Musical Perception and Enjoyment in Post-Lingual Patients With Cochlear Implants

Luis Lassaletta, Alejandro Castro, Marta Bastarrica, Rosa Pérez-Mora, Belén Herrán, Lorena Sanz, M. Josefa de Sarriá, and Javier Gavilán
Servicio de Otorrinolaringología, Hospital Universitario La Paz, Madrid, Spain

Objectives: To evaluate music perception and enjoyment following cochlear implantation and its impact on quality of life (QOL).
Material and method: Eighty-eight adult post-lingually deaf cochlear implant users entered the study. The music questionnaire analyzed musical background, listening habits, and quality of musical sound through the cochlear implant. Music perception was evaluated with the Primary Measures of Music Audiation (PMMA). The Glasgow Benefit Inventory evaluated the quality of life (QOL). The music questionnaires, the PMMA and the GBI were completed by 84%, 74%, and 82% of patients, respectively.
Results: Subjective enjoyment of music and listening habits decreased post-implantation when compared with prior to deafness. Mean scores for music perception were: tone 71%, rhythm 78%, timbre 61%, songs 59%, and melodies 23%. The quality of music sound through the cochlear implant was associated with music enjoyment and with QOL.
Conclusions: Music enjoyment and perception are possible with a cochlear implant. The quality of music sound through the cochlear implant influences post-operative QOL.

Key words: Cochlear implant. Music. Quality of life.

Percepción y disfrute de la música en pacientes poslocutivos con implante coclear

Objetivos: Evaluar la percepción y el disfrute de la música tras la implantación coclear y su impacto en la calidad de vida.
Material y método: Participaron en el estudio 88 adultos con sordera poslocutiva y portadores de un implante coclear. El cuestionario de la música analizó la experiencia musical, los hábitos musicales y la calidad del sonido musical a través del implante coclear. Para estudiar la percepción de la música se empleó el PMMA (Primary Measures of Music Audiation). La calidad de vida fue evaluada mediante el GBI (Glasgow Benefit Inventory). El cuestionario de la música, el PMMA y el GBI fueron contestados por el 84, el 74, y el 82 % de los pacientes, respectivamente.
Resultados: El disfrute de la música y los hábitos musicales disminuyeron tras el implante coclear cuando se compararon con la situación previa a la sordera. Los valores medios de percepción de la música fueron: tono, el 71 %; ritmo, el 78 %; timbre, el 61 %; canciones, el 59 %, y melodías, el 23 %. La calidad del sonido de la música a través del implante coclear se relacionó con el disfrute de la música y con la calidad de vida.
Conclusiones: Es posible disfrutar y percibir la música con un implante coclear. La calidad del sonido de la música a través del implante influye en la calidad de vida.

Palabras clave: Implante coclear. Música. Calidad de vida.

INTRODUCTION

Until a relatively short time ago, people with severe or profound hearing loss who could not achieve sufficient benefit with the adaptation of a prosthetic hearing aid were obliged to remain isolated from the world of hearing individuals. This situation, difficult to bear in any sphere of life, has become even more critical with the importance gained by audio-visual resources in our current lifestyle. Music forms part of our daily life and is present in the mass media for its advertising appeal as well as being part of our culture and leisure. Deafness isolates patients from all these forms of presentation of music, but it also represents an added problem for individuals with musical knowledge or hobbies, as they lose a part of their enjoyment of life and recreation.

Specialist centres with a cochlear implant programme offer patients with profound hearing loss a comprehensive treatment comprising the assessment of candidate, the type

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Correspondence: Dr. L. Lassaletta.
Servicio de Otorrinolaringología. Hospital Universitario La Paz.
Paseo de la Castellana, 261. 28046 Madrid. España.

