Vestibular function in cochlear implant: a video-head impulse test study

Original Article

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Abstract

Objectives: The goal of this study is to compare semicircular canal function in high frequencies of the implanted ear before and after cochlear implantation.
Study Design: Prospective study that included adults that underwent cochlear implantation, that had performed pre-operative video-Head Impulse Test (v-HIT).
Material and Methods: The patients underwent new v-HIT and tonal audiometry post-surgery.
Results: Seventeen patients were included in this study, with a mean age of 52 years. The hearing loss was severe in 3 cases (17,6%) and profound in 14 patients (82,4%).
The mean gain of the Vestibulo-Ocular Reflex for the lateral, posterior and anterior semicircular canals on the implanted side before and after surgery varied from 0,82±0,32 to 0,82±0,29 (p=0,64, 0,5±0,25 to 0,49±0,22 (p=0,48), and 0,8±0,21 to 0,80±0,27 (p=0,93), respectively.
Conclusion: This study showed good preservation of semicircular canal function though v-HIT after cochlear implantation.
Keywords: Sensorineural hearing loss; Cochlear Implant; Vestibular Function; v-HIT

Introduction

Unilateral or bilateral cochlear implantation is a surgical procedure for hearing rehabilitation of patients with severe-to-profound hearing loss who do not benefit functionally from hearing aids, and it has a positive impact on the patients' quality of life[1,2,3].

A cochlear implant is an external processor that detects the sound stimulus in the environment, converts it into an electric signal, and transmits it to a second component, which is an implanted receptor/stimulator that directly stimulates the cochlear nerve, thus bypassing the normal hearing mechanism[2,4].

The potential candidates for cochlear implantation undergo an extensive evaluation that involves a multidisciplinary

team consisting of an otorhinolaryngologist, audiologist, and speech therapist[2].

The preoperative workup should include a vestibular assessment because this may influence the choice of the ear to be implanted or help in managing the patient's expectations regarding the vestibular symptoms that may occur after the surgery. In our institution, this evaluation is performed using videonystagmography and/or the video-head impulse test (v-HIT).

Cochlear implantation is a well-defined and safe procedure with a current complication rate of 15%–20%[1,5]. Most surgical risks are related to the surrounding anatomic structures, one risk being damage to the vestibular receptors during electrode insertion in the cochlea[6]. Among patients undergoing cochlear implantation, the incidence of vertigo varies from 2% to 35% and that of vestibular changes between 20% and 80%[7].

The objective of the present study was to compare the vestibular function before and after cochlear implantation and investigate its correlation with residual hearing.

Materials and Methods

This prospective study included adult patients who underwent unilateral cochlear implantation at the department of Otorhinolaryngology and Neck-face Surgery of the Centro Hospitalar Universitário de Santo António (CHUdSA), and who had previously undergone v-HIT. For the study, the patients underwent a second v-HIT and tonal audiometry. Data on sociodemographic factors, surgical procedure, and the complementary diagnostic tests were collected.

All procedures were performed by the same surgeon. The facial recess approach was used for all procedures, including mastoidectomy with posterior tympanotomy and insertion of the electrode through the round window after incision of its membrane.

Pre- and postoperative v-HIT were performed by the same otorhinolaryngologist using the ICS Impulse system (Otometrics™). The vestibulo-ocular reflex (VOR) test was used for evaluating the bilateral semicircular canals (SCCs) in a well-lit room. While sitting, the patient was instructed to fixate on a visual target in front of him/her, at a distance of approximately 1 m. The tester stood behind the patient and generated the brain impulses by making abrupt and random movements of the patient's head in the horizontal plane (10°–20°) to both sides, with a peak velocity between 150° and 300°/second (impulses outside these intervals were rejected by the software). The vertical SCCs were tested in pairs, left anterior-right posterior (LARP) and right anterior-left posterior (RALP), by performing brain rotation 30°–40° laterally from the point of fixation, and the movements were generated in the vertical plane. The gain was calculated using the ratio of head to eye velocity. The VOR gains were recorded and deemed normal if >0.7 for the anterior and posterior SCCs, and >0.8 for the lateral SCC. Using these thresholds, the result of the v-HIT was converted into a categorical variable, "normal gain" vs "reduced gain".

Tonal audiometry was performed on the side without the cochlear implant to determine residual hearing.

The presence of subjective vestibular complaints was recorded as a categorical variable according to the difference between before and after surgery ("improved"/"worsened"/"no change").

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS™), version 29 . The categorical variables were analyzed using the chi-square test and paired variables were tested with the Wilcoxon test. This study was approved by the Ethics Committee of the CHUdSA (219-22 (178-DEFI/181-CE)).

