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Original Research Article

Comparison of neural response telemetry via cochleostomy or via round window in cochlear implantation

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ABSTRACT

There are two techniques for inserting cochlear implant (CI) electrodes: via cochleostomy or via round window (JR). **Objective**: comparing neural response telemetry (NRT) in the immediate postoperative period, checking for differences in auditory nerve stimulation between these two techniques. **Methods**: prospective and cross-sectional. Twenty-three patients were evaluated. Six underwent surgery via cochleostomy and 17 via JR. **Results**: comparison of mean current units (MCU) for high-pitched sounds: via JR with a mean of 190.4 (± 29.2) and via cochleostomy 187.8 (± 32.7), p = 0.71. Comparison of the MCUs for intermediate sounds: via JR, mean 192.5 (± 22) and via cochleostomy 178.5 (± 18.5), p = 0.23. Comparison of the MCUs for low sounds: via JR, mean 183.3 (± 25) and via cochleostomy 163.8 (± 19.3), p = 0.19. **Conclusions**: This study showed no difference in the uptake of action potentials in the distal portion of the auditory nerve in patients using multichannel cochlear implants who underwent surgery via cochleostomy or via JR, using the implant itself to elicit the stimulus and record the responses. Therefore, both techniques stimulate the cochlear nerve equally, and based on this, we conclude that cochlear implantation via cochleostomy or RW is a choice that depends on the surgical experience and choice of the surgeon.

Keywords: cochlear implants; round window; ear; telemetry

1. Introduction

In Brazil, it is estimated that there are about 347,000 deaf individuals, many of them with indication for cochlear implantation. For patients with low cochlear reserve who do not achieve good discrimination, even with sound amplification, cochlear implantation (CI) is an alternative for the rehabilitation of hearing impairment[1]. The benefits of cochlear implants are improved hearing quality, better speech perception and production, providing a permanent and upward gain in quality of life in several aspects, such as self-sufficiency and socialization[2–5]. Since the 1970s to the present day, it is estimated that 400,000 patients have been implanted[6].

The CI partially replaces the functions of the cochlea, transforming sound energy into electrical signals[7]. The survival of sufficient neural structures in the cochlear nerve allows this electrical stimulation to be transmitted to the cerebral cortex.

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The surgical procedure for HF is well standardized through the trans mastoid approach. Cochleostomy was first described in the 1980s[8]. There are two techniques for cochlear implant insertion: via cochleostomy, in which the promontory is drilled to insert the CI, and via the round window. The latter technique requires less bone perforation, thus reducing perilymph trauma and loss, and minimizing the entry of bone dust into the tympanic scale[9]. Conservation of residual hearing has proven possible and beneficial due to combined electrical and acoustic stimulation, but requires a non-traumatic electrode insertion to minimize damage to inner ear structures and, consequently, less neural tissue degeneration[6].

There are different ways to obtain objective measures of the auditory nerve in CI users from electrical stimulation of the auditory system, such as brainstem audiometry (BA), mid-latency responses and late potentials, and stapedial reflex research[1]. Neural Response Telemetry (NRT) is a technique that allows the direct measurement of the ECAP (Electrically Evoked Compound Action Potential ECAP) intraoperatively or postoperatively in implanted patients and has become important to properly monitor the functioning of the external and internal hardware and to assess the stimulation of the cochlea with the neural response[10].

The objective of this prospective, cross-sectional study is to compare the neural response telemetry in the immediate postoperative period of 23 patients, of both sexes, who underwent CI via cochleostomy or via JR, to find out if there are differences in auditory nerve stimulation between these two techniques.

2. Material and methods

This study was approved by the Medical Ethics Committee for Research in Human Beings under number 004/2010, being the ethical standards established by Resolution No. 196/96 of the Ministry of Health.

Twenty-three patients were evaluated, seven men and 16 women. Six patients underwent HF surgery via cochleostomy and 17 patients via round window. In all patients, the same Cochlear Corporation implants were used. The surgeries were performed by the same surgeon.

The multichannel cochlear implants used consist of 22 electrode bands, numbered 1 to 22, inserted in the cochlea, the apical one being 22. These electrodes were grouped as follows for analysis: 1–7 treble sounds, 8–15 intermediate sounds, 16–22 low sounds. This division was necessary because during NRT we did not always get neural response in the same electrode without changing the evaluation parameters, and so we let the software itself choose randomly within this grouping the electrodes for analysis. For comparison, we had to group the electrodes by sound frequency range in treble, intermediate and bass to make statistical averages, since not all electrodes were analyzed individually.