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of surgery, scheduling, and rehabilitation. Post-lingual implantees are currently able to understand conversations normally, recognizing up to 70%-80% of phrases in a silent setting.[1,2] The change represented by a cochlear implant for individuals with severe or profound hearing loss goes far beyond an audiological improvement. There are many aspects of their quality of life that improve with the implant and all the process surrounding it.[3,4]

Despite its more than demonstrated usefulness, cochlear implants present certain limitations. Some of these constraints affecting the daily life of implantees are the use of the telephone,[5] oral discrimination in noisy contexts and the perception of music. The information transmitted by current cochlear implants is enough to obtain good results in the perception of language, but is insufficient for the average user to achieve a satisfactory appreciation of music. It is often said that most implantees do not enjoy music or do so much less than before their hearing loss.[6,7] This has been attributed to their ability to perceive rhythm patterns reasonably accurately[8] but with great difficulties in recognizing tonal patterns and in recognizing and enjoying timbre.[9]

There is very little information about the factors related with cochlear implants that have an influence on the perception of music. And the little information that does exist is contradictory. The duration of deafness and the time with a cochlear implant do not seem to be related with music perception parameters, and oral discrimination only slightly. Only a slight correlation has been found between musical training prior to hearing loss and the perception of tone and rhythm.[6] In other studies, this relation does not even appear.[8] Nonetheless, while there appears to be a close relation between the frequency with which music is listened to after the cochlear implant and the perception of tone and rhythm, it is not clear whether training after the implant improves musical skills or whether patients who obtain a relatively pleasant musical signal after the cochlear implant are more inclined to spend more time listening to music.[6]

From all of the above, it is inferred that the perception and enjoyment of music are aspects not yet resolved by current cochlear implants. The complexity of music, which may be defined as anything from combination of pleasant sounds to an expression of a state of mind, acquires a totally different relevance for each individual. For this reason, the evaluation of the patient's perception and enjoyment of music after receiving the implant is based on objective aspects of the identification and discrimination of tones and rhythms, related with the performance of their implant, and also on the fact that the tastes, culture, concerns and musical education of the individual play a more relevant role than their hearing ability. The lack of studies on music and cochlear implants in our country, the verification that the perception of music is one of the main requests from our patients and the high degree of collaboration by the implantees at our centre in previous studies have been the main reasons for implementing a study to assess the perception of music in post-lingual implantees. Specifically, we intend to assess the degree to which users enjoy music following cochlear implant and compare it with the situation prior to the implant; evaluate the capacity of the implantees to discriminate different tones and rhythms or recognize different musical instruments and popular songs, and to analyze which factors related with the experience of music, deafness, the cochlear implant and the auditory results have an influence on both the enjoyment and the perception of music. Finally, we analyze the impact of the perception and enjoyment of music on patients' quality of life.

MATERIAL AND METHOD

The study included 88 patients with severe or profound post-lingual hearing loss who received a multichannel cochlear implant between January 2001, and January 2006, at our centre. Other inclusion criteria were: 18 years of age or older, without disabilities in addition to deafness and at least 6 months of use of a Nucleus or MED-EL implant. The mean age was 50 years (interval, 20-73). The mean duration of their deafness was 7 years (interval, 1-52); 41 of the patients were female and 47 male; 54 patients wore a MED-EL device (22, Combi40+; 32, Pulsar CI100) and 34 a cochlear implant (16, Nucleus 22 and 18, Nucleus 24); 63 patients had worn hearing aids prior to the cochlear implant. The mean time of use of the cochlear implant was 49 months (6-165). The mean percentage for discrimination of monosyllables and disyllables without lip-reading was 77% and 71%, respectively.

Music Questionnaire

In order to assess the enjoyment of music, a specific musical questionnaire was used, inspired in that used by Gfeller et al,[6] with questions on musical experience, musical habits and the quality of music perceived through their cochlear implant. Users of cochlear implants were asked about their prior musical training and experience. They were asked to assess how much time they spent listening to music each week (0-2 h, 3-5 h, 6-8 h, 9 h, or more) prior to their deafness and after implantation. They were also asked to give a personal assessment of their enjoyment of music before their hearing loss and after receiving the implant, by means of a Likert-type attitude scale: in response to the statement "I would describe myself as a person who enjoys music a lot," users give an answer ranging between 1 (I completely disagree) and 4 (I agree entirely).

In order to assess (musical) sound quality through the cochlear implant subjectively, 4 visual analogical scales were used, each measuring 100 mm and corresponding to bipolar pairs of adjectives: "like-dislike," "sounds like music-doesn't sound like music," "natural-mechanical," "easy to follow-hard to follow."

Music Test. Discrimination of Tone, Rhythm, Instruments, and Songs

In order to assess the discrimination of tone and rhythm, Primary Measures of Music Audiation (PMMA)[10] test was used. This test, widely used for studies into the recognition

Table 1. Music Test. Instruments and Popular Songs

Instruments	*Popular Songs*
Drums	Al partir un beso y una flor
Flute	Allá en el rancho grande
Guitar	Bésame mucho
Harmonica	Clavelitos
Oboe	Eva María se fue...
Piano	Francisco alegre
Accordion	La bamba
Church organ	Las mañanitas
Clarinet	Mi carro
Saxophone	Mira como beben los peces en el río
Trumpet	Que viva España
Double bass	Ramito de violetas
Violin	Si tú me dices ven
	Solamente una vez
	Un rayo de sol

Table 2. Musical Experience Prior to Receipt of Cochlear Implant

Musical training prior to hearing loss	
Formal music lessons	4 (6%)
Membership of choir or musical group	6 (9%)
Classes in musical appreciation (at primary school, high school, ...)	15 (22%)
Self-assessment of musical training	
People without formal musical training, little musical knowledge and little experience in listening to music	26 (29%)
People without formal musical training or musical knowledge but with informal experience in listening to music	33 (37%)
Self-taught musician participating in musical activities	1 (1%)
People with some musical training, a basic knowledge of musical terminology and participation in music lessons or musical groups at school and/or university	7 (8%)
People with several years of musical training, with extensive knowledge of music and participation in musical groups	2 (2%)

of tone and rhythm in various pathologies, comprises 2 series of 40 pairs of tone or rhythm patterns so that patients can decide if they are the same or different. The examiner notes the number of correct responses. It is a standardized test that does not require any musical training, the instructions are straightforward and it takes about 40 min. In the instrument test (recognition of timbre), patients must recognize which musical instruments are being played. First they are invited to choose 10 instruments out of a list of 13, and they will then hear, at random, 7 of the 10 they have chosen and a note will be taken of the ones correctly identified (Table 1). In the song test, users have to recognize popular songs. The objective is to evaluate their ability to recognize a song they were familiar with prior to becoming deaf. To this end, they are shown a list of 15 popular songs (Table 1), from which they choose the 10 they are most familiar with. They are then played 7 of the 10 songs chosen in their original version and also in melodic version (14 versions in total) in a random order. A note is taken of the ones correctly identified.

Evaluation of the Quality of Life by Means of the Glasgow Benefit Inventory

The Glasgow Benefit Inventory (GBI) is a questionnaire designed and validated to quantify the benefit obtained by patients from various otorhinolaryngological procedures, including cochlear implants. The benefit is understood as the positive changes in their health status as a result of a medical, surgical or nursing action.[11] The GBI has to be completed after surgery. It comprises 18 items assessing the changes generated by the treatment in the various aspects of the person's life. Each response is based on a scale of 5 levels that range from a "great change for the worse" to a "great change for the better." The score is transferred to a benefit scale ranging from -100 (maximum negative benefit) to +100 (maximum positive benefit), passing through 0 (no change). This questionnaire can be divided into 3 sub-scales according to which the first 12 items indicate changes in the individual's general health condition, the next 3 items reflect changes in the person's social relations and the last 3 items, changes in his or her physical status (somatic changes).

Statistical Analysis

For the analysis of the results for musical experience before and after the cochlear implant, Wilcoxon's test for paired data was used. In order to assess the influence of the socio-demographical and clinical variables on the results of their musical habits after receiving a cochlear implant, a bivariable association analysis was performed using the χ^2 test and Fisher's test. To assess the influence of the socio-demographical and clinical variables on the results of the musical tests, and the influence of the latter on quality of life, comparisons of means were made between groups using non-parametric methods (Mann-Whitney). A P value less than .05 was considered significance.

