Research Article
Open Access

Study on the efficacy of harmonic frequencies applied through music therapy intervention techniques in cochlear implant patients

Abstract

This article deals with research conducted through therapeutic intervention to three people with cochlear implants from 2016 to 2021, in which the effectiveness of music therapy as a tool in the auditory rehabilitation of cochlear implant patients was studied, not only for the improvement in the perception of music and its elements but also because it contributes to the development of oral language comprehension post-implant and improves the quality of life indices of these patients. For this purpose, the auditory rehabilitation techniques carried out in speech therapy were adapted to sound-musical activities in a structured and progressive manner. The results obtained indicate that the three patients achieved a good development in the activities and that they improved their levels of frequency and phonological discrimination as well as their language comprehension and perception in their quality of life.

Keywords: cochlear implant, music therapy, hearing impairment, auditory rehabilitation.

Volume 7 Issue 3 - 2022

Alejandra Hernández Fuentes,[1] José Fernando Fernández Company[2]
[1]Creator of "Harmonic Frequency Therapy" and the Comunicancion Project, Spain
[2]Faculty of Humanities of the International University of La Rioja, Spain

Correspondence: Alejandra Hernández Fuentes, Creator of "Harmonic Frequency Therapy" and the Comunicancion Project, Spain, Tel 635897200, Email inf@comunicancion.com

Received: October 14, 2022 | **Published:** November 02, 2022

Introduction

The positive impact that music generates in humans has been widely studied[1] from different fields such as, for example, for its positive influence on well-being,[2] repercussion in the emotional sphere[3] cognition and language perception or speech processing.[4] Specifically, regarding speech stimulation and rehabilitation in cochlear implant recipients, most of the research related to music therapy is directed to the perception, appreciation, and emotional responses that the implanted person may have towards music after therapeutic exposure to it, but the fewest focus on music therapy as a rehabilitation tool in auditory processing whose results have a direct impact on an improvement in the understanding and development of oral language. Thus, music, as a stimulus, has been a resource used in the rehabilitation of hearing-impaired people with and without cochlear implant.[5–7] Similarly, from a perspective of music as a rehabilitative tool in the development of post-implantation auditory skills numerous researchers have worked in this area.[8–10]

Thus, van Besouw et al.[9] show that from an intervention program implanted children rapidly improved their receptive auditory and vocal skills. However, the results also suggest that preschool CI children receive less exposure to music without visual support than with it. Similarly, Lima et al.[11] indicate an improvement in the musical skills of post-lingual implanted patients after music therapy. However, there was no improvement in the auditory frequency perception test in these individuals. This study does not provide data relating progress in the musical area to the development of linguistic skills and language comprehension in these adult patients.

Following this line of continuity, Looi and She et al.[12] proposed an investigation whose objective was aimed at analyzing the enjoyment of music listening by implanted individuals who listened to music before hearing loss in comparison to their postimplant music perception. Furthermore, this work showed that musical enjoyment was only obtained after subjecting patients to a period of guided music listening, reporting that more time spent listening to music improves auditory enjoyment. From another perspective, Hutter et al.[13] proposed a program of musical activities to improve music perception and speech prosody in which 12 adult patients with postlocution deafness participated in ten sessions, six weeks after implantation. Psychological and musical tests were performed before and after therapy.

The musical activities consisted of melody recognition and timbre identification, concluding that: the new concept of individualized music therapy seems to provide an effective treatment option in the rehabilitation of adult CI users. Further research is needed to evaluate the effects around prosody perception and to separate the effects of therapy from the general effects of learning in CI rehabilitation.[13]

Similarly, Fuller et al.[14] posited the development of music training to improve music perception in CI patients to, in turn, improve speech comprehension, based on previous studies conducted with musicians, although the latter, are unclear. The activities consisted of identifying words, phrases and vocalization of emotions. The identification of melodies, tones, instrument timbres and sounds of everyday life was also practiced, suggesting the results:

Group music therapy may be a useful addition to rehabilitation programs for CI users, many of which are primarily speech-based. More research is needed to determine the best combination of training exercises to enable CI users to remain engaged and pay attention to cues for speech and music.[14]

However, the present study has been designed based on the premises established in the study conducted by Falcón[15] who considers that: "patients with frequency programming of the cochlear implant assigned to the fundamental have better musical perception and recognition" (p. 60) for which the author proposed the following objectives:

1. To evaluate and compare the performance for instrumental recognition in patients with cochlear implants in their various stimulation modalities: unilateral electric and bilateral electric, as well as electric and acoustic (bimodal biaural).
2. To compare the recognition ability between stimulation modalities, identifying the variables that may be determining a better performance, to promote the optimization of musical perception with cochlear implant.

