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Original Article

Vestibulo-Cochlear Function After Cochlear Implantation in Patients With Meniere's Disease

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OBJECTIVES: To measure the auditory (pure tone audiometry and word recognition scores) and vestibular (video head impulse test and vestibular myogenic potentials) outcomes in patients diagnosed with Meniere's disease (MD) who underwent cochlear implantation.

MATERIAL AND METHODS: This prospective study included 23 cochlear implant users with MD and 29 patients diagnosed with far-advanced otosclerosis (the control group).

RESULTS: The preoperative mean pure tone average thresholds were 99 and 122.5 dB for the Meniere's and control groups, respectively. Word recognition scores after cochlear implant yielded a median of 80% and 72% for the Meniere's and control groups, respectively. Semicircular canal gain was not observed to vary post implantation (mean variation for lateral, posterior, and anterