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Original Article

Comparison eCAP and behaviour thresholds in post lingual medel cochlear implant users

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Abstract

Aim: Our purpose with this study is to determine the most effective and suitable cochlear implant programming method for CI users' implants to experience quality hearing and for the users to achieve efficiency from their implants.

Materials and Methods: Twenty-five cochlear implant users with post lingual progressive hearing loss were included in the study. Twelve electrodes' ART (auditory nerve response telemetry) thresholds were determined and were statistically analyzed to be evaluated in the study. For 12 electrodes whose AutoART threshold was determined, the MCLs (most comfortable loudness) were determined behaviorally.

Results: No correlations were found between the 12 electrodes and AutoART. It was seen that there was a correlation between the pure tone average obtained from 500-1000-2000 and 4000Hz and the speech reception threshold.

Conclusion: The use of two test batteries together to determine thresholds can be helpful in the programming of the speech processor. The more audiologists work with cochlear implant patients and do programming, the more they accumulate data and gain occupational experience. With the occupational experience acquired in this manner, more accurate programming can be done.

Keywords: Behavioral test; cochlear implant; eCAP; subjective test; objective test

INTRODUCTION

Cochlear implants (CI) are a very effective surgical treatment method used for the restoration of hearing in children and adults with severe profound loss (1). A CI is an electronic device that is set uniquely for the person and has a coding strategy (2). CI are indicated for patients who have severe profound loss, do not receive benefits from hearing devices, have a cochlear structure that is suitable for the placement of electrodes, and have a vestibulocochlear nerve that is thick enough to carry the signal it receives from the cochlea (3). These indications have been expanded in the last decade. Patients with advanced unilateral hearing loss and high-frequency hearing loss have been added to the new indications (4). However, each patient's speech development and cochlear implant success is not the same. After cochlear implants, audiological results and the improvements in speech development display individual differences depending on numerous factors such as the chronological age of the patient, the patient's age when CI are placed, duration of deafness, residual hearing, and an effective programming applied to the patient after implantation (5).

The patients are placed on speech processors about 2–4 weeks after they have the CI surgery. The values obtained from parameters used while doing programming such as eCAP (electrically compound action potential) and impedance can change in the first few months but usually become stable after the first year (5-9). Programming is quite important in order for the patients to benefit from CI at a maximum level (3). The level adjustments of the programming are important in terms of perceiving speech and supporting a good hearing quality (1).

Electrical impedance and eCAP measurements are the most frequently used methods in programming. Electrically elicited stapedius reflex threshold (eSRT) is another objective programming used most frequently after eCAP. Electrically evoked brainstem responses (e-ABR) are used very rarely. MCL, an approximation of the MCL charge requirement, is important in terms of which electrode will be used actively, and which method will be faster, easier, and more extensive with an efficient program (10).

Producing companies have given different names to these eCAP techniques. These are, neural response imaging (NRI, Advanced Bionics Corporation), neural response

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telemetry (NRT, Cochlear Corporation), or auditory nerve response telemetry (ART, MED-EL) (10).

MED-EL has lastly adopted the Medel® maestro system software auto-art application for eCAP measurements. All data are analyzed automatically with auto art; therefore, it is possible to reach eCAP parameters in a faster time than those whose arrangement manually is time consuming.

This study was planned to determine whether the objective auto-art method can be used reliably in CI programming and whether there is harmony between this method and the MCL levels. Our purpose with this study is to determine the most effective and suitable cochlear implant programming method for CI users' implants to experience quality hearing and for the users to achieve efficiency from their implants.

MATERIAL and METHODS

Ethical approval was obtained from the Hatay Mustafa Kemal University Ethics Committee. (Date11.04.2019; Number:9). Informed consent was obtained from all subjects.

Twenty-five cochlear implant users with idiopathic post lingual progressive hearing loss were included in the study. Patients who have regularly used the cochlear implant for at least 12 months, have post lingual hearing loss, and do not have inner ear anomaly were included in the study. Patients who have any kind of revision surgery, explanation, or reimplantation, have inner ear anomaly, otosclerosis, or meningitis history were excluded from the study. All participants' hearing loss is progressive. Implant and participants properties are shown Table 1.