3. To know the difficulties in the recognition of instruments and musical patterns, pitch, harmony of patients with cochlear implant.
4. To create programs of frequency assignment and modification in the fundamental, assigned to the cochlear implant and to compare with the programs elaborated in a standard way.[15]

The results achieved showed an improvement in the recognition of instruments and tonal scales, harmonics and pitch recognition thanks to the frequency programming in conclusion, it is considered that all the objectives and activities proposed in this study were based on frequency reassignment as an essential tool in achieving improvement in the hearing of these patients.

On the other hand, hearing impairment is conceived as a pathological state of the sense of hearing, which prevents (if it occurs from birth) or can make us forget (if its appearance is later) language, affecting the establishment of communicative interactions carried out by the subject. In this sense, it is crucial to know the degree of hearing loss for its definition. For this purpose, two elements are considered: intensity, measured in decibels (dB) and the frequency range affected, measured in Hertz (Hz). In this regard, the speech perception zone is between 500Hz and 4000Hz. The greater the hearing loss in the frequencies that pick-up speech sounds, the greater the negative consequences on language development and the rest of the cognitive processes, although indirectly in the latter.

When reference is made to hearing impairment and its characteristics, these are defined based on the greater or lesser repercussions they have on the acquisition or development of oral language. These differences must be observed when making a diagnosis and establishing an intervention program, as well as being able to predict the extent of the impairment and the possibilities of rehabilitation of lost functions. From this perspective, the time of onset, the degree of hearing loss and the site of the lesion could be made explicit. Following this line of analysis, hearing involves a cerebral process, so auditory training consists precisely in the modification of brain structures and the increase and strengthening of the neural networks responsible for auditory processing, through appropriate training carried out by a specialized follow-up program. In this way, hearing is achieved effectively enough to overcome difficulties in speech comprehension. Thus, to achieve speech understanding, auditory training or reeducation goes through different phases: detection, discrimination, identification, recognition, and comprehension.

From this perspective, the present study follows a line of research based on the use of music and its elements as an effective tool in post cochlear implant auditory rehabilitation in relation to auditory training in these 5 phases mentioned above,[16] which are used as Speech Therapy techniques for the rehabilitation of cochlear implant recipients.

Likewise, a cochlear implant is a small electronic device created specifically to recover or enable hearing in deaf people, specifically with sensorineural hearing loss or severe or profound deafness. Thus, the patient "recovers the ability to hear and provides the opportunity to acquire oral language completely and in all its complexity". Unlike a hearing prosthesis (hearing aids) in which only the auditory stimulus is amplified, the cochlear implant requires a surgical intervention aimed, basically, at replacing the function of the cochlea with a receiver and replacing the electrical transmission of the ciliary cells by means of electrodes that transmit the information to the auditory nerve by means of a sequence of electrical impulses.[17]

Based on these considerations, the primary objective of this research is to evaluate through audio metries the hearing and auditory development of patients with cochlear implants who use Music Therapy, as well as to study the suitability of Music Therapy as an alternative post or co-treatment of speech therapy for a better development in the rehabilitation of people with cochlear implants.

Materials and Method Participants

The intervention was carried out thanks to the voluntary and disinterested participation of three adult patients, 66.7% of whom were women (MS=51 years, SD=4.359). This study was conducted according to the requirements established in the Declaration of Helsinki.[18] The participants are carriers of Med-el, Cochlear (Nucleus) and Advanced Bionics (Clarion) cochlear implants. No additional exclusion criteria were used for this study.

