two studies[16,18] did not report the children's age at the moment of the assessment.

Four studies[13,15,16,18] reported that the children were exposed to SL in the family environment, as one of the parents was deaf. In the study by Rinaldi and Caselli[17], the children were exposed to the SL at home as well as at school, while in the study by Geers, Nicholas & Sedey[12], their exposure took place exclusively in the classroom. The study by Jiménez, Pino & Herruzo[14] reports that in one of the groups children were raised in an environment where SL and spoken language were present, but it does not specify whether the exposure occurred exclusively in school settings or within home settings as well.

Five studies[12,14-16,18] compared the performance of children with cochlear implant exposed to SL and spoken language with that of children exposed to the spoken language only. Other two studies[13,17] assessed children with CI exposed to the spoken language and SL without a comparative group.

Table 1. Main data of studies included in the review (n = 7)

Year	First author	Country	n	Age undergoingthe CI	Studypopulation	Assessment of the spoken language	Main results	Conclusion
2017	Geers AE	USA	97	3 years and 2 months	3 groups: (1) children non-exposed to the SL since the activation until 3 years after CI (n = 35); (2) children exposed to the SL after the activation and/or until 12 months after the CI but without using the SL at 24 and 36 months (n = 26); (3) children exposed to the SL since the activation of the CI.	CASL	Children without early exposure to the SL showed better skills of speech recognition in the first 3 years after the CI, and significant speech and reading advantage at the end of the middle school; more than 70% developed spoken language adequate to their age compared with only 39% of those exposed to the SL for 3 years or longer; higher speech intelligibility in children without SL.	There was no advantage in the use of the SL by parents before or after the CI.
2014	Rinaldi P	Italy	1	2 yearsand 6 months	Child exposed to the SL and to the spoken language since the diagnosis (1 year) at school and at home.	Leiter-R; PVB-s, PiNG, PPVT, BNT	Reached the top of the vocabulary test after 1 one year of CI, expressive vocabulary equivalent to the listening peers after 10 months; change to bimodal bilingual communication.	The early exposure to the SL may favor the construction of conceptual representations and support the acquisition of the spoken language.
2012	Hassanzadeh S	Iran	14	1 year and 6 months to 5 years and 7 months	2 groups: (1) children with CI and deaf parents – exposed to the SL (n=7); (2) children with CI and listening parents – non-exposed to the SL (n=7)	Speech Intelligibility Scale and Sentence Imitation Test	Statistical differences between the groups: children with deaf parents and exposed to the SLshowed better speech production.	Learning the SL before CI may favor spoken language acquisition after the CI.

Year	First author	Country	n	Age undergoingthe CI	Studypopulation	Assessment of the spoken language	Main results	Conclusion
2012	Melo TM	Brazil	4	1 year to 1 year and 10 months	2 groups: (1) CI users with deaf parents (n=2); (2) CI users with listening parents (n=2)	Oral communication attitudes in playful interactions; MUSS	Linguistic development similar to the first year, but later better auditory and linguistic development in children exposed to the SL and spoken language.	Being in an adequate educational environment, with the offer of the spoken language, makes the knowledge of the SL not deleterious to the evolution of the spoken language.
2009	Jiménez MS	Spain	18	15 months to 5 years	2 groups: (1) exposed to the SL and to the spoken language; (2) onlyexposed to the spoken language.	Induced Phonological Register; PPVT; ITPA; ICAP; Adaptive Behavior Inventory	G1 had better performance in Manual and Verbal Expression in the ITPA; G2 rated better in auditory discrimination. No differences in receptive vocabulary, social/ communicative skills and sequential memory.	Children with CI, exposed to the SL and spoken language, showed better gesture expression, symbol understanding and verbal fluency; however, those with exclusively oral communication outdo in pronunciation, auditory comprehension and grammar.
2003	Cassandro E	Italy	1	7 years	Child exposed to the SL and spoken language (listening father; mother and family users of the SL)	P.Ca.P; T.I.P.I; PFLI; PPVT;MacArthur Development Inventory; TCGB; playful recordings	Global communicative and linguistic evolution. After 12 months, only two missing phonemes. Increasing use of complex and compound sentences.	There were no temporal or qualitative differences in the speech evolution comparing with children in exclusively auditory and oral rehabilitation.
2003	Geers AE	USA	181	5 years	2 groups: (1) spoken language only (n=98); (2) SL + spoken language (n=83)	TACL-R; WISC-III; speech analysis recorded under two conditions	No differences in comprehension or verbal reasoning. Group with only spoken language showed better narrative, more words, use of morphemes and more complex syntactic structures.	Use of the SL did not add advantages to the development of receptive and expressive language.