RESULTS

Music Questionnaire

The percentage of responses for the music questionnaire was 84% (74 patients). Most of the users of cochlear implants had very limited musical experience (Table 2). In Table 3 we

can see the variation of musical habits prior to hearing loss and after the cochlear implant. The weekly hours of musical listening fell significantly after implantation (P<.001). In the same way, the enjoyment of music diminished after the cochlear implant when compared with the situation prior to hearing loss (P=.005). Users who spent more than 2 hours a week listening to music were also considered to be people who enjoyed music (P=.009). We found no association between the enjoyment of music and other variables such as age, prior use of hearing aids, duration of deafness, model of cochlear implant, musical experience, or auditory results.

The mean values for the sound quality of the music through the cochlear implant were 58 for "like-dislike," 58 for "sounds like music-doesn't sound like music," 49 for "natural-mechanical," and 45 for "easy to follow-hard to follow" (Figure 1). The values for the 4 adjectives were significantly associated with the enjoyment of music after receiving a cochlear implant (Table 4). The values for the bipolar adjective "sounds like music-doesn't sound like music" were significantly greater for users of MED-EL implants than for those with Nucleus implants (P=.004). The score for the adjective "like-dislike" was associated with the prior use of hearing aids (P=.03). We found an inverse relation between previous musical experience and the adjective "natural-mechanical." The users with the greatest musical training assessed the sound as more mechanical than those with less musical experience (P=.02). We found a slight association between the oral discrimination results and the adjective "easy to follow-hard to follow." Users able to discriminate >80% of monosyllables gave a better score to "easy to follow" (P=.02). We found no association between the bipolar adjectives and other demographic or auditory data.

Music Test. Discrimination of Tone, Rhythm, Instruments, and Songs

The percentage participation for the music test was 74% (65 patients). Figure 2 shows the mean values obtained by the users taking part in the discrimination tests for tone, rhythm, timbre, and popular songs. The discrimination values for rhythm were greater than those for tone and

Table 3. Variation in Musical Habits Prior to Hearing Loss and After Receipt of Cochlear Implant (CI)[a]

Hours Spent Listening to Music Every Week	*Before Hearing Loss*	*After Cochlear Implant*
0-2 h	21 (32%)	43 (61%)
3-5 h	22 (33%)	12 (17%)
6-8 h	8 (12%)	7 (10%)
9 h or more	15 (23%)	7 (10%)
"I Consider Myself a Person Who Enjoys Music"		
I completely disagree	10 (14%)	10 (14%)
I disagree	8 (11%)	24 (35%)
I agree	22 (31%)	22 (32%)
I agree entirely	30 (43%)	13 (19%)

[a]Despite the significant reduction in musical habits, 37% optional subjects users listen to 3 h of music or more a week and 51% state that they enjoy music through their cochlear implant.

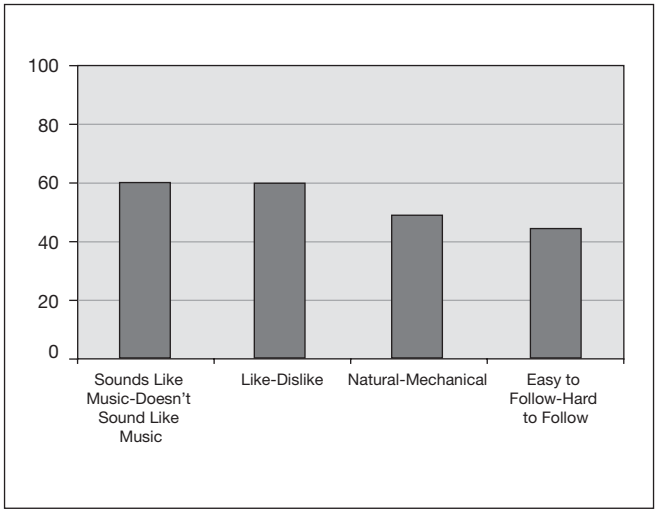

Figure 1. Evaluation of the quality of the music through the cochlear implant. Users scored each of the bipolar adjectives from 0 to 100.

