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Review Article

Some Key Points of a Cochlear Implant Fitting and a Work with Parents of CI Patients

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Abstract

Based on 15 years clinical practice with more than one thousand implanted patients, the author has published several articles in recent years. The purpose of these articles was a detailed examination of various aspects of a cochlear implant fitting and a work with parents of implanted children. This paper presents some important points of this procedure, described in detail in the mentioned publications. They are partially considered in the article [1,2]. References to world sources are in the references to the articles presented below. In addition to the goal of achieving the maximum possible result of the CI-patient's rehabilitation, optimal fitting is also necessary for the development of new coding strategies. Only if there is a clear (optimal) fitting in which the patient can receive through the implant a maximum possible information, it is possible to reliably evaluate existing strategies and rely on the results of their use for the development of new ones. The author has results on reliable comparison of different programs conducted on the CI model [3], but to verify this development, an access to the actual software of the CI system is required.

CI MEMO on Cochlear Implantation for Audiologists and Parents of Implanted Patients – 2021" [4].

"CI Memo" has been compiled in order to familiarize the parents of implanted patients with the operation of the Med-El cochlear implantation (CI) system, to train the management of the cochlear implant, as well as with the intention of answering the questions of the parents of implanted patients about cochlear implantation and explaining their complicity in the process of fitting the speech processor. It also describes the goals and actions of the audiologist during the first switch on and during subsequent fittings of the speech processor. The "CI Memo" is written on the basis of 15 years of clinical practice with more than one thousand implanted patients and their parents in order for parents, audiologists and teachers, after reading the "MEMO", to begin to better understand each other and the problem of cochlear implantation in general. The authors have published dozens of articles on the topic of "CI MEMO", obtained several patents, made reports, which supports all "CI MEMO" provisions, arguments and conclusions. The co-author of the Memo has a medal from the Ministry of Education for the high scientific quality of the master's thesis.

A Program for Demonstrating to Parents of Implanted Patients the Problems of their Children (MIMIC Patent) [5]

Speech recognition by cochlear implant (CI) users and speech recognition processed by a comb filter by subjects with normal hearing have a number of common features [6]. Based on this similarity, in order to illustrate to parents, the problems faced by their implanted children, to demonstrate their solution, to explain the differences between implanted patients, the different speed of mastering speech and the alignment of results in the learning (rehabilitation) process, we created a demonstration program "MIMIC" [5]. The demonstration is carried out on the participant's own ear, i.e. vootiu (oto - ear). To a certain extent, this program is a model of perception of the "implanted" language. MIMIC allows

parents to take an "inside" look at the problems of their implanted children. MIMIC does not depend on the type of implant. This article describes the procedure for conducting a demonstration, discussion the results obtained from the patient and answers some specific questions.

Electro Audiometry - Testing of Candidates for Cochlear Implantation

Electro testing of candidates for cochlear implantation is a rather complicated procedure and unconvincing in its results — the electro audiogram does not display the condition of the cochlea [7]. Especially it is vague in children. How can small child explain that he hears sound but doesn't feel a current? I felt. I think that there is also my contribution in refusing to use this method.

Insertion problem of an electrode chain during CI

Sometimes it happens that during the insertion of an electrode chain into the cochlea, it does not enter completely. In previous years, in such cases, the insertion was discontinued. I had a separate item in the registration card: "How many electrodes have not been inserted?" Once when such a problem occurred during surgery, I suggested to the surgeon slightly rotate the chain clockwise and counterclockwise around its axis, while simultaneously pushing the electrodes forward [8]. The surgeon, doubting success, nevertheless did so and was very impressed with the result – the chain of electrodes easily advanced into the cochlea. The director of the Institute, while undergoing surgery, approved my idea. Since then, the question of the insertion of the electrode chain has not been raised - the surgeon moved the tip of the chain with a slight rotation from the point of stop. And I have since deleted the item in the registration card: "How many electrodes have not been inserted?" and subsequently observed the manipulation I proposed in action.