Procedure

Music therapy sessions were carried out once a week with a duration of 45-50 minutes. The patients received this treatment from the date shown in Table 1 until June 30, 2021, except for breaks due to vacation periods. In the case of patient 1, he was in recess from this intervention for one year, resuming it later. Before starting the therapy, the programmer of each patient was asked to add to the standard programming of his implant a Music Therapy program, which would consist of a specific frequency reassignment of the active electrodes that the patient has in his implant and a specific configuration of the filters and other parameters that would facilitate a wider and clearer perception of the sounds that were intended to be worked on. This step did not condition the beginning of the therapy, since, as in the case of Med-el implants, they do not need a specific program because the processor has the capacity to self-regulate itself in response to the stimuli and auditory frequencies it receives. Once this process was completed, the sessions were started by applying to the patient the different instruments to evaluate his current auditory discrimination capacity and other data that would help in the subsequent evaluation of his progress. Likewise, the most updated audiometry were requested at the beginning of the intervention.

Table 1 Patient hearing and characteristics

Patient	Patient 1	Patient 2	Patient 3
Hearing loss	Bilateral profound post- locution (since the age of 3 years). Auditory remnants in left ear	Bilateral profound pre- locution hearing loss (at 2 years of age) with residual hearing in childhood (use of technical aids) and cophosis at present	Profound bilateral neonatal hearing loss. Auditory remnants in left ear. Cofosis in right ear
Implant and prosthesis	CI Advanced Bionics Naída Q70 in right ear. Hearing aid in left ear (Bimodal)	CI Cochlear Nucleus CP800 in left ear. Unilateral mode	CI Med-el Sonnet in left ear. Unilateral mode
Implantation date	12/2015	05/2011	03/2017 with need for reimplantation in 2018
Date of start of music therapy	09/2016	06/2017	07/2020
In speech therapy treatment	yes	no	yes
Mode of intervention	face-to-face	face-to-face	online

Table 2 Related samples t-test of the music therapy program pre- and post-test

			IC 95%				
			Bottom	**Top**	**t**	**gl**	**P**
		1	-60,407	23,074	-1,924	2	,194
		2	-54,034	21,368	-1,864	2	,203
		3	-85,488	40,821	-1,522	2	,268
		4	-70,030	34,697	-1,452	2	,284
		5	-92,481	16,481	-3,001	2	,095
		6	-38,009	-9,324	-7,100	2	,019
		7	-125,044	18,378	-3,200	2	,085
		8	-148,588	23,255	-3,138	2	,088
		9	-69,348	-41,985	-17,506	2	,003
	Phrases		-25,513	5,513	-2,774	2	,109
Phonological tests	Test de Quilis		-85,977	9,977	-3,408	2	,076
	Inteligibilidad		-76,286	-1,047	-4,422	2	,048
		250	-24,189	27,522	,277	2	,808
Tone audiometry Frequency at Hz		500	-37,648	19,648	-1,352	2	,309
		1000	-16,513	26,513	1,000	2	,423
		2000	-7,306	30,640	2,646	2	,118
		4000	-35,287	51,953	,822	2	,497

The approach was based on the creation of an intervention model, Harmonic Frequency Therapy, which takes into consideration two essential premises:

1. The activities are structured and designed to be performed sequentially in phases, which follow the guidelines of auditory training in speech therapy.[16]
2. The activities are focused on those frequency areas in which the patient has the greatest difficulty, based on the data provided by previous audiometry.

Stimuli and measures

1. Incentives. The main activities carried out and whose progress was strictly monitored were as follows:
2. Identification and recognition of string musical instruments (timbre, duration, pitch, intensity).
3. Identification and recognition of wind musical instruments (timbre, duration, pitch, intensity).
4. Discrimination of equal or different tones.
5. Identification of ascending or descending intervals.
6. Discrimination and identification of major scales, ascending, descending and mixed scales with the piano and voice.
7. Identification and recognition of sequences of notes in major scales in intervals of fifth and third (pitch, duration, number of beats).
8. Discrimination of major and minor chords.
9. Identification and recognition of sequences chords.
10. Identification and recognition of combinations of tonic, subdominant and dominant sequences in major scale in different octaves.

