Literature Review

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Proposed protocol for the assessment of patients with single-sided deafness

Proposta de protocolo para a avaliação de pacientes com surdez unilateral

Thales Rafael Correia de Melo Lima[1], Brenda Carla Lima Araújo[2], Fabíola Andrea Andrade dos Santos[3], Carlos Kazuo Taguchi[4], Ronaldo Carvalho Santos Junior[5], Silvia de Magalhães Simões[6]

ABSTRACT

Purpose: To synthesize the scientific publications on single-sided deafness with a view for developing an assessment protocol and indications for hearing solutions for patients with single-sided deafness. **Research Strategy:** A search was performed in the following databases: PubMed, Virtual Health Library (VHL), Embase, Scopus, Cochrane, Science Direct, Scientific Electronic Library Online, Google Scholar and Open Theses & Dissertations, without time and language filters, between December 2020 and October 2023. **Selection criteria:** Studies with content referring to the assessment, treatment and/or follow-up of patients with SSD who are candidates for Cochlear Implant (CI), Bone Anchored System (BAS) and/or contralateral routing of signals (CROS), regardless of age and/or gender and methodological design. Data analysis: Data were extracted from the articles and stored in an analysis matrix, which contained information regarding title, authors, year of publication, location, study type, sample size, objectives, hearing impairment, tests and questionnaires used in the evaluations, outcome data and tested device. **Results:** A total of 552 studies were identified in the initial search; 12 of which were selected for qualitative analysis. The cochlear implant was the most commonly used hearing solution in the studies. The protocol suggests testing bone-anchored hearing aids and contralateral routing signal hearing aids for three consecutive months and the application of tests and questionnaires to assess speech understanding in noise, sound localization, quality of life, tinnitus and the benefits of devices. **Conclusion**: This protocol can assist professionals and patients in choosing the best treatment option for single-sided deafness.

Keywords: Unilateral hearing loss; Protocol; Cochlear implant; Bone-anchored prosthesis; Hearing aid

RESUMO

Objetivo: Sintetizar as publicações científicas sobre surdez unilateral com vistas ao desenvolvimento de um protocolo de avaliação e indicações para soluções auditivas para pacientes com surdez unilateral. **Estratégia de pesquisa**: Foi realizada uma busca nas seguintes bases de dados: PubMed, Biblioteca Virtual em Saúde (BVS), Embase, Scopus, Cochrane, Science Direct, Scientific Electronic Library Online, Google Scholar e Open Theses & Dissertations, sem filtros de data e idioma, entre dezembro de 2020 e outubro de 2023. **Critérios de seleção**: Estudos com conteúdo referente à avaliação, tratamento e/ou acompanhamento de pacientes com surdez unilateral candidatos ao Implante Coclear (IC), Prótese Auditiva Ancorada no Osso (PAAO) e/ou *contralateral routing of signals* (CROS), independentemente da idade e/ou sexo e do desenho metodológico. Análise de dados: Os dados foram extraídos dos artigos e armazenados em uma matriz de análise, contendo informações sobre título, autores, ano de publicação, local, tipo de estudo, tamanho da amostra, objetivos, deficiência auditiva, testes e questionários utilizados nas avaliações, dados de desfecho e dispositivo testado. **Resultados**: Um total de 552 estudos foram identificados na busca inicial; Doze dos quais foram selecionados para análise qualitativa. O implante coclear foi a solução auditiva mais utilizada nos estudos. O protocolo sugere testar aparelhos auditivos ancorados no osso e o CROS por três meses consecutivos, além da aplicação de testes e questionários para avaliar a compreensão da fala no ruído, a localização sonora, a qualidade de vida, o zumbido e os benefícios dos dispositivos. **Conclusão**: Este protocolo pode auxiliar profissionais e pacientes na escolha da melhor opção de tratamento para surdez unilateral.

Palavras-chave: Perda auditiva unilateral; Protocolo; Implante coclear; Prótese ancorada no osso; Aparelho auditivo

Study carried out at Universidade Federal de Sergipe – UFS – São Cristóvão (SE), Brasil.
[1]Programa de Pós-graduação Profissional em Gestão e Inovação Tecnológica em Saúde, Universidade Federal de Sergipe – UFS – Aracaju (SE), Brasil.
[2]Departamento de Fonoaudiologia, Universidade Federal de Sergipe – UFS, Aracaju (SE), Brasil.
[3]Hospital Universitário, Universidade Federal de Sergipe – UFS – Aracaju (SE), Brasil.
[4]Departamento de Fonoaudiologia, Universidade Federal de Sergipe – UFS – Aracaju (SE), Brasil.
[5]Departamento de Medicina, Hospital Universitário – EBSERH, Universidade Federal de Sergipe – UFS – Aracaju (SE), Brasil.
[6]Programa de Pós-graduação Profissional em Gestão e Inovação Tecnológica em Saúde, Universidade Federal de Sergipe – UFS – Aracaju, SE, Brasil.
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Corresponding author: Thales Rafael Correia de Melo Lima. E-mail: thalles_rafa@hotmail.com
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INTRODUCTION

Profound unilateral hearing loss is a condition in which an individual has deafness in one ear and hearing within the normal range in the other. The cause of this change can be congenital or acquired, usually resulting from infections[1].