Sweep Stimulation-Registration of the Stapedial Reflex (Patent)

Impedance measurement is one of the objective methods used in CI fitting. In order to improve this technique, we have developed and patented a new method for registering threshold levels of the stapedial reflex (SWEEP method), in which the examination time is reduced by half, or three times compared to the conventional method [9,10]. Naturally, this method greatly facilitates the reflexometry procedure for a small child. Moreover, with the help of our method, the threshold levels of the reflex are determined much more accurately than by the routine method, and they are recorded on all 12 electrodes of the implant - that is, there is no need to approximate anything and record approximate values in the missed channels, as it is done by the routine method. It should be emphasized that since the levels of stimuli slightly higher and equal to the threshold levels of the stapedial reflex are used during SWEEP the registration is carried out without the slightest rejection of these levels by small subjects. This means that the threshold levels of the stapedial reflex are below the maximum comfortable levels, which does not contradict normal physiological characteristics. Therefore, threshold reflex levels cannot be used as the final maximum comfortable levels recorded in the program of optimal (final) processor settings, which is recommended by some "experts". The SWEEP method can be modified for implants with any number of electrodes.

Objective Registration of the Stapedial Reflex During CI (Patent)

To solve intraoperative problems when it is impossible to visually register the stapedial reflex by a surgeon through a microscope, we have developed and patented an "Objective method for registering the stapedial reflex during cochlear implantation surgery" [11]. When conducting this examination, periodic changes in a gas pressure in the middle ear during the operation should be taken into account [12].

Registration of the Stapedial Reflex to Sound Stimuli

When measuring the thresholds of the stapedial reflex to sound stimuli, we found that in the vast majority of cases, the electrical threshold levels of the reflex to sound are below the most comfortable levels (MCL) of work (optimal) programs. Moreover, we found a normal range of individual threshold sound pressure levels of the stapedial reflex from 70 to 100 dB SPL (on average 80-90 dB of SPL), which confirms our long-standing assumption about the presence of the recruitment phenomenon in CI patients. It is obvious that the threshold levels of the stapedial reflex to electrical stimuli cannot be used as the MCL of the work (optimal) program [13].

Pure Tonal Audiometry (PTA) in CI Patients

The PTA procedure in CI patients is markedly different from the routine PTA. First you need to carry it out, make corrections to the threshold current levels, repeat the PTA, make corrections to the threshold levels, etc. until a threshold electrical audiogram for sounds with a 40 dB SPL is obtained. Obviously, this is a time-consuming and ridiculous procedure. It is ridiculous, because if a CI patient can give reliable results in such a PTA "examination", then there is no point in conducting it. After all, such a smart patient can simply be given electrical stimuli from the Maestro program, determine current threshold levels in each of the 12 (!) channels and record them in the processor program [14].

Link the correct setting of threshold levels with successful perception (and even understanding!) of whispering speech by CI-patient is wrong. The whisper has a sound pressure level of 20-25 dB, which is below the threshold level of the processor program, i.e., the processor simply cannot "hear" the whisper and, naturally, at such SPLs, it does not produce electrical stimuli. Therefore, about the intelligibility of real whispered speech by a patient at a distance of 6 m (!!!) and there can't be a whisper. To announce to parents that the patient will have 1-2 degrees of hearing loss after surgery means to put it mildly, to mislead them. The response to threshold

sounds (40 dB SPL) can be recorded successfully at inflated electric threshold levels. This result can be misinterpreted by an audiologist and perceived by parents as the result of a wonderful fitting. In fact, inflated current thresholds worsen the understanding of speech.