Table 1. Implant and participants information of the subjects

Case	Gender	Age (years)	Age at CI (month)	Duration of Hearing Loss (years)	Implant Type (sonata/syncorny)	CI Ear (right/left)	Brand
1	F	20	22	8	Sonata	Left	Med-El
2	M	68	16	13	Syncorny	Left	Med-El
3	M	26	13	15	Syncorny	Left	Med-El
4	F	37	22	17	Sonata	Right	Med-El
5	F	46	115	15	Sonata	Right	Med-El
6	F	38	33	10	Sonata	Right	Med-El
7	F	51	60	8	Sonata	Left	Med-El
8	F	45	13	6	Syncorny	Right	Med-El
9	F	10	13	10	Syncorny	Left	Med-El
10	F	23	27	15	Sonata	Right	Med-El
11	M	49	29	14	Sonata	Right	Med-El
12	M	68	38	9	Sonata	Right	Med-El
13	F	44	30	15	Sonata	Left	Med-El
14	F	21	22	15	Sonata	Right	Med-El
15	M	71	19	28	Sonata	Left	Med-El
16	F	21	42	13	Sonata	Right	Med-El
17	M	63	39	20	Sonata	Left	Med-El
18	F	53	14	23	Syncorny	Right	Med-El
19	M	48	20	21	Sonata	Right	Med-El
20	F	73	37	23	Sonata	Right	Med-El
21	M	58	25	20	Sonata	Right	Med-El
22	M	72	13	22	Syncorny	Right	Med-El
23	F	80	13	32	Syncorny	Left	Med-El
24	F	53	99	18	Sonata	Right	Med-El
25	M	69	33	12	Sonata	Right	Med-El

Implant programs used by all participants in routine were made using behavioral method. Participants in this study were satisfied their implant fitting with made behavioral method and when these participants came to control autoart thresholds were determined and it was evaluated whether there was any correlation between MCL levels and autoart.

Twelve electrodes' ART thresholds were determined and were statistically analyzed to be evaluated in the study. The ART thresholds were determined using the Auto ART mode. The programming parameters were analyzed with Maestro system software 7.1 version, which is used in a routine manner after CI. Default parameters were used. Default parameters were formed as maximum charge 30qu, stimulation rate 60Hz, minimum phase duration 40μs, and interphase gap 2,1μs.

Behavioral Evaluation

For 12 electrodes whose AutoART threshold was determined, the MCLs were determined behaviorally. The parameters used in the evaluation were determined to be the same for each patient. The parameters were:

Dynamics stimulation: MCL-Burst 300 ms, burst gap 1000 ms, Dynamics % 100MCL, THR-Burst 300 Ms.

Balancing stimulation: MCL-Burst 300 ms, burst gap 1000 ms, Dynamics % 100MCL, THR-Burst 300 Ms, cycle gap 1000 ms.

Sweeping stimulation: MCL-Burst 300 ms, burst gap 1000 ms, Dynamics % 100MCL, THR-Burst 300 Ms, cycle gap 1000 ms.

Loch THR % 10, algorithm for interpolation; linear, test/default volume % 75.

SRT was evaluated in free fields. We read three syllable words to patients for repeating after us. SRT was accepted as the threshold for the patient to know 3 of 5 words correctly.

The patients' hearing thresholds with the CIs were determined with pure tone stimuli at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz in a free field. After this, their speech reception thresholds were determined as well. How satisfied the participants were with their cochlear implants was evaluated using the visual analog scale (VAS). The purpose of using VAS is to determine the level of satisfaction of participants from fitting using behavioral method.

Statistical Analysis

The data were obtained with the SPSS 22 software. Normal distribution was analyzed with the Shapiro-Wilk test and the Spearman correlation was used.

RESULTS

Demographic Characteristics

The average age of the participants in the study was 48.28±19.81 years (min age 20, max age 80). Of the participants, 15 were female and 10 were male.

Table 2. Correlation between AutoART – MCL

	1st Electrode	2nd Electrode	3rd Electrode	3rd Electrode	5th Electrode	6th Electrode	7th Electrode	8th Electrode	9th Electrode	10th Electrode	11th Electrode	12th Electrode
Correlation	-.008	-.098	-.266	.025	.123	.077	.197	.169	.304	.399	-.348	-.306
P	.969	.642	.198	.907	.559	.713	.345	.420	.139	.048	.088	.137

Cochlear Implant Results

The average duration of CI use by participants with cochlear implants was 32.28±25.37 months (min 13 months, max 115 months).

All of the participants used their cochlear implants regularly. From the VAS results, it was determined that they were satisfied with their cochlear implants. Score of VAS is 8, 2±1, 5. (min score is 5, max score is10). If the patient is satisfied his/her CI, he/she said that his/her score is 10. If the patient is not satisfied his/her CI, he/she said that his/her score is 0.

Behavioral and Electrophysiological Evaluation Results

No correlations were found between the 12 electrodes and AutoART (Table 2).

It was seen that there was a correlation between the pure tone averages (PTA) obtained from 500-1000-2000 and 4000Hz and the speech reception threshold (SRT) (Figure 1).