Evidence indicates that single-sided deafness (SSD) can compromise social communication[2,3]. The main difficulties are in speech understanding, especially in a noisy environment[4], the location of the sound source[5,6], negative psychological effects, restrictions on social participation[7], and impacts on learning and labor productivity[8]. In addition, these patients make an effort to compensate for SSD in complex auditory environments[9], which, over time, can result in hearing fatigue[10].

For the hearing rehabilitation of patients with SSD, the existing options are the contralateral routing of signals (CROS) hearing aids, Bone Anchored System (BAS) and cochlear implant (CI)[11].

CROS hearing aids are non-invasive, aesthetically acceptable, and a relatively low-cost option for patients with SSD, its adaptation is possible from the age of seven[12], composed of a hearing aid used in the ear with hearing loss, containing a microphone and transmitter, and another, in the ear with hearing within the normal range, containing a receiver. The hearing aid of the ear with hearing loss captures and transmits the acoustic signal to the receiver of the hearing aid used in the ear with hearing within the normal range[13]. However, some patients reported negative opinions about the use of this intervention[14], with hearing dificults when speech is located on the side with normal hearing, with noise on the side with hearing loss. Furthermore, having an auditory mold occluding the ear with normal hearing was presented as a negative point[15].

The main benefits obtained with this device are better sound perception on the impaired side and better hearing in noisy environments, when speech is located on the impaired side[13]. On the other hand, BAS can offer a more effective rehabilitation for patients with SSD, as it improves the quality of life of these patients[16].

Adult patients with unilateral hearing loss who underwent CI surgery report improvement in sound localization, understanding of speech in noise[17,18] in quality of life[19], significant reduction in discomfort caused by tinnitus[20], better auditory use and performance at work[21]. There is also evidence of benefits in pediatric patients with SSD[22]. The CI, when compared to other hearing solutions, is the only one that allows binaurality, that is, the user can hear again on the side that was deaf[8], in addition to promoting normal cortical reestablishment[23].

To select one of these existing hearing solutions for patients with SSD, tests with CROS and BAS are recommended[11,24,25], through a standardized protocol.

The Ministry of Health of Brazil (MS) recommends the use of CI for auditory habilitation and rehabilitation of people with bilateral, severe and/or profound sensorineural hearing loss, and the use of BAS for cases of bilateral conductive or mixed hearing loss[26]. There exist no protocols published in the national literature on the approach for this group of patients, which makes the topic little explored.

Given this, an integrative review of the literature was carried out, with the guiding question being: “Given the hearing solutions available for SSD, how can we evaluate the patient and indicate the best option to (re)habilitate hearing?”

PURPOSE

The aim of this study was to review and synthesize the scientific publications on profound unilateral hearing loss with a view for the developing an assessment protocol and indications for hearing solutions for patients with SSD.

RESEARCH STRATEGIES

Between December 2020–October 2023, a search was performed in the following databases: PubMed, Virtual Health Library (VHL), Embase, Scopus, Cochrane, Science Direct and Scientific Electronic Library Online. As for gray literature, the following databases were consulted: Google Scholar and Open Theses & Dissertations, without time and language filters. The following descriptors were used in English, registered in the Health Sciences Descriptors (DeCs) and/or Medical Subject Headings (MeSH), combined through the Boolean operators “AND” and “OR”: (“hearing loss” or “hearing loss, unilateral” or “unilateral deafness”) AND (“cochlear implants” or “cochlear implant” or “cochlear prosthesis”) OR (“bone-anchored prosthesis”) OR (“cros hearing aids”) AND (“clinical protocols”).

SELECTION CRITERIA

The inclusion criteria were studies with content referring to the assessment, treatment and/or follow-up of patients with SSD who are candidates for CI, BAS and/or CROS, regardless of age and/or gender and methodological design. Book chapters, review studies, editorials, research notes and comments were excluded.

DATA ANALYSIS

After ensuring the inclusion criteria, the articles were initially selected by reading the titles and abstracts; the studies that seemed to meet the inclusion criteria underwent full reading of their texts. Data were extracted from the articles and stored in an analysis matrix, which contained information regarding title, authors, year of publication, location, study type, sample size, objectives, hearing impairment, tests and questionnaires used in the evaluations, outcome data and tested device. After the final selection of the studies included in the analysis, the main information was gathered in tables for systematization. The studies were exported to a reference manager and duplicate studies removed.

RESULTS

Fifty-two studies were identified in Pubmed, one in the VHL, three in Google Scholar, 111 in Embase, 31 in Scopus, 219 in Cochrane, 22 in Science Direct, five in Open Theses & Dissertations and 108 in Scielo, for a total of 552 articles. Of these, 13 were read in full and ten were selected according to eligibility criteria. The other three articles were excluded because in one of them the study population did not have SSD and in another, the authors did not specify the degree of unilateral hearing loss; thus, it was not possible to identify whether the study involved patients with SSD.

The third excluded article had different outcomes from those researched in this review. Two article was included after a manual search was performed on the references of the included articles. A final 12 articles were included in this review. The flowchart of the article selection process is shown in Figure 1.

The studies included were: five prospective studies(27-31), two protocol studies(25,32), a longitudinal study(3), a case-control study(33), a retrospective study(34), a cross-sectional study(35) and a randomized controlled trial(36).

The selected studies were published between 2006–2021, carried out in Belgium(28,30,33), the United Kingdom(3,32), Brazil(35), Germany(34), France(31), the United States of America (USA)(27), China/Canada(25) and the Netherlands(29,36).

Table 1 presents the data extracted from the studies selected for this review. Six articles had, as the object of study, individuals with SSD: four articles with SSD and AHL, two with SSD and tinnitus and one with SSD, AHL and tinnitus. 163 patients were diagnosed with SSD and age ranged from eight months(30) to 80 years(34). Hearing-related impairments in patients with SSD were highlighted by all studies included in this review. Regarding tests and questionnaires, speech recognition in noise was the most used(3,25,27,29-31,35,36) and a quality of life questionnaire was applied in five of the articles(3,25,31-34,36). After a qualitative analysis of the studies included in this review, evidence suggests that cochlear implants were the most used hearing solution in patients with SSD(25,27-31,34-37).

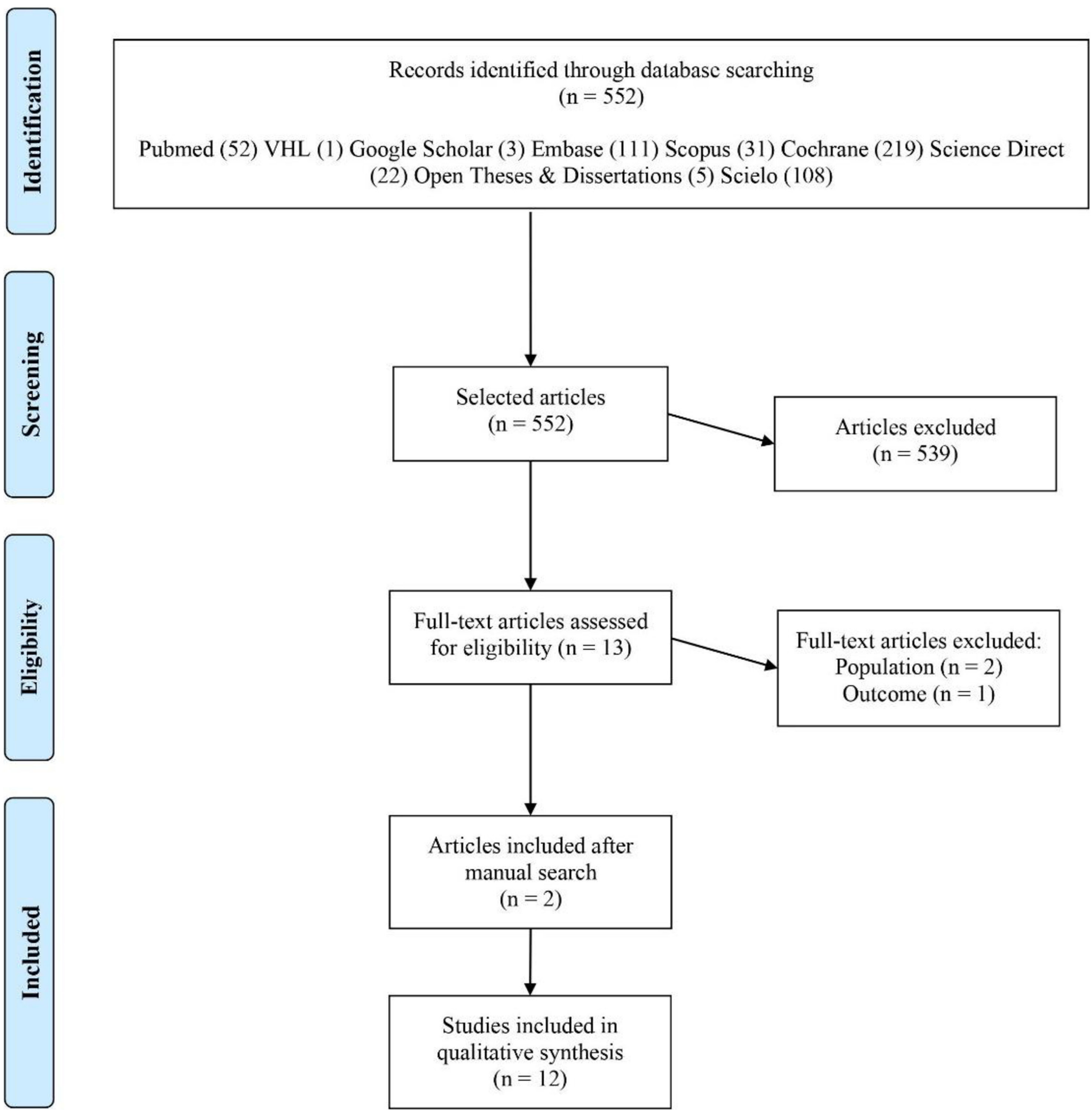

Figure 1. Flowchart of the selection of studies for the review

Table 1. Characteristics of the studies, hearing disorders, tested devices, tests/questionnaires, and main outcomes of the selected studies

AUTHOR/YEAR/ COUNTRY	STUDY DESIGN	N	OBJECTIVE	HEARING CHANGES	TESTED DEVICES	TEST PERIOD	TESTS/ QUESTIONNAIRES	OUTCOMES
Lin *et al.*, 2006, USA[27]	Prospective, Intervention	18	Evaluate the specific rehabilitative benefits observed in adults with SSD and hearing within the normal range or moderate sensorial hearing loss in the functional ear, using CROS and BAS.	SSD and AHL	CROS and BAS	Four weeks	Speech Recognition in Silent and Noise and Sound Location/APHAB and HINT	Patients with AHL realized greater benefits, especially in background noise and speech understanding, with BAS amplification compared to patients with SSD. There was satisfaction with BAS and low acceptance by CROS.
Punte *et al.*, 2013, Belgium[28]	Cohort, open prospective	7	To investigate the effect of electrical stimulation of the cochlea on tinnitus in SSD.	SSD and Tinnitus	CI	-	EVA scale and Tinnitus questionnaire (TQ)	All tinnitus assessment measures (VAS for intensity, comparison of psychoacoustic tinnitus volume at 1 kHz and the Tinnitus Questionnaire) remained unchanged with 1, 2, 3 or 4 pairs of activated electrodes. With complete activation of the IC, tinnitus significantly decreased. The non-implanted group did not show tinnitus reduction.
Kitterick et al, United Kingdom 2014[3]	Longitudinal study	-	Evaluate the sound localization, speech perception in noise and quality of life of patients who reported insufficient benefit of CROS and underwent CI	SSD	CROS e CI	12 weeks	Sound localization, speech recognition in noise, general and specific quality of life, tinnitus	CROS system was found to be effective compared to an unaided condition in improving speech perception in noise, but the system does not improve the ability to localize sounds. Cochlear implant in SSD can restore the ability to localize sounds by providing access to the interaural cues that support accurate localization and therefore has the potential to support useful aspects of binaural hearing.
Rösli *et al.*, 2015, Germany[34]	Retrospective	8	To evaluate the quality of life in the postoperative period of 20 patients with unilateral hearing loss treated with cochlear implants, by means of questionnaires and 4 a visual analogue scale.	SSD and AHL	CI	-	NCIQ APHAB HHIE HPS (Hearing Participation Scale)	Except for the perception of loud everyday sounds (sound aversion scale - APHAB) reported by patients in group 2 (contralaterally moderate hearing loss), all study participants significantly improved their quality of life with the implant.
Almeida, 2017, Brazil[35]	Cross sectional	-	To investigate the sound source localization ability and speech recognition in the presence of noise in subjects with unilateral hearing loss who use implantable hearing aids (cochlear implant or bone-anchored prostheses) using the LISTEN-SOUND and LOCALIZE-SOUND tests.	SSD	CI and BAS	-	LISTEN-SOUND, LOCALIZE-SOUND/SSQ.	Implantable hearing aids were efficient in rehabilitating the hearing of individuals with unilateral hearing loss. The results with the skills of speech recognition in the presence of noise and location of the sound source in the presence of noise were more evident in cochlear implant users
Arts *et al.*, 2017, Netherlands[29]	Crossover, prospective and randomized	-	Evaluate whether intracochlear electrical stimulation independent of environmental sounds suppressed tinnitus and evaluate the effects of this treatment option on speech perception	SSD, AHL and tinnitus	CI	-	Speech Recognition in Silence and Noise/SSQ and EVA Scale.	Standard clinical CI in SSD or AHL was shown to be beneficial for speech perception in silence and noise and subjective hearing ability. The specific electrical stimulation of tinnitus did not influence speech perception.

Subtitle: SSD – *Single Sided Deafness;* AHL – *Asymmetric hearing loss:* BAS - Bone Anchored System*;* CI – Cochlear implant; CROS – *Contralateral Routing of Signals;* APHAB - *Abbreviate Profile of Hearing Aid Benefit;* EVA – Escala Visual Analógica; SSQ - *Spatial and Qualities of Hearing Scale*; HPS - Hearing Participation Scale; NCIQ - *Nijmegen Cochlear Implantation Questionnaire*; HHIE - *Hearing Handicap Inventory for the Elderly*

Table 1. Continued...

AUTHOR/YEAR/ COUNTRY	STUDY DESIGN	N	OBJECTIVE	HEARING CHANGES	TESTED DEVICES	TEST PERIOD	TESTS/ QUESTIONNAIRES	OUTCOMES
Sangen *et al.*, 2017, Belgium[33]	Case-control	17	Investigate whether the loss of sensory data on only one side would affect the language development of children with SSD, according to standardized behavioral tests.	SSD	CI	-	Hearing, linguistic and cognitive tests/ SSQ	This study showed differences between children with SSD and children with hearing within the normal range in different language skills and auditory behavior.
Van de Heyning *et al.*, 2017, China/ Canada[25]	Protocol study	-	To elaborate a protocol for evaluating current treatment options in patients with SSD/AHL	SSD e AHL	CROS, BAS and CI	Three weeks	Speech recognition in silence and noise, Sound location, Quality of life and tinnitus	Recommended measures included (1) speech-in-noise test; (2) location testing; (3) questionnaires to collect measures of quality of life and frequency of device use; and (4) questionnaires to assess the impact of tinnitus before and after treatment, if applicable.
Van Wieringen *et al.*, 2018, Netherlands[30]	Proposal for a multi-center, prospective study	-	To investigate the development of spoken language, cognition and spatial/binaural hearing longitudinally in ten children with SSD who will receive a cochlear implant	SSD	CI	-	Language tests, sound localization test, speech recognition in noise tests, behavioral tests and questionnaires to parents.	The article presents a multicenter prospective study of cochlear implants in children with SSD. The proposed evaluation included language tests, sound localization tests, speech recognition tests in noise and behavioral tests.
Marx *et al.*, 2019, France[11]	Proposal of a prospective, randomized, controlled multicenter study	-	Evaluate the efficiency of the CI in SSD/AHL, compared to the standard of care in France (observation), after the failure of the CROS and Bone Conduction trials, using a cost-utility analysis	SSD and AHL	CROS, BAS and CI	Three weeks	Speech recognition in noise, quality of life, sound localization/NCIQ	The article describes a prospective randomized multicenter study. The proposed protocol included a trial period with CROS and BAS. Patients who opt for a IC will be randomized between the initial observation and the performance of the cochlear implant surgery
Katiri *et al.*, 2020, United Kingdom[32]	Protocol study	-	To elaborate a set of outcomes for use in future trials of SSD interventions.	SSD	CROS, BAS and CI	-	Quality of life, sound localization, tinnitus.	A list of 43 suggested outcomes was thematically organized into ten categories: (1) psychological effects, (2) device being tested, (3) quality of life, (4) hearing loss, (5) spatial hearing, (6) physical effects, (7) self-perception, (8) quality of sound, (9) hum and (10) other effects
Peters *et al.*, 2021, Netherlands[36]	Randomized controlled trial	113	Evaluate CROS, BAS and CI treatments in adult patients with SSD	SSD	CROS, BAS and CI	3 and 6 months	Speech recognition in noise, quality of life, sound localization, tinnitus.	Speech perception in noise improved in all configurations for the CI group, whereas speech perception in noise improved or deteriorated for the BCD and CROS groups. Sound localization improved in the CI group only. Patients with no tinnitus at baseline did not develop tinnitus after any intervention. After cochlear implantation, three patients reported that their tinnitus had disappeared. All treatment options improved quality of life.

Subtitle: SSD – *Single Sided Deafness;* AHL – *Asymmetric hearing loss:* BAS - Bone Anchored System*;* CI – Cochlear implant; CROS – *Contralateral Routing of Signals;* APHAB - *Abbreviate Profile of Hearing Aid Benefit;* EVA – Escala Visual Analógica; SSQ - *Spatial and Qualities of Hearing Scale*; HPS - Hearing Participation Scale; NCIQ - *Nijmegen Cochlear Implantation Questionnaire*; HHIE - *Hearing Handicap Inventory for the Elderly*

Tests and questionnaires

The tests and questionnaires used in the studies included in this review were the: Hearing Handicap Inventory for the Elderly (HHIE), Hearing in Noise Test (HINT), Abbreviated Profile of Hearing Aid Benefit (APHAB), "ESCUTA-SOM" and "LOCALIZA-SOM" questionnaire Speech, Spatial and Qualities of Hearing Scale (SSQ), Tinnitus Functional Index (TFI), Tinnitus Questionnaire (TQ), Visual Analog Scale (VAS), and Cochlear Implant Questionnaire (Nijmegen Cochlear Implant Questionnaire [NCIQ]; Hearing Participation Scale [HPS]).

Proposed protocol for evaluating patients with profound unilateral hearing loss

Population - inclusion and exclusion criteria

According to the integrative review carried out in this study, patients must meet all the following inclusion criteria: diagnosis of SSD with definition of etiology, when possible; and ability to perform all assessments required in the protocol. The exclusion criteria for each hearing solution were:

CI: presence of retrocochlear lesion in the ear to be implanted, cochlear ossification, cochlear malformation, absent/compromised auditory nerve, presence of infection in the external and/or middle ear or tympanic perforation; manifestation of unrealistic expectations about the possible benefits.

BAS: presence of bone structure of the skullcap smaller than 3 mm; age less than five years; manifesting unrealistic expectations about the possible benefits; and

CROS: presence of anatomical abnormalities; manifestation of unrealistic expectations about the possible benefits.