Caption: CASL = Comprehensive Assessment of Spoken Language; CI =Cochlear Implant; SL = Sign Language; PPVT = Peabody Picture Vocabulary Test; ITPA = Illinois Test of Psycho-linguistic Abilities; ICAP = Inventory for Client and Agency Planning; P.Ca.P = First Perception Categories; PFLI = Phonologic Evaluation of Infant Language Tests; TCGB = Grammar Comprehension Test for Children; TACL-R = Test for Auditory Comprehension of Language–Revised; WISC-III = Wechsler Intelligence Scale for Children – Third Edition; PVB-s = Il Primo Vocabolario del Bambino Sordo; PiNG = Picture Naming Game; BNT = Boston Naming Test; MUSS = Meaningful Use of Speech Scale; USA = United States of America.

Discussion

Children who underwent cochlear implant at an early age tend to evidence better results regarding speech perception, speech intelligibility, receptive and expressive language skills, reading skills and cognitive skills[19], regardless of the sound processing strategy[20]. However, apart from the age of the device activation, the development of the spoken language in that population is also related to the characteristics of the mother's language[21].

Geers, Nicholas & Sedey[12] and Geers et al.[18] did not observe any advantages in the exposure to the SL for the development of the spoken language in children with CI, although one of them had not reported any statistically significant differences between the assessed groups[12]. The authors found worse speech recognition in the first three years following the CI; statistically significant speech and reading disadvantage close to the end of the middle school; lower probability for the development of spoken language proper to the age; poorer oral

narrative skills; production of less distinct words; use of less connected morphemes and production of less syntactically complex structures in spontaneous speech as well as in dialogues. These two studies[12,18]had the largest sampling sizes among the included studies in this review.

Lyness et al.[22] claimed that factors, such as length of time of sensory deprivation and age when the implant occurred are controlled, exposure to the SL cannot be associated with poor results and CI. In that sense, by assessing 14 children divided in two homogeneous groups regarding beginning and degree of deafness, time length of sensory deprivation, age undergoing surgery, time length using the CI and device model, Hassanzadeh[15]pointed out that deaf children with deaf parents showed better results with the CI when compared with those of listening parents and without exposure to the SL. Melo et al.[16]assessed two pairs of children with profound SNHL, pre-lingual in origin, all using the same CI model with complete insertion of electrodes and the same strategy of speech coding. All the children had made use of hearing aids before the surgery and were enrolled in a program of audio-oral rehabilitation. Both pairs showed similar linguistic skills during the first year using CI. Subsequently, the children exposed to SL (with deaf parents) demonstrated better hearing and linguistic performance, became capable of building sentences with over five words, using connectors, plurals and proper verbal conjugation after three years making use of the CI. On the other hand, children exposed to spoken language only did not reach the same proficiency level, even after five years using the device. However, it is important to point out the reduced number of participants in the study.

Jiménez, Pino e Herruzo[14] disclosed mixed results. They observed that children, CI users exposed to SL, apart from the spoken language, showed higher skills in verbal fluency, being able to evoke higher number of words from visual stimulation. The authors suggest that there may be a generalization of verbal skills acquired by means of the formerly learned SL into the spoken language. On the other hand, they also observed some disadvantages regarding pronunciation, auditory comprehension and use of grammatical rules in children exposed to SL.