Results

Seventeen patients participated in this study. Table 1 shows the sociodemographic and surgery-related data. The results of the v-HIT of the implanted ear before and after surgery are shown in Table 2. The separation of the overall results of the preoperative v-HIT into "normal gain" and "reduced gain" according to the thresholds described in the Methods

Table 1
Sociodemographic and surgery-related data

Sex, n (%)	
Female	8 (47.1)
Male	9 (52.9)
Age, mean in years (SD)	50.2 (15.0)
Grade of hypoacusis in the implanted ear, n (%)	
Severe	3 (17.6)
Profound	14 (82.4)
Etiology of the deafness, n (%)	
Unknown, gradual onset	11 (64.7)
Unknown, sudden onset	3 (17.6)
Meningitis	2 (11.8)
Chronic Otitis Media	1 (5.9)
Implanted ear, n (%)	
Left	6 (35.5)
Right	11 (64.7)
Surgical time, mean in minutes (SD)	149.1 (41.9)

Abbreviation: SD, standard deviation

Table 2
Pre- and postoperative results of VOR gain on the operated side

v-HIT	Result, mean (SD)	*p*
Lateral SCC		
Pre	0.82 (0.32)	0.64
Post	0.82 (0.29)	
Anterior SCC		
Pre	0.81 (0.21)	0.93
Post	0.80 (0.27)	
Posterior SCC		
Pre	0.50 (0.25)	0.48
Post	0.49 (0.22)	

Abbreviations: v-HIT, video-head impulse test; VOR, vestibulo-ocular reflex; SCC, semicircular canals; SD, standard deviation

section resulted in five patients (29.4%) with normal function and 12 patients (71.6%) with reduced function. Of these 12 patients, four (33.3%) exhibited hypofunction in three SCCs, two (16.7%) had reduced function in two SCCs (one in the posterior and lateral SCC and the other in the posterior and anterior SCC), and the remaining six patients (50.0%) had hypofunction only in the posterior SCC.

The age of the patients was not significantly correlated with "reduced gain" in the preoperative VOR (p=0.95).

There was no case of worsening of vestibular function from "normal" to "reduced" after the surgery, for any of the SCCs. The postoperative v-HIT was performed between two and 15 months after surgery, and there were no statistically significant correlations between the VOR gains in the anterior, lateral, and posterior SSCs and this time interval (p=0.62, 0.40, and 0.77, respectively). With regard to the subjective vestibular symptoms, eight patients denied any symptoms before or after the surgery, three reported worsening, four reported improvement, and two reported no change. There was no correlation between the vestibular function assessed by the v-HIT and patients' subjective complaints (p=0.80).

The mean preoperative and postoperative pure-tone average (PTA) values were 102.5±12.3 Hz and 111.2±.6 Hz (p=0.01), respectively. There was no correlation between the PTA and preoperative (p=0.70) or postoperative (p=0.77) vestibular function, nor between the grade of hypoacusis and the results of the preoperative (p=0.53) or postoperative (p=0.35) v-HIT.

Discussion

In the present study, there was no correlation between the preoperative vestibular function and grade of hearing loss, preoperative PTA, and age. The mechanisms of interference of the cochlear implant with vestibular function are still not fully understood, although there appears to be a relationship with traumatic insertion of the electrode during surgery, or degeneration of the vestibular receptors due to changes in the endolymph or perilymph pressure[8]. Some studies have been conducted to assess the vestibular function after cochlear implantation using various complementary diagnostic tests that evaluate different structures within the vestibular system. Most studies used vestibular evoked myogenic potential (VEMP) and caloric testing, and demonstrated vestibular lesions after cochlear implantation[6,9-13]. Cervical VEMP (cVEMP) appears to be the most affected, with its function decreasing between 19% and 36%[9,11,14]. Some variation may be attributed to the

heterogeneity of the population undergoing cochlear implantation, with age and etiology of sensorineural hearing loss found to affect the pre- and postoperative vestibular function[15].

The v-HIT is a quick, non-invasive, and easy to interpret test that detects a vestibular lesion as a fall in the VOR gain or the occurrence of de novo overt or covert saccades in the postoperative period. However, in symptomatic patients, it is less sensitive for the detection of vestibular lesions than caloric testing [16-18].

In this study, v-HIT results showed that cochlear implantation did not worsen vestibular function. The approach that we use in our institute to insert the electrode in the tympanic ramp is through the round window (surgeon's preference). This approach has been considered to be more protective of vestibular function than cochleostomy, although some studies did not find significant differences between the two[9,14].

Similarly to most previous studies[6,10], the present study did not show a correlation between worsening of vestibular function assessed by one of these tests and the patient's subjective complaints.

However, there are some limitations of this study, namely the small sample size and the variable interval between the surgery and application of v-HIT.

Conclusion

In the present study, there was no significant worsening of vestibular function, according to the v-HIT results, in patients who had undergone cochlear implantation. In addition, there was no correlation between the vestibular function and residual hearing after surgery.

Conflict of interest

The authors declare no conflict of interest regarding this article.

Data confidentiality

The authors declare that they followed the protocols in use at their working center regarding the publication of patients' data.

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Availability of scientific data

There are no publicly available datasets related to this study.

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