Otorhinolaryngological and audiological evaluation

The otorhinolaryngological assessment aims to investigate the cause of hearing loss and provide guidance for treatment possibilities for hearing loss, diagnosed by complete audiological assessment, through the results of tonal and vocal audiometry, analysis of acoustic immittance measures, auditory evoked potential of brainstem (BAEP) and otoacoustic emissions, in addition to imaging exams, such as magnetic resonance and computed tomography. These resources make it possible to investigate the cause of hearing loss, guide the possibilities of hearing solutions, and assess prognoses, in addition to the search for relevant information about hearing complaints, general health and sociodemographic data that may interfere in the process[38,39].

Tests and questionnaires included in the protocol

The tests and questionnaires included in the protocol, listed in Table 2, were the: Hearing in Noise Test (HINT), LOCALIZE-SOUND, Speech questionnaire, Spatial and Qualities of Hearing Scale (SSQ), Tinnitus Handicap Inventory (THI), World Health Organization Quality of Life assessment (WHOQOL-brief) and Questionnaire Nijmegen Cochlear Implant Questionnaire (NCIQ-P).

Speech recognition tests (HINT), sound source localization (LOCALIZE-SOUND) and the SSQ questionnaire were applied at all stages. The THI questionnaire was applied in cases in which there is a complaint of tinnitus. Quality of life was assessed by a validated questionnaire (WHOQOL-brief) and a specific questionnaire (NCIQ-P) applied at the beginning, after the tests and in the follow-up phase, after choosing the treatment.

Table 2. Characteristics of the questionnaires/tests included

QUESTIONNAIRES /TEST	VALIDATED IN BRAZIL BY	AGE	INTERPRETATION
HINT	Bevilacqua *et al*., 2008[40]	From 8 years old	Identify the sentence recognition threshold in silence and in the presence of masking noise
LOCALIZE-SOUND	Almeida, 2017[35]	Any age	Normality pattern: locate at least 70% of the presented stimuli
SSQ	Gonsalez and Almeida, 2015[41]	Any age, can be applied to parents/guardians	Scoring scale ranges from "0" to "10" or "Not applicable". 10: patient is able to perform the investigated situation; 0: patient feels unable to perform the investigated situation; Not applicable: the task is not part of the patient's daily life
THI	Ferreira *et al*. 2005[42]; Schmidt *et al*. 2006[43]	5 years	Possible answers: "yes"; "no"; "sometimes". "Yes" answers = 4 points; answers "no" = 0 points; answers "sometimes" = 2 points. The highest possible total score corresponds to one hundred points and reveals a maximum handicap in the patient's quality of life due to tinnitus. The lowest possible score corresponds to zero point and does not show handicap in quality of life.
WHOQOL-bref	Fleck *et al*., 2000[44]	Any age, can be applied to parents/guardians	Score from one to five per word. For questions 3, 4 and 26, the score is inverted: 1=5, 2=4, 3=3, 4=2 and 5=1. The final score is determined by multiplying the average of all items included within a domain by four. The final score can range from 0 to 100. The higher the value, the better the quality of life domain assessed.
NCIQ-P	Santos *et al*., 2017[45]	Any age, can be applied to parents/guardians	Possible answers (first 55 questions): 1= Never; 2= Sometimes; 3= Regularly; 4= Generally; 5= Always; not applicable. Possible answers (5 final questions): 1= No; 2= Unsatisfactory; 3= Satisfactory; 4= Good; 5= Very well; not applicable. At least seven of the ten items must be completed to complete a specific subdomain. Score for each answer in subdomain: 1 = 0; 2 = 25; 3=50; 4 = 75; 5 = 100. After completing the sum of all items in a subdomain, the total value is divided by the number of complete answers.

Subtitle: HINT – *Hearing in Noise Test;* **SSQ -** *Spatial and Qualities of Hearing Scale***; THI:** Tinnitus Handicap Inventory; **WHOQOL-bref**: World Health Organization Quality of Life assessment; **NCIQ-P** *Nijmegen Cochlear Implantation Questionnaire*

Service flowchart proposal

Based on the integrative review carried out in this study, the flowchart shown in Figure 2, prepared for the assessment of patients with SSD, is suggested.

The patient should undergo evaluations with the otolaryngology and speech therapy teams. After the diagnosis of SSD, the patient should test the CROS for three months and the BAS for another three months (by means of an elastic tiara), with speech recognition tests performed in silence and noise (HINT), source location test sound (LOCALIZA-SOM), quality of life questionnaire (WHOQOL-brief and NCIQ-P) and application of the SSQ questionnaire to assess the advantages and disadvantages of using each tested hearing solution. After the six-month experience (three with CROS and three with BAS), the patient should have four options to choose from with the team: CROS, BAS, CI or no treatment. It should be noted that CI is the only option without the possibility of testing; thus, there will be a favorable recommendation for the CI after the conclusive analysis of the limited benefits with the tested technologies (CROS and BAS). The final recommendation should consider the comparison between the results obtained in the tests (speech perception and sound source location), with and without the use of devices and between devices, and between the scores obtained in the application of the SSQ questionnaire using the CROS and BAS.