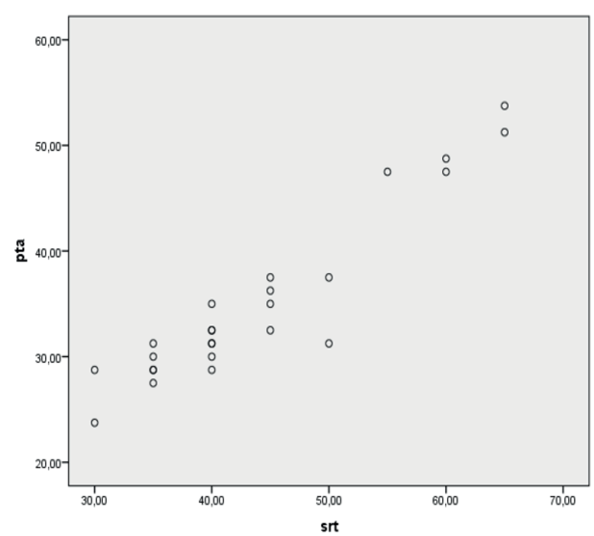

Figure 1. Correlation between PTA and SRT

DISCUSSION

This study showed that there is no correlation between AutoART, which is an objective evaluation method, and MCL, which is a behavioral evaluation method, in patients who use cochlear implants.

While doing programming in CI, both behavioral and objective methods are used (11). AutoART is useful for determining the MCLs in cochlear implant users (12). In this study, both methods were used in the programming of cochlear implants. No correlation was found between the objective method and the behavioral method. A study by Kosaner et al. also determined that there is no correlation between these two methods. This is because the two methods give information about different parts of the auditory path. While the objective method gives only the response of the peripheral auditory neurons, the behavioral method is the reply to all auditory pathways and the patient's auditory perception (2). ECAP is the synchronized reply of the hearing nerve fibrils. The time histogram after the stimulus shows that the synchronization is related to the amplitude of the stimulus—the more the amplitude increases, the more the nerve fibrils synchronize (13). This explains why CI patients clearly hear these stimuli while their ECAP thresholds are being determined and why their action potentials are lower than the MCL (14). While the MCL is determined, the default parameters used in objective and subjective methods being different from each other can be regarded as an important factor which causes disagreement between the methods.

The threshold levels used in the initial programming are very important in terms of speech perception (1). The programming of C levels between the electrodes in a balanced manner positively affects speech perception (15,16).

Many audiologists train themselves by working with a number of cochlear implant patients with the goal of developing their programming skills. The systematic analysis of programming guides the audiologist in the understanding of the programming level settings (9). There are many different CI programming methods used by audiologists with good results. The method differs depending on the patient, the center in which programming is done, the CI companies, and the audiologist doing the programming (17). The duration of the deafness, its etiology, or the placement of the electrodes also affect programming (1,18,19). Therefore, accessing these data can be helpful to audiologists in programming. CI companies can facilitate programming with their software (8).

In this study, we found that programming differs according to the patient and that the thresholds determined for adult patients using the behavioral method are better than those determined by programming done with ECAP. In addition, the CI programming method to be used for the patient differs based on the CI Company.

In a meta-analysis study by Vos et al., the researchers stated that there are a small number of studies which support using ECAP thresholds in the programming of cochlear implants (20). Similarly, in our study, there was no correlation between the behavioral programming method and the ECAP method. In addition, the patients stated that they benefited more from behavioral programming.

The levels used in programming can be arranged in accordance with the data obtained from objective measurements. Some researchers have found that there is a weak correlation between objective measurements and behavioral thresholds. However, they have stated that objective measurements are clinically valuable (1,21,22).

Some researchers have claimed that post-operative objective measurements such as ESRT, ECAP and EABR are correlated with behavioral tests and that it would be correct to use these methods while doing programming. However, these studies were with child and adult patients who had attention deficit disorders, growth deficiencies, and cognitive problems (2,3,23,24). In post lingual children or adult patients who have no additional handicaps, the behavioral programming method is sufficient for optimal results. Doing cochlear implant programming of the implants of small children is clinically difficult even for experienced audiologists. Therefore, objective methods have emerged as alternatives (2,3,25).

The patients' personal characteristics should be taken into consideration while programming. Using objective methods in children and adults with additional handicaps for whom doing programming is difficult, or programming through behavioral methods in post lingual children will allow for the creation of a more accurate program.

Speech reception gives information about the functionality of all auditory pathways including the central auditory pathways (26). While making the cochlear implant decision, the speech reception threshold (SRT) is taken into consideration. Therefore, a positive relationship between SRT and PTA in patients with cochlear implants is expected (27).

In our study, it was seen that there was a correlation between the SRT and the PTA average. Since cochlear implant users understand speech at the threshold levels they hear, the SRT and PTA were found to be in agreement. This correlation is proof that programming done behaviorally is productive.

CONCLUSION

It was seen that there was no correlation between the ECAP and behavioral thresholds. However, the use of two test batteries together to determine thresholds can be helpful in the programming of the speech processor. Participants are satisfied with the behavioral method fittings and there is no correlation or connection between the behavioral method and autoart thresholds, behavioral method fitting is more reliable and more comfortable for the patients.

The more audiologists work with cochlear implant patients and do programming, the more they accumulate data and gain occupational experience. With the occupational experience acquired in this manner, more accurate programming can be done. In addition, it should be kept in mind by audiologists that the etiology of hearing loss and the patient history together contribute to accurate programming unique to the patient.

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