A recent study unveiled that the exposure to SL may enhance the executive function, the cognition and the language processing in children with CI[8]. A systematic review[22] suggests that auditory and visual information is mutually reinforced in the brain. That integration favors the success with the use of the CI, and the use of SL with deaf children who wait for the device may promote cognitive development. Further studies using neuroimaging testing may contribute to deepen such findings.

Other two studies included in this review[13,17] showed that children with CI exposed to the SL achieved the development of the spoken language compatible with their age, according to the expected in listening children. However, the results in these studies must be interpreted with caution as they are case studies and do not include a comparative group. Therefore, they cannot prove the advantages or disadvantages of SL exposure. It is worth asking whether outcomes would be the same or even better in case those children had been exposed to the spoken language only. Still, those studies also suggest that the exposure to the SL by itself does not prevent the development of the spoken language in children, users of the CI, as long as other intervening variables are controlled.

According to Hall[23], language exposure refers to the presence of linguistic stimuli within the child's environment, while access refers to the child's ability to perceive and cognitively process the received signals. Additionally, the author points out that the exposure by itself is not enough to deaf children; it is necessary to reassure the access to it. Moeller and Tomblin[24] state that the amount as well as the quality of the language offered to the child are essential to influence his/her linguistic skills along his/her development. In this review, studies that address the exposure to the SL of children with CI were included. However, the amount or quality of that exposure remain unknown. Given the relevance of such aspects, further studies with that population, considering those aspects, are recommended.

Parents' goals when considering the CI to their children can be summarized in expectations related to their child's ability to communicate by means of speech as well as by means of SL[25]. Mitchiner[26] assessed 17 families of deaf parents with their children, users of the CI, and reported that they expressed high expectations and wished to support their children for them to become fluent in both languages. Jones and Roberts[27] concluded that, along the process of decision-making, parents' main priority was to understand the extent to which

their choices would influence their children's future access to opportunities and relationships.

Parental attitudes in relation to deafness were associated with decisions on the cultural and linguistic training of their children. Viewing that acculturation under an ableist perspective may lead parents to choose an exclusively oral approach, with little or no contact with the deaf community[28]. However, parents may advocate their children's treatment more efficiently if they may openly discuss their choices with health professionals, educators and support groups who are receptive to know their preferences in terms of results, beliefs, values and pragmatic considerations, which also impact on the outcome[25].A study[27] found that the most frequent factor rated as "very important" by parents when considering the use of the spoken language was: "*The future academic success of my child"* (96.19%). By considering the use of the SL, the factor most frequently rated as "very important" was: *"My child's ability to build up friendships and relationships in the future"* (82.52%).Therefore, health professionals must consider addressing those factors at the very beginning of the decision-making process in order to support parents on an informed choice of the communicative method to be used with their children.

Kartheiser et al.[29] compared the cognitive outcomes of CI users and evidenced that in CI users whose device was implanted at a later age, the early access to the SL might have grounded proper cognitive development, while in the group which had the device implanted at an early age, the early access to the spoken language was beneficial to the same purpose. The authors concluded that the early access to the language – whether spoken or sign language – can be crucial to the cognitive development. Assuring the early access to quality visual-manual modality of communication to deaf children from listening parents is challenging, once most listening parents are beginners in SL. Thus, the partnership between those parents and early intervention programs, which support bilingual development aiming at those families, is extremely necessary[30].

The auditory-oral approach is one of the factors that interferes in parental engagement during the auditory process of rehabilitation of a child with CI[31]. In that sense, it is also important to respect parents' choice, fluent in SL, who have opted for the CI aiming at the full development of their hearing-impaired child[16].

Deaf children present diverse and broad characteristics related to age, history, progress and development who will affect their degree of success by using the CI. Therefore, it is fundamental for the individuals involved in the process of decision making to be realistic regarding the prospective outcomes for each child[25]. According to Melo et al.[16]andCassandro et al.[13], if the implanted child is in a proper educational environment, which provides him/her with adequate auditory experiences and access to the spoken language, the knowledge of the SL will not hinder the progress of his/her auditory and linguistic skills.