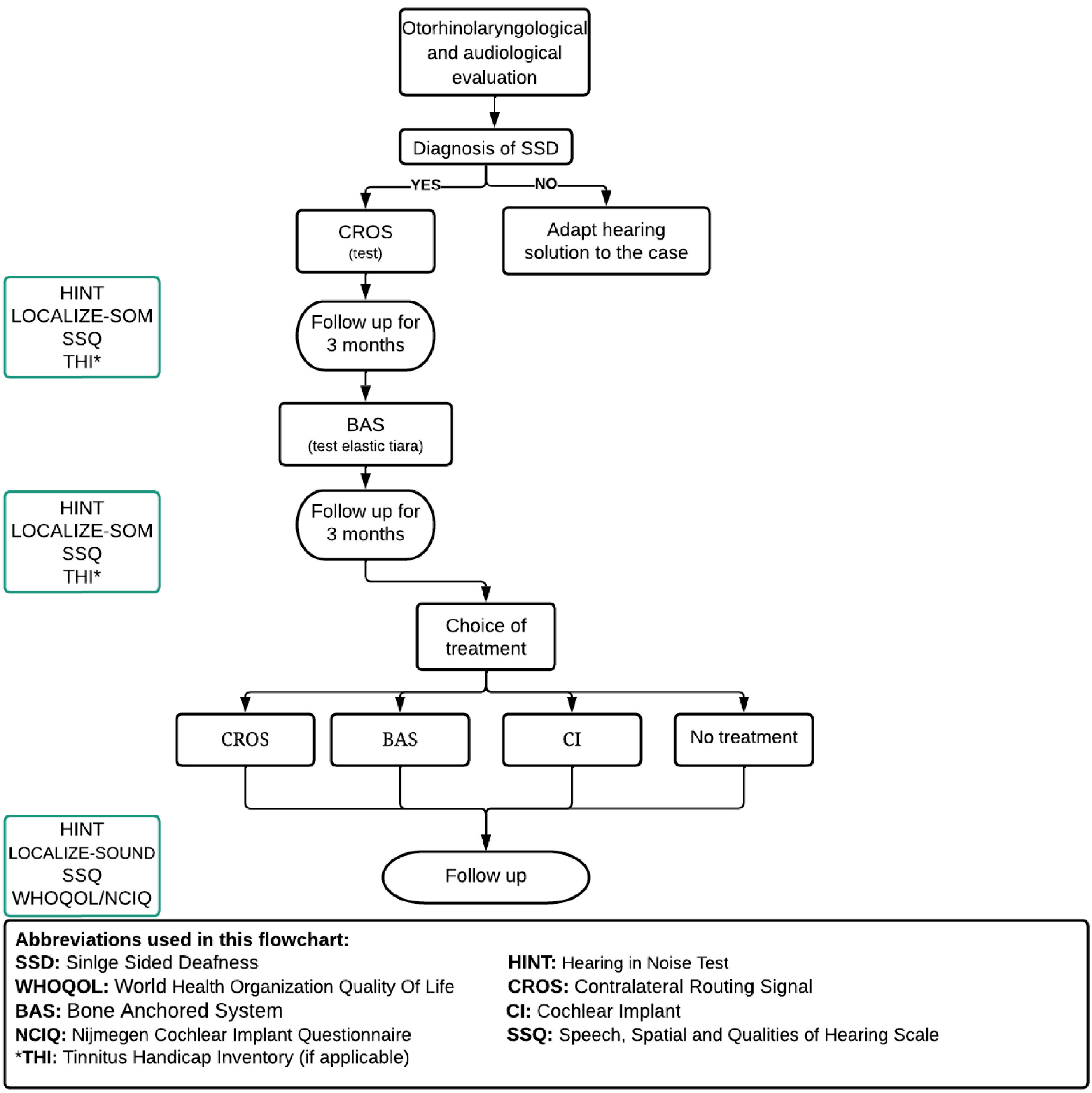

Figure 2. Flowchart for evaluating patients with SSD

Regardless of the hearing solution defined for each case, the patient should continue to be monitored by the entire multidisciplinary team that makes up the health establishment qualified for the specialized care for people with hearing impairment. This especially includes speech therapy, with audiological evaluation, application of speech recognition test in silence and noise, sound localization test and quality of life questionnaire.

Several authors have referred to the treatments available for SSD over the years[31,46-49]. According to Marx et al.[11], treatment options for patients with SSD include BAS, CROS hearing aids, and CI. Of these solutions, CROS and BAS can be previously tested, for a limited time, before the final choice for the patient is made[11,24,25].

There are no treatment options for patients with SSD in the SUS. Otorhinolaryngologists and speech therapists have expressed concern regarding the impacts caused by SSD, suggesting auditory solutions that meet the expectations and lifestyles of patients. SSD impairs communication with people[2,3,11] and emphasizes the importance that rehabilitation options should be considered and available in the SUS.