The surgical technique for placing a cochlear implant consists of: (1) general anesthesia in children and local anesthesia with sedation in adults; (2) retro auricular access with an incision of about 3 cm; (3) subcutaneous and muscle plane dissection; (4) production of a Y-shaped periosteal flap; (5) displacement of the periosteum of the cranial cap at the site of placement of the internal unit; (6) simple mastoidectomy; (7) posterior tympanotomy; (8) cochleostomy located in the anteroinferior region of the JR in cases of placement through cochleostomy or drilling of the lip of the cochlear implant; (9) simple mastoidectomy; (10) neural response telemetry; (11) closure by muscle and skin layer planes with vicryl 3-0.

All patients were discharged from the hospital on the same day, staying with a compressive dressing for 2 days. Amoxicillin + clavulanic acid was routinely used for 10 days. The activation of the implant is done 30 days postoperatively.

The Coustom Sound AutoNRT measurement system consists of the following elements: (1) computer with Windows Vista Home Basic system, Intel® Pentium® Dual processor; (2) software version

Custom Sound EP 2.0 (2.0.4.7298) and 3.2 (3.2.3855); (3) programming interface-POD; (4) freedom sound speech processor and SPrint headset; (5) Freedom Implant (Contour Advance). The NRT software was developed by the Cochlear Corporation Engineering Department[11].

A computer equipped with a programming interface is used to stimulate specific electrodes within the cochlea. A series of two-way communication pulses of information using a radio frequency code are transmitted from the Freedom Processor Interface through an external antenna placed inside a sterile pouch on the skin on top of the internal receiver-stimulator. This radio frequency code controls the stimulation parameters used to evoke the ECAP. The Freedom Contour IC's internal receiver-stimulator is equipped with an amplifier and an analog-to-digital converter. These additional components allow the voltage recorded at a pair of intracochlear electrodes to be amplified, sampled, and transmitted back to the external antenna and subsequently to the programming interface. These voltages are analyzed, and the resulting ECAP waveform is displayed on a screen, and its data can be stored in the computer. The ECAP recording consists of a negative peak (N1), with a latency of 0.2–0.4 ms, followed by a positive peak (P2) with a latency between 0.5–0.7 ms. The amplitude of the response is measured from N1 to P2 and has a range between 40–2,000 µV. The response amplitude varies with current level and between individuals. The parameters used to measure the AutoNRT threshold are: Threshold search is started at 170 CL units, the standard interval between stimulation levels is 6 CL units, and the stimulation speed is 250 Hz.

3. Results

Among patients undergoing HF via JR, the minimum age was 4 years and the maximum age was 84 years, with a mean of 32 years and 3 months. Among those who underwent surgery via cochleostomy, the minimum age was 4 years and the maximum age was 54 years, with a mean of 19 years.

For the statistical analysis, the Mann-Whitney test was used, a non-parametric test that allows the comparison of two groups of independent samples of different sizes.

Comparison of the average current units for the high-pitched sounds (electrodes 1 to 7), between cochlear implant insertions via the round window and cochleostomy, showed no statistically significant differences (**Table 1**).

Table 1. Comparison of mean current units for treble sounds between cochlear implant insertions via the round window and cochleostomy

Cochlear Implant In-sergies	No.	Medium current units				Mann-Whitney test
		min–max	Aver-age	±	SD	p
Via round window	17	110–237	190.4	±	29.2	0.71
Cochle-ostomy route	6	146–239	187.8	±	32.7	

n: number of patients; min-max: minimum and maximum values; SD: standard deviation; p: level of statistical significance. Source: Prepared by Hammerschimt R, Schuch LH and Rezende RK.

The comparison between the intermediate sounds (electrodes number 8 to 15) between the two techniques showed no statistically significant differences (**Table 2**).

Table 2. Comparison of the mean current units for the intermediate sounds between cochlear implant insertions via the round window and cochleostomy

Cochlear Implant In-sergies	No.	Medium current units				Mann-Whitney test
		min–max	Aver-age	±	SD	P
Via round window	17	152–236	192.5	±	22.0	0.23
Cochle-ostomy route	6	161–206	178.5	±	18.5	

n: number of patients; min-max: minimum and maximum values; SD: standard deviation; p: level of statistical significance. Source: Prepared by Hammerschimt R, Schuch LH and Rezende RK.

Finally, the comparison of the mean current units for bass sounds between cochleostomy and round window at CI insertion showed no statistically significant differences, as shown in **Table 3**.

4. Discussions

In cochlear implant surgery in deaf patients, structural tissue preservation during surgery is not essential. However, since the introduction of combined electrical and acoustic stimulation in patients with residual hearing, conservation of structural tissues and preservation of hearing during electrode insertion has become essential[12]. Residual hearing loss is the result of a combination of factors, including the technique used to create the cochleostomy and the electrode neuronal stimuli, as well as the location of the cochleostomy[8]. With the advent of new electrodes and greater emphasis on preserving residual hearing, there has been renewed interest in the use of the round window as a portal for electrode insertion[8]. Compared to cochleostomy via the promontory, insertion via the round window should significantly reduce the amount of drilling required for lead placement, thereby reducing the risk of trauma and loss of perilymph and also minimizing the entry of bone dust into the tympanic scale. Irregularities in the contour of the round window margin may make the insertion challenging, which may require perforation of the anteroinferior margin[8]. Drilling in this region should be approached with special care because of the proximity of the cochlear aqueduct opening[8].

Table 3. Comparison of mean current units for bass sounds between cochlear implant insertions via the round window and cochleostomy

Cochlear Implant Insergies	No.	Medium current units				Mann-Whitney test
		min–max	Average	±	SD	p
Via round window	17	134–223	183.3	±	25.0	0.19
Cochleostomy route	5	143–190	163.8	±	19.3	

n: number of patients; min-max: minimum and maximum values; SD: standard deviation; p: level of statistical significance. Source: Prepared by Hammerschimt R, Schuch LH and Rezende RK.

Cochlear implantation requires programming of each electrode to achieve appropriate levels of electrical stimulation. The unit used for programming the electrodes is arbitrary and is called "current units" (CU). An important factor regarding the CU is that the amount of current required to elicit an auditory sensation is different for each individual and for each stimulation channel. Thus, the electrical stimulation parameters in the speech processor must be individually adjusted to suit the user's needs. This is done by a process called mapping.

A more direct way to measure cochlear nerve function is the electrically evoked compound action potential (ECAP). The ECAP reflects the synchronous firing of cochlear nerve fibers and is in many ways similar to the wave I found in the ABR, occurring at a latency of less than 0.5 ms[11]. In humans, originally these measurements could only be made intraoperatively or via cochlear implants using percutaneous stimulation.

The stapedial reflex can be measured in response to electrical stimulation in the cochlea by direct observation of stapedial muscle contraction during surgery, or by using standard measurements of acoustic impedance in the ear contralateral to the implanted ear. Electrically evoked stapedial reflex thresholds can be used to estimate level C. However, there is a lot of variability in these measurements both within and between subjects. Moreover, according to several authors, these reflexes are not recorded in approximately 40% of the population[13,14].

Thus, NRT is a technique that allows the direct measurement of ECAP intraoperatively or postoperatively in implanted patients with greater sensitivity, since this measurement is present in more than 80% of the evaluated individuals. The NRT technique is a valuable tool in confirming the integrity of the internal device, objectively determining which electrodes can be included in a given map, the best stimulation speeds and speech coding strategies, as well as estimating the T levels that measure the amount of current that first induces an auditory sensation and C levels, which are the maximum intensity sensation levels that the patient will accept for electrical stimulation, which will be of extreme clinical importance[15].

The comparison of neural response telemetry showed no differences between cochlear implant insertion via cochleostomy and via round window, inserted into the tympanic scale. In the comparison of the averages for electrode numbers 16 to 22, one patient had to be excluded from the analysis (cochleostomy) since he or she did not have neural response measurements in the bass sound frequency range.

In comparison, the study by Karatas et al.[8] demonstrated that electrode insertion via a round window provides the best stimulus compared to electrode insertion through a cochleostomy via a promontory when comparing electrically evoked stapedius reflex thresholds (ESRT) and stimulus duration time. In summary, the best response was defined for the shortest response time.

The two cochlear implant insertion techniques are already well established in the literature, and the cochleostomy technique is currently the most widely used. The surgical procedure is chosen according to the surgeon's preference and training, and there are no significant differences in surgical time and/or risk of complications between the two techniques.

As this paper presents preliminary results, we have not done an analysis of neural stimulation comparing age groups. We know that the auditory nerve of a child responds better to stimulation than that of an elderly person. Thus, in a next step, we will need to randomize the groups as to the different age groups, for a better conclusion of variables by this criterion.

This work allows new studies to be done, increasing the sample size, especially regarding the cochleostomy technique and the measurement of all electrodes in the immediate post-operative period. As well as being part of a technical-scientific effort so that we can always seek and achieve the best possible results in sound stimulation and auditory rehabilitation of the countless patients that present with deafness.

5. Conclusions

The comparative statistical results of this preliminary research allow us to state that there is no significant difference in the capture of the action potential of the distal portion of the auditory nerve by neural response telemetry in patients using a multichannel cochlear implant, submitted to surgery via cochleostomy or via JR, using the implant itself to elicit the stimulus and record the responses. Therefore, both techniques stimulate the cochlear nerve equally, and based on this, the choice of surgical technique depends on the surgeon and his or her professional experience.

Conflict of interest

The authors declare no conflict of interest.

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