In addition, the cognitive processes of auditory processing such as auditory sequential memory, auditory figure-background discrimination, auditory analysis, and synthesis were worked on.

Measurements

The following tests were used for the initial assessment of the patient's auditory discrimination:

1. Self-made intelligibility test presenting bisyllabic words with combinations of the different phonemes of Spanish.
2. Speech audiometry of sentences in free field at 40 dB without lip reading.[19] Quilis phonological list. This is a phonetic discrimination test composed of a list of identical words that differ only in one phoneme.

For the assessment of pre- and post-implant musical habits, the Munich Music Questionnaire was used.[20] Similarly, to perform the subjective assessment of the patient's quality of life, the Cochlear Implant Subjective Assessment of the Cochlear Implant Recipient was used. This ad hoc questionnaire attempted to evaluate the patient's perception pre and post treatment on how his auditory discrimination in noisy environments was, if he makes use of the telephone, if he discriminates conversations in low tone and how he scores his self-confidence. Likewise, for the analysis of the patient's hearing rehabilitation progress data, the indexes provided by the tone audiometry and speech audiometry (both requested and carried out by the patient's ENT specialists) were used. Likewise, to carry out the comparative analysis of the audiometric results, a template was created ad hoc to visualize the dynamic field of hearing.

Data analysis

For data analysis and follow-up of progress in the musical activities, a descriptive analysis was carried out with the number of correct scores that the patient had in each activity, subsequently translated into percentages. Likewise, the results obtained from the first data of the variables studied were used to statistically analyze the evolution of all the items. The SPSS Stadistics v25 program IBM was used to perform the statistical calculations and the graphs were made with Microsoft Excel. In the first instance, the Shapiro-Wilk normality test was performed. Subsequently, the T-test for related samples was performed with the intention of comparing the pre and post corresponding means of each variable. For this purpose, a confidence

interval was established for the difference between the means ($p < .05$) to determine their statistical significance.

Results

Table 2 shows that there are significant differences ($p < .05$) in the identification and recognition of intervals of fifth and third in major scales (pitch, duration, and number), identification and recognition of chord progressions with tonic, subdominant and dominant structures and the intelligibility factor of the phonological tests performed. Next, the results for each patient will be presented.

Note

5. Identification and recognition of stringed musical instruments (timbre, duration, pitch, intensity).
6. Identification and recognition of wind musical instruments (timbre, duration, pitch, intensity).
7. Discrimination of equal or different tones.
8. Identification of ascending or descending intervals.
9. Discrimination and identification of major scales, ascending, descending and mixed scales with the piano and voice.
10. Identification and recognition of intervals of fifth and third in major scales (height, duration and number).
11. Discrimination of major and minor chords.
12. Identification and recognition of sequences chords.
13. Identification and recognition of combinations of tonic, subdominant and dominant sequences in major scale in different octaves.

Figure 1 shows progress in all the activities performed, the most significant being the discrimination and identification of chords, since at the beginning of the treatment the patient was unable to perform them.

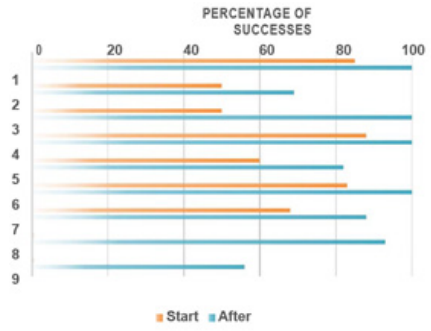

Figure 1 Patient 1session progress.

In relation to phonological tests, the greatest difficulty of hearing-impaired patients is being able to discriminate the minimum units of language, i.e., phonemes (Quilis and Intelligibility Test). However, their scores are high when they have a context present, as in the case of sentences. Even so, after an auditory rehabilitation process, their progress in all the tests has been positive, as shown in Figure 2. The results are directly proportional to the work done in certain frequency areas during the sessions. For example, patient 1 had a significant frequency drop in the high frequency region. By focusing on this area during the treatment, he was able to recover his understanding of these frequencies and for the first time to discriminate words indicating the plural.

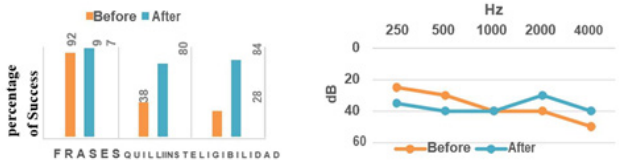

Figure 2 Phonological tests and tonal audiometry of patient 1.

One of the most significant results in the treatment are those related to oral language comprehension, represented in the Speech audiometry performed on the patient, which we see in Figure 3. This measure is represented by determining the percentage of correct answers vs. the decibels at which they are correct. A higher percentage of successes at a lower number of decibels shows a better understanding of language.

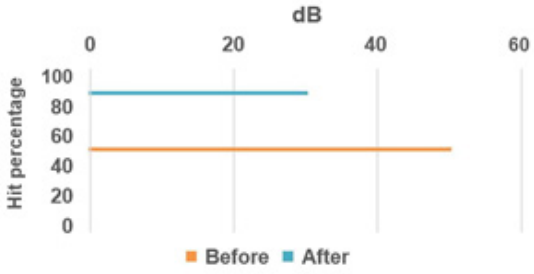

Figure 3 Patient 1 speech audiometry.

Figure 4 shows the progress in all the activities of patient 2. The progress in chord discrimination and identification can also be clearly seen.

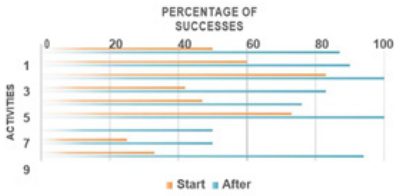

Figure 4 Patient 2 session progress.

This improvement in his ability to discriminate tones, intervals, scales and chords has resulted in an improvement in his ability to discriminate and understand phrases, words and phonemes, as shown in Figure 5. Similarly, with patient 2 we worked with the middle frequencies, showing a tonal improvement between the frequencies of 1,000Hz to 2,000Hz, achieving a better discrimination between phonemes P, T and K.

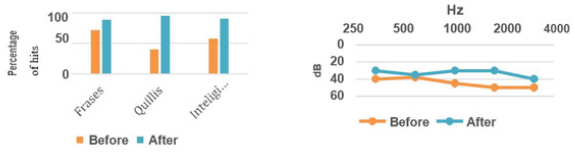

Figure 5 Phonological tests and tonal audiometry of patient 2

As in the previous case and as shown in Figure 6, patient 2 has managed to increase his comprehension of oral language, decreasing by 30 dB his ability to understand what he hears.

Citation: Fuentes AH, Company JFF. Study on the efficacy of harmonic frequencies applied through music therapy intervention techniques in cochlear implant patients. *Int Phys Med Rehab J.* 2022;7(3):117–122. DOI: 10.15406/ipmrj.2022.07.00316

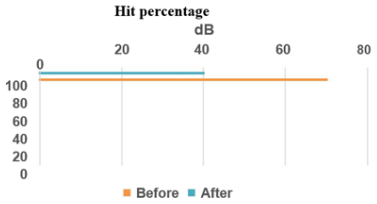

Figure 6 Patient 2 Speech audiometry

We can observe in Figure 7 that patient 3 was unable to understand aurally the concept of "chord" at the beginning of the treatment and with time the development of auditory skills through musical activities has had a positive development.

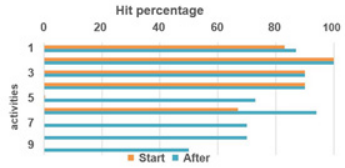

Figure 7 Patient 3 Progress in sessions

As in the previous cases, by improving auditory skills, the patient improves his understanding of language, as can be seen in Figure 8. Although with patient 3 the low frequencies have been worked on with more emphasis, a mismatch in his implant programming has prevented him from perceiving the extent of the therapy in relation to his tonal perception. This disturbance can be seen in the "drop" of the low frequencies.

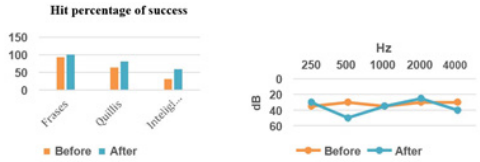

Figure 8 Phonological tests and tonal audiometry of the patient 3.

Figure 9 shows that, despite the mismatch suffered in the programming, thanks to the training at the "central processing" level, patient 3 has also gained in oral language comprehension, achieving 100% of the stimuli presented at 45 dB, 30 dB being considered normal hearing.

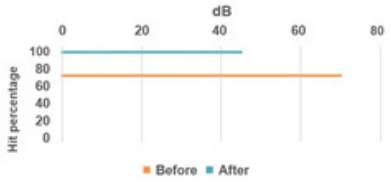

Figure 9 Patient 3 Speech audiometry.

Finally, the results of the subjective evaluations made by the patients before and after the treatment are indicated, which consider the following items:

a. Discriminates one voice in noisy environment.

b. Discriminates more than one voice in noisy environment

c. Difference between male and female voices

d. Difference between several male voices

e. Difference between several female voices

f. Uses telephone

g. Hears the tone signal on the telephone

h. Recognizes a voice on the phone

i. Discriminates the conversation of others talking on the phone

j. Discriminates whispers

k. Discriminates soft sounds such as light sneezing, sobbing, etc.

Regarding the evaluation of self-confidence, in which the items contemplate a score from 1 to 5, 5 being the best, the data indicate that patient 1 goes from a subjective perception of 3.1 to 4.8 on average in all the items answered. Thus, patient 2 goes from a subjective perception of 1.2 to an average of 4.5 in all the items answered, while patient 3 goes from a subjective perception of 2.3 to an average of 3.41 in all the items answered. All participants report an increase in their security and self-confidence because of having been able to develop listening skills.

Discussion

The results of this study show that musical training and stimulation improve both musical perception and auditory discrimination ability in cochlear implant patients,[8,9,11,13,14,21] specifically significantly in the identification and recognition of intervals of fifth and third in major scales (pitch, duration and number of sound strokes), identification and recognition of chord progressions with tonic, subdominant and dominant structures and of the intelligibility factor of the phonological tests performed.

However, unlike the study by Lima et al.[11] the results of this study indicate that music therapy did improve auditory frequency perception in these individuals. On the other hand, while the studies only suggest an improvement in speech perception or, at worst, do not collect data related to it, the present research provides data from tests conducted by professionals external to this intervention that show an improvement in oral language comprehension after having carried out the music therapy treatment.

Likewise, we agree with Falcón [15] that the proposed activities have served as an example to develop the intervention presented and develop auditory skills in patients that allow them a greater understanding of musical parameters, coinciding in this case with the results achieved in another research.[6,10] In contrast, it appears that this development does not require prior and specific frequency reallocation in the implanted electrode channels, although it is recommended for certain implant models.

While it is true, to the best of our knowledge, that this research contributes novel data to the literature on music therapy and cochlear implants, this study is not without limitations. First, we must mention the small sample size. Secondly, we consider that the number of factors studied was too numerous. In short, we believe that it is important to replicate this study with a larger sample, with a wider age range, mainly in the juvenile population, and with greater precision and selection of the variables to be studied.

Nevertheless, the findings indicate that audiometry and speech audiometry of cochlear implant patients show that music therapy improves their listening and auditory development. Consequently, music therapy improves language comprehension in cochlear implant patients. Similarly, the subjective perception that these patients have of how they listen in their daily context improves with music therapy. Thus, it is plausible to consider that music therapy is a tool to support and develop hearing during or after speech therapy in the rehabilitation of cochlear implant patients. Thus, the implementation of music therapy can be useful in the clinical treatment of auditory rehabilitation of cochlear implant recipients. In short, improvements in the auditory development of cochlear implant patients through music therapy are the result of a planned, personalized and progressive training of musical activities that directly affect the individual's central auditory processing regardless of the quality of the sound, the patient's level of auditory development and the implant technology used.