All studies included in this review applied a test and/or questionnaire in their respective assessments, and most of them used speech perception tests in silence and in noise[25,29,30,35,50,51], sound localization test[25,30,35,50,51] and a questionnaire to assess the benefit of the auditory solution[29,33,34,50,52].

Regarding the test time for a new device, several studies suggest different periods: three weeks[25,51], four weeks[50] and 12 weeks[53]. According to Kitterick et al.[53], the duration of the test must follow the recommendation of each service, but the authors suggest a minimum time of four weeks. In the general guidelines for specialized care for people with hearing impairment in the SUS, one of the indication criteria for CI is that the patient tests individual sound amplification devices for a minimum period of three months[26]. For the elaborated protocol, the longest test time described in the literature was suggested as three months with each device (CROS and BAS). Studies show that this period may be enough for the patient's perception of the benefits, as well as their adaptation to the devices being evaluated, to be certified[26,53].

In the literature, there are some studies that assessed speech comprehension in silence and noise[15,54-56]. A systematic review involving implantable prostheses as a way to rehabilitate patients with unilateral hearing loss found that the HINT was the most used test to measure speech recognition[57]. In this review, the included studies used different instruments to test speech perception in silence and noise; however, the HINT should be part of the suggested protocol because it has been adapted to Brazilian Portuguese[40], since it has been used in Brazil to assess patients with SSD[58], CI[59] users and BAS[60] users.

One of the most impaired auditory skills in patients with SSD is sound localization, especially when exposed to noise[47,61,62]. Thus, the importance of applying tests to assess this skill is highlighted. The LOCALIZA-SOM, developed and validated by Almeida[35], has proven to be practical in organization, execution and low cost, which encourages and makes its insertion in clinical practice easier, helping clinicians and researchers in the area.

The SSQ has been used in several studies to assess the benefits of different solutions for the rehabilitation of hearing loss[63-66]. This instrument has been frequently used in the population with SSD in clinical research and rehabilitation environments[49,67,68]. It was adapted to Brazilian Portuguese in 2015 by Gonsalez and Almeida[41]. In this protocol, the SSQ will be applied at all stages and comparisons will be made between the scores obtained at each stage.

The choice of hearing solution is associated with higher scores in questionnaires that assess quality of life, regardless of the duration and etiology of deafness and audiological measures[11]. Thus, the use of these questionnaires should assist the team in advising the patient regarding the choice of treatment for SSD. The questionnaires included in the protocol were the WHOQOL-brief[44] and NCIQ-P[45], as they were translated, adapted and validated for Brazil, making general and specific auditory assessment possible.

The importance of the patient's opinion regarding the experience with the tested devices is also emphasized. According to Bakhit et al.[69], the opinion of the patient is indicated in order to involve the patient in the final decision, especially in cases in which more than one treatment option is available. Shared decision-making is the process of integrating patients' goals and concerns with scientific evidence to achieve high-quality decisions[70]; it increases knowledge regarding more realistic options and expectations regarding possible benefits and harms, in addition to more consistent choices[71].

The TFI and Mini-TQ questionnaires that assess tinnitus have been validated and translated into Portuguese[72], however, in Brazil, the THI is the most used[73]. This specific questionnaire that assesses the emotional, functional and catastrophic aspects caused by tinnitus[74] was adapted and validated in Portuguese by Ferreira et al.[42] and Schmidt et al.[43], and has been used in patients with IC[75] and BAS[76]. Discomfort caused by tinnitus in patients with SSD has been frequently studied[21,77].

One study suggests the use of a maximum of two questionnaires during assessments since the overload of different questionnaires can increase the effect of response change and reduce patient compliance[78]. However, in research with patients with SSD[11,25,51], the assessment of speech in noise, sound location, quality of life, tinnitus (when applicable) and the benefits of devices have been performed to define indications for treatment. All these aspects are important for choosing the best device, which is why this protocol has incorporated all these assessments.

The proposed protocol can be applied to patients of any age. The questionnaires and tests included in this protocol were used in studies to assess the pediatric population with SSD: the SSQ[79], THI[80], HINT[55,81], NCIQ[82], and WHOQOL-Bref[83]. In addition, sound localization assessment can be performed at any age[84].

We consider, as limitations of this review, the small number of participants in the included studies and that three studies did not specify the frequencies of patients with SSD and AHL. Furthermore, one study did not indicate the number of patients with severe and profound unilateral hearing loss. This protocol was not applied as a pilot project, but the literature studies included in this review validate the use of devices, questionnaires, and hearing tests.

CONCLUSION

After synthesis of scientific publications on single-sided deafness, it was possible to develop an assessment protocol and indications for hearing solutions for patients with single-sided deafness. The application of the protocol developed in this review study for the evaluation of patients with SSD, in addition to the benefit for this population, allows for a qualitative standardization of the assessment of the advantages and disadvantages of available hearing solutions for SSD, which can generate an increase in scientific evidence.

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