Setting the Frequency Range of CI

The frequency range (FR) of the cochlear implant is an important parameter of the implant operation [15]. The article deals with the issue of setting the boundaries of FR in relation to the perception of a speech signal, since the main goal of CI is successful speech communication. The author came to the conclusion that a wide FR is not suitable for speech perception regardless of the number of electrodes, coding strategy and implant model due to a decrease in channel selectivity of stimulation (CSS). All the above arguments are applicable to the CI systems of any types. The search for a golden mean between the loss of speech information due to the narrowing of the frequency range of CI and its acquisition due to an increase in the CSS should be continued. The issue of disconnecting failed, and short-circuited electrodes is discussed.

Categorical loudness scaling to fit the CI and HA

To obtain subjective estimates of the loudness of electrical stimuli from the child, we suggest to use the method of categorical loudness scaling (CLS). In CLS we use four finger pictures corresponding to the categories: "No sound", "Quiet", "Good" and "Loud" depending on the level of the electrical stimulus or the intensity of sound stimuli when setting up a hearing aid or holding up a SHCHUP, i.e., we carry out a cross-modal loudness measurement. After a short training, the child begins to orient himself in his feelings and give real answers. We believe that our pictures, unlike circles, squares, cubes, etc., are more understandable and natural pictures for the child to display subjective estimates of loudness. Children can understand the meaning of these "finger signs" from birth [16]. During CLS we "communicate" with the child, "ask" and "explain", correct mistakes, rejoice in the correct answer. Naturally, by signs: gestures, fingers, touches, facial expressions. The child cooperates with the audiologist with understanding, we praise him for his work. We are sure that CLS is an interesting game procedure for CI-children and a useful method for an audiologist to successfully configure speech processors and hearing aids in young children. In addition, CLS is an interesting procedure that inspires parents with faith in CI - mothers see the correspondence of the child's reaction to our words about the change in intensity (louder or quieter) . Mom is glad that her child correctly evaluates the loudness of sounds.

Using White Noise to Evaluate the CI Setting

The spectral loudness summation was studied by numerical estimates of the loudness of white noise bands that simultaneously excite three adjacent implant channels. CI patients gave a numerical assessment of the loudness of the band stimuli presented to them on a scale from 1 to 10 [17]. A close to linear increase in numerical estimates of the loudness of band stimuli was found with an increase in the numbers (and width) of three-channel bands. It follows from this that white noise with a constant spectral density can be used to check the adjustment of a cochlear implant mainly in the high frequency region. Based on the results of the conducted research, we have developed a new method of CI fitting - SHCHUP.

A New Method to fit Cochlear Implants — Patent SHCHUP

Since the assessment of loud sounds is reflected by the CI-patients by their behavior, in so far we should also use sounds for fitting. To assess the maximum loudness level, discomfort is an effective and reliable clinical measure to characterize the "threshold of discomfort" [18] and therefore, for optimal fitting, we need to determine the threshold of auditory discomfort. What kind of sound stimuli? White noise gives little information to adjust the fitting of channels [17]. Estimating the loudness of single-channel stimuli is difficult even for adults, and therefore we have created a SHCHUP method in which we use special 4-channel step noise stimuli [19]. The SHCHUP is convenient for practical use, since we increase the sound intensity slowly, so we can slightly touch the threshold of discomfort with any sound level and immediately reduce the sound intensity. Touch, notice the beginning of a negative reaction and immediately reduce the intensity of the stimulus. The child's experience in CLS [16] is useful in the SHCHUP. According to the results of the evaluation of the loudness of step noise, the adjustment of the most comfortable levels of electrical stimuli is carried out. The SHCHUP is especially convenient for fitting of patients with two implants!

Choosing the Optimal (Working) Program

To choose a work program, we give this instruction-explanation to parents [4]. "As you know, we all go to the same program. Sometimes we hear loudly. But we don't use earplugs around the clock. Why can't the implanted patient feel loud sounds sometimes? Can. And should. Sometimes! Therefore, the program in which the patient hears sometimes loudly is optimal – working program." Parents agree with such a logical construction and their children come for repeated fittings on the 2nd, 3rd or 4th programs. And it is natural that not all absolutely patients come at the second program.

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