Finally, in line with other research,[7,21] it is agreed that music therapy improves perception and pleasure towards music in patients who had no previous references or who had lost it. But, in addition, this research provides data on the perception of the patients themselves in relation to the benefits of the treatment in their daily lives. Although there is a wide interest in the recognition of music in the auditory rehabilitation of cochlear implant patients, we agree on the need to broaden the scope of these investigations to obtain replicable and more significant results.[5] In conclusion, we consider that some significant results have been achieved thanks to the prolonged intervention with each of the patients. We express a position in favor of the use of music and music therapy in the treatment and rehabilitation of patients with cochlear implants from an early age.

Acknowledgments

None.

Conflicts of interest

The authors declare that there are no conflicts of interests.

References

1. Welch GF, Biasutti M, MacRitchie J, et al. The impact of music on human development and well–being. *Frontiers in Psychology*. 2020;11:1246.
2. Fernández company JF, García Rodríguez M, Alvarado JM, et al. Adolescencia y música, una realidad positiva. *En M del C*. 2020:47–59.
3. García Rodríguez M, Fernández Company JF, Alvarado JM, et al. pleasure in music and its relationship with social anhedonia (placer por la música y su relación con la anhedonia social). *Studies in Psychology*. 2021;42(1):158–183.
4. Merten N, Fischer ME, Dillard LK, et al. Benefit of musical training for speech perception and cognition later in life. *Journal of Speech, Language, and Hearing Research*. 2021;64(7):2885–2896.
5. Shukor NF, Lee J, Seo YJ, Han W. Efficacy of music training in hearing aid and cochlear implant users: a systematic review and meta–analysis. *Clinical and Experimental Otorhinolaryngology*. 2021;14(1):15–28.
6. Drennan WR, Jacob JO, Kate GF, et al. Clinical evaluation of music perception, appraisal and experience in cochlear implant users. Int J Audiol.2015;54(2):114–123.
7. Olivier M, Alexia D. Perception of musical timbre by cochlear implant listeners: a multidimensional scaling study. Ear Hear. 2013;34(4):426–436.
8. Gfeller K, Guthe E, Driscoll V, et al. A preliminary report of music–based training for adult cochlear implant users: rationales and development. *Cochlear Implants International*. 2015;16 suppl3:22–31.
9. van Besouw RM, Grasmeder ML, Hamilton Me, et al. Music activities and responses of young cochlear implant recipients. *International journal of audiology*. 2011;50(5):340–348.
10. Chari DA, Barrett KC, Patel AD, et al. Impact of auditory–motor musical training on melodic pattern recognition in cochlear implant users. *Otol Neurotol*. 2020;41(4):e422–e431.
11. Janaina PL, Sônia MS, Eliane S. Musical and temporal auditory skills in cochlear implant users after music therapy. Codas. 2018;30(6): e20180006.
12. Looi V, She J. Music perception of cochlear implant users: a questionnaire, and its implications for a music training program. *International Journal of Audiology*. 2010;49(2):116–128.
13. Hutter E, Argstatter H, Grapp M,et al. Music therapy as specific and complementary training for adults after cochlear implantation: A pilot study. *Cochlear Implants International*. 2015;16 suppl3:13–21.
14. Fuller CD, Galvin JJ, Maat B, et al. Comparison of two music training approaches on music and speech perception in cochlear implant Users. *Trends in hearing.* 2018;22:2331216518765379.
15. Falcón JC. Study of musical and melodic auditory recognition in patients with cochlear implants (doctoral thesis). *University of Las Palmas de Gran Canaria (Spain).* 2012.
16. Salesa E, Perelló E, Bonavida A. Tratado de Audiología. *Elsevier*. 2013.
17. Chaverri PJ. The cochlear implant: its indications. Acta méd. Costarric. 2018;60(3):132–135.
18. World Medical Association. World medical association declaration of helsinki. ethical principles for medical research involving human subjects. *Bull World Health Organ*. 2001;79(4):373–374.
19. Falcón J. Recognition of music and melody in patients with cochlear implants, using a new programming approach for frequency assignment. *Acta Otorrinolaringológica Española*. 2014;65(5):289–296.
20. Brockmeier SJ. Munich music questionnaire. 2016.
21. Quique Y. Musicoterapia en niños con implante coclear. *Revista Otorrinolaringología Cirugía Cabeza Cuello*. 2014;74(3):215–227.