Table 4. Relationship Between the Quality of the Music Through the Cochlear Implant (CI) and the Enjoyment of Music Following Implantation

	Enjoyment of the Music Through IC		
Quality of the Music Through the CI	*I Disagree/I Completely Disagree*	*I Agree/I Agree Entirely*	*P*[a]
Sounds like music (50-100)	6 (27%)	16 (73%)	.02
Doesn't sound like music (0-49)	27 (60%)	18 (40%)	
Liked (50-100)	1 (5%)	18 (95%)	<.0001
Disliked (0-49)	33 (67%)	16 (33%)	
Natural (50-100)	8 (26%)	23 (74%)	<.0001
Mechanical (0-49)	24 (71%)	10 (29%)	
Easy to follow (50-100)	9 (27%)	24 (73%)	.002
Hard to follow (0-49)	24 (71%)	10 (29%)	

[a]Fisher's test.

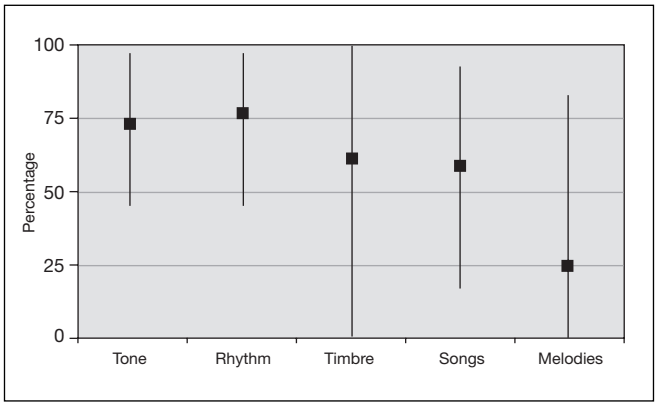

Figure 2. Scores in the music test. The chart displays the mean values and the percentage range of correct responses in discrimination of tone (71; 42-92), rhythm (78; 40-95), timbre (61; 0-100), songs (59; 14-93), and melodies (23; 0-83).

Table 5. Score in the GBI Quality of Life Test After Implantation of a Cochlear Device Depending on the Sound Quality of the Music Through the Cochlear Implant (CI)[a]

Quality of the Music Through the CI	*Total GBI Score, Mean (SD)*	*P*[b]
Sounds like music (50-100)	+49 (21)	.038
Doesn't sound like music (0-49)	+34 (30)	
Liked (50-100)	+48 (21)	NS
Disliked (0-49)	+36 (26)	
Natural (50-100)	+52 (22)	.016
Mechanical (0-49)	+36 (28)	
Easy to follow (50-100)	+51 (19)	.027
Hard to follow (0-49)	+37 (22)	

[a]GBI indicates Glasgow Benefit Inventory; NS, no statistical significance; SD, standard deviation.
[b]Mann-Whitney test.

timbre. On the other hand, the recognition of popular songs in their original version was clearly superior to that of melodies. The results of the music test were not associated with enjoyment of music. We found a slight association between the auditory results and the music test. Users with percentages >80% for the discrimination of monosyllables obtained better results in the instruments test (P=.02) and in the recognition of melodies (P=.01), but not in the discrimination of tones or rhythms.

Quality of Life Assessment of Using the Glasgow Benefit Inventory

The GBI quality of life questionnaire was completed by 72 patients (82%). The total benefit for cochlear implants was +45, with positive values for all 3 domains: +60 for the general domain, +23 for the social domain, and +6 for the physical domain. The immense majority of patients (97%) obtained a positive total score. We found a significant association between the GBI scores and the quality of the music heard through cochlear implants (Table 5). Users who evaluated the adjectives "sounds like music-doesn't sound like music," "natural-mechanical," and "easy to follow-hard to follow" with higher scores obtained the best results on the GBI. We did not find any association between the values of the GBI and demographic variables, musical experience, musical habits, the duration of their hearing loss, or the model of cochlear implant.