Limitations

A limitation in this study is the fact that it is a scoping review. Therefore, some studies might have been excluded from the sample. Likewise, case studies were included, as it is a scoping review. Despite that, the results of the case studies and case series are interchangeably consistent, evidencing a probable outcome for children with CI in relation to their exposure to SL. It should also be pointed out that studies which assessed the development of other skills exclusively (for example, cognitive skills, reading and written skills, etc.) among that population, were not included.

Considering the technological breakthroughs and the current results of children, users of the CI, further studies are necessary. The outcomes in children with CI entail several variables, which makes it difficult to carry out controlled studies on the theme addressed here. In that sense, the findings may contribute to the debate, fundamentally regarding parents' choices on the exposure or not of their children to the SL, concomitantly with their auditory-oral treatment.

Implications and Future Perspectives

Further longitudinal studies are deemed necessary, with methodological rigor, and control of the variables involved in the development of the spoken language in children with CI, exposed to the SL. Equally important is the sampling size of those studies, which should be robust, enabling statistical tests that evidence the significance of the findings.

This review raises the question whether the outcomes in the spoken language of children with CI, exposed to the SL may be influenced by the

characteristics of that exposure. Do children with CI, exposed to the SL since birth within household settings, present different outcomes from those children whose exposure only occurs within the school setting? May the age when that exposure has started influence the results? Would the exposure to SL have a more positive or negative impact on a specific linguistic skill?

Another relevant question concerns studies which evidence certain advantages when the SL is the parents' first language. Is the observed advantage in the linguistic development of the child with CI due to his/her exposure to the SL, or that would be related to the fact that the SL is his/her parents' native language, therefore communication becomes clearer and natural? In that context, would it be more adequate to encourage listening parents to use their native language (spoken language) with their children, CI users?

The results of this review point to the current scarcity of robust scientific evidence which enables a definitive conclusion whether the exposure to the SL favors or hinders the development of the spoken language in children with CI. Most available studies present significant methodological limitations, such as reduced samples, absence of control groups, diversity in the selection criteria, and use of observational study designs or case reports, which hinders finding generalization.

This study aims to be a starting point for critical and informed debate on the feasibility and potential benefits of bilingual and bimodal approaches, in which concomitant exposure to the oral language and SL is understood as a strategy of linguistic enhancement, not an obstacle to speech development. Given the importance of the early access to a natural language – whether spoken or signed – for the cognitive, linguistic and social development, it is essential that further research explores the effects of bilingual exposure on different profiles of children with CI in a more systematic and longitudinal way, considering variables, such as age undergoing the implant, time length of language deprivation, fluency of the speakers and family and school settings.

Therefore, further studies are proposed to adopt more robust methodological designs, with representative samples, longitudinal analyses and objective measures of linguistic development in both modalities. In addition, studies, which make use of neuroimaging, may enhance understanding on the interaction between visual stimuli from the exposure to the SL and the development of the spoken language in children with CI.

Conclusion

It is not possible to conclude with the current findings in a definitive way whether the exposure to the SL is an advantage or disadvantage in the development of the spoken language in hearing-impaired children who make use of the CI. In addition, the limitation of the current studies regarding their sampling size and methodological robustness should also be pointed out. Away from definitive answers, the findings stress the need of caution when interpreting isolated data, and also they unveil the importance of clinical and educational decisions grounded in consistent evidence.

In view of the aforementioned, it is essential that discussion on methods of linguistic intervention in children with CI be conducted in a critical, ethical way, as well as open to the diversity of prospective paths. A priori exclusion of the SL or devaluation of the spoken language potential may hinder the full access to language – fundamental element for the cognitive, social and emotional development. .

This review does not close any discussions, but it aims to contribute as a starting point to broader reflections on bilingual-bimodal care. With that, it is intended to foster critical, informed debate on the feasibility and potential benefits of approaches that integrate different linguistic modalities, acknowledging that the right to language also encompasses the respect for each child's singularities. It is expected that clinical practice and scientific production increasingly converge to ensure deaf children, users of the CI, the right to develop themselves in rich, accessible and inclusive linguistic contexts.

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