DISCUSSION

In the last few years, new aspirations have arisen for patients with cochlear implants. Being able to communicate, the fundamental goal of these devices is no longer enough. Users of an implant want to enjoy as normal a life as possible and music undoubtedly forms a part of modern life. It is clear that the technical limitations of current implants, particularly the lack of information about low frequencies, are the cause of the difficulty encountered by implantees in perceiving music correctly. Many of them describe the sound of music as unpleasant or mechanical,[12] and many find difficulty in identifying rhythms, recognizing melodies,[8] and detecting changes of tone.[13] And all of this may occur despite obtaining excellent levels of discrimination in conversations. As in previous studies,[14] We have found better results in the discrimination of simple musical patterns (rhythm and tones) than in complex ones (songs). Among the former, rhythm is better discriminated than tone and, among the latter, original songs are recognized better than melodies. Nonetheless, the enjoyment of music, comprising not only acoustic but also cultural or social factors, cannot be reduced solely to a question of their ability to perceive or discriminate. The results of our study reflect the difficulty people with cochlear implants have in maintaining musical habits prior to their hearing loss. Both the amount of time they spend listening to music each week and their enjoyment of music diminish significantly following the implant procedure. However, the results are not completely negative if we bear in mind that half the implantees say they enjoy music after receipt of the implant and almost 40% listen to 3 hours or more of music a week. The opinion of implantees regarding their ability to continue enjoying music depends on the instruments used to assess it. In one survey sent out to 63 adult implantees, 75% said they enjoyed music prior to their hearing loss, while 83% reported a reduction in their enjoyment of music following implantation, and 51% considered the sound through their cochlear implant to be unpleasant or hard to follow.[15] In the study by Leal et al,[7] the percentage of users who enjoyed music was 62%. When we analyzed which factors influence their enjoyment of music, we found that it was not related to auditory results nor to scores in the music test. These findings emphasize that the enjoyment of music does not depend only on the performance of the cochlear implant, and in fact it is not essential to recognize instruments or melodies in order to enjoy music. The enjoyment of music after implantation is not related to demographic variables, musical experience, or the results of oral discrimination.

One of the main complaints from users of a cochlear implant is the quality of the sound they perceive through it. In our study, the scores from users for the adjective pairs were acceptable, at around 50 out of a 100. The most significant finding was the relationship between the quality of the sound through the cochlear implant and the enjoyment of music. Users who gave the best score for sound quality also gave themselves a higher score in terms of music enjoyment. Therefore, despite the complexity of the music and the variations between individuals in terms of training, tastes and musical experience, the sound quality of the music seems to be a basic factor for people with cochlear implants to be able to enjoy music. Another controversial aspect regarding the perception of music involves differences between the various models de cochlear implant and their corresponding to encoding strategies. In our study, we have found that users of MED-EL implants gave a better assessment to the adjective "sounds like music" than users of Nucleus devices. Nonetheless, we did not find significant differences among the rest of the adjectives referring to the quality of the musical sound. One of the possible explanations for this finding would be the depth of insertion determining the position of the most apical electrode in the cochlea. Complete insertion of the MED-EL electrode guide reaches 31 mm, whereas that of the Nucleus is only 20 mm. It is assumed that a longer electrode guide implies a stimulation of more nerve endings and this may lead to an advantage in the perception of music.[16] In the study by Hochmair et al,[17] with 10 MED-EL implantees (complete insertion), word discrimination was better when 8 electrodes were used, distributed long the entire length of the guide, than when only the 8 basal electrodes were used. In the study by Gfeller et al,[18] MED-EL users had better results in the discrimination of timbre than users of Nucleus. Nonetheless, in a more recent study by the same group that included 7 Nucleus 22, 38 Nucleus 24, 6 Nucleus Contour, 22 Clarion, and 6 Ineraid with a MED-EL processor, no substantial differences were found between the different types of cochlear implant nor between the various encoding strategies.[19] In our study we did not find significant differences between both types of implant in the auditory results. Nor were there differences in the discrimination of rhythms, tones, instruments, and songs. There is a new current based on electro-acoustic stimulation, in which a cochlear implant with a very short electrode stimulates the high frequencies in the more basal area of the cochlea, whereas a hearing aid integrated in the device would amplify hearing at lower frequencies to be preserved during surgery. Despite being a controversial technology, the early results in terms of music perception are encouraging. In a recent study at the University of Iowa into the recognition of familiar melodies, the users of several conventional implants obtained a percentage of around 30% in correct responses, without differences in terms of the type of implant or encoding strategy. Users of short electrodes obtained scores of around 80% in correct responses.[20]

Another disputed aspect of perception and enjoyment of music is musical training.[21] Fujita et al[9] performed a study with children's songs on 8 adult implantees. They showed that they based their recognition of the songs on a mixture of clues that included rhythm, tone, tempo, but basically on the verbal information. In this study, users with more musical experience were able to recognize songs more easily, indicating that they were able to extract the maximum information from fewer musical elements. In the studies by Kong et al[8] and Gfeller et al,[6] on the other hand, no differences were found in the recognition of melodies between users with greater or lesser musical training. In our study, musical experience was not related to the enjoyment of the music. Curiously, users with more musical experience obtained worse scores for the adjective "natural-mechanical" than those with less experience. While people with more musical training might obtain better results in the perception of melodies, at the same time this makes them more critical in their assessment of sound through the cochlear implant.

Individuals with cochlear implants do not find the sound of musical instruments to be as pleasant as people with normal hearing do, especially when they are playing high-pitched sounds,[18] and, above all, they are unable to capture the characteristics of clarity, brilliance or richness, features of great importance to be able to appreciate the sounds of the music correctly and in their full magnitude. In our study we found better results in the discrimination of rhythms than of tones, and better results in the discrimination of songs in their original version than with just the melodies. These findings corroborate, as in previous studies, that implantees can recognize simple musical patterns better than complex ones, and that the recognition of songs is based on vocal cues rather than the melody.[9]

Numerous studies have shown that the implantation of a cochlear device implies an improvement in quality of life for the vast majority of users,[3,22] with benefits that transcend merely auditory gains. Reports have been published of improvements in their self-confidence, increased social activity and, in general, better physical, psychological, and social functions.[23] Curiously, the factors affecting quality of life[24] have not yet been clarified and there is no correlation between audiological outcomes and user satisfaction. Music plays a fundamental role in modern-day life and represents a relevant contribution to quality of life. Both people with normal hearing and individual with hearing loss are continually exposed to music. In our study, we found an association between the quality of the sound through the cochlear implant and the quality of life following its implantation. Those users who described the sound as more like music, who liked it, or thought it was more natural and easier to follow obtained higher scores in the GBI quality of life test. The enormous complexity of both music and quality of life cannot be distilled into a single questionnaire. Nonetheless, our results indicate that, despite the enormous variations in terms of enjoyment of music among subjects with normal hearing and in implantees, the improvement in sound quality through the cochlear implant is important to improve the quality of life of implantees, and this must be the fundamental goal of a cochlear implant procedure.

CONCLUSIONS

The perception and enjoyment of music are objectives not yet completely resolved with current cochlear implant technologies. Although music-related habits diminished with hearing loss, approximately half the people with implants said they enjoyed music.

Neither the enjoyment nor the perception of music is clearly related to the auditory results or to variables habitually related to the benefit of the cochlear implant, such as the duration of the hearing loss or the age at implantation. Nonetheless, the quality of the music through the implant is related to the enjoyment of the music.

The perception of simple musical patterns (rhythm or tone) is much easier for implantees than the perception of complex patterns, and the recognition of songs is based on the verbal cues rather than on the melody.

The subjective valuation of the sound of the music through the cochlear implant is related to quality of life after receipt of the implant, and this improvement must be the primary goal of the cochlear implant procedure.

REFERENCES

1. Osberger MJ, Fisher L, Kalberer A. Speech perception results in adults implanted with the CLARION Multi-Strategy cochlear implant. Adv Otorhinolaryngol. 2000;57:421-4.
2. Helms J, Muller J, Schon F, et al. Evaluation of performance with the COMBI40 cochlear implant in adults: a multicentric clinical study. ORL J Otorhinolaryngol Relat Spec. 1997;59:23-35.
3. Lassaletta L, Castro A, Bastarrica M, de Sarria MJ, Gavilan J. Quality of life in postlingually deaf patients following cochlear implantation. Eur Arch Otorhinolaryngol. 2006;263:267-70.
4. Faber CE, Grontved AM. Cochlear implantation and change in quality of life. Acta Oto-Laryngologica. 2000;120 Suppl 543:151-3.
5. Castro A, Lassaletta L, Bastarrica M, Prim MP, de Sarriá MJ, Gavilán J. Comparison of different mobile telephones in Combi40 + users. Acta Oto-Laryngologica. 2006;126:714-7.
6. Gfeller K, Christ A, Knutson JF, Witt S, Murray KT, Tyler RS. Musical backgrounds, listening habits, and aesthetic enjoyment of adult cochlear implant recipients J Am Acad Audiol. 2000;11:390-406.
7. Leal MC, Shin YJ, Laborde ML, Calmels MN, Verges S, Lugardon S, et al. Music perception in adult cochlear implant recipients. Acta Otolaryngol. 2003;123:826-35.
8. Kong YY, Cruz R, Jones JA, Zeng FG. Music perception with temporal cues in acoustic and electric hearing. Ear Hear. 2004;25:173-85.
9. Fujita S, Ito J. Ability of Nucleus cochlear implantees to recognize music. Ann Otol Rhinol Laryngol. 1999;108(7 Pt 1):634-40.
10. Gordon EE. Chicago: GIA publications; 1979. Available at: www.giamusic.com/scstore/P-musicaudiation.html
11. Robinson K, Gatehouse S, Browning GG. Measuring patient benefit from otorhinolaryngological surgery and therapy. Ann Otol Rhinol Laryngol. 1996;105:415-22.
12. Lassaletta L, Castro A, Bastarrica M, et al. Does music perception have an impact on quality of life following cochlear implantation? Acta Otolaryngol. 2007;127:682-6.
13. Gantz BJ, Turner C, Gfeller KE, Lowder MW. Preservation of hearing in cochlear implant surgery: advantages of combined electrical and acoustical speech processing. Laryngoscope. 2005;115:796-802.
14. Gfeller K, Lansing CR. Melodic, rythmic, and timbral perception of adult cochlear implant users. J Speech Hear Res. 1991;34:916-20.
15. Tyler RS, Gfeller K, Mehr MA. A preliminary investigation comparing one and eight channels at slow rates on musical appraisal in adults with cochlear implants. Cochlear Implants International. 2000;1:82-7.
16. Kong YY, Stickney GS, Zeng FG. Speech and melody recognition in binaurally combined acoustic and electric hearing. Acoust Soc Am. 2005;117:1351-61.
17. Hochmair I, Arnold W, Nopp P, et al. Deep electrode insertion in cochlear implants: apical morphology, electrodes and speech perception results. Acta Otolaryngol. 2003;123:612-7.
18. Gfeller K, Witt S, Woodworth G, Mehr MA, Knutson J. Effects of frequency, instrumental family, and cochlear implant type on timbre recognition and appraisal. Ann Otol Rhinol Laryngol. 2002;111:349-56.
19. Gfeller KE, Olszewski C, Turner C, et al. Music perception with cochlear implants and residual hearing. Audiol Neurootol. 2006;11 Suppl 1:12-5.
20. Gantz BJ, Turner C, Gfeller KE. Acoustic plus electric speech processing: preliminary results of a multicenter clinical trial of the Iowa/Nucleus Hybrid implant. Audiol Neurootol. 2006;11 Suppl 1:63-8.
21. Abdi S, Khalessi MH, Khorsandi M, Gholami B. Introducing music as a means of rehabilitation for children with cochlear implants. Int J Pediatr Otorhinolaryngol. 2001;59:105-13.
22. Castro A, Lassaletta L, Bastarrica M, Alfonso C, Prim MP, de Sarriá MJ, et al. Calidad de vida en pacientes con IC. Acta Otorrinolaringol Esp. 2005;56:192-7.
23. Francis HW, Chee N, Yeagle J, Cheng A, Niparko JK. Impact of cochlear implants on the functional health status of older adults. Laryngoscope. 2002;112:1482-8.
24. Cohen SM, Labadie RF, Dietrich MS, Haynes DS. Quality of life in hearing-impaired adults: The role of cochlear implants and hearing aids. Otolaryngol Head Neck Surg. 2004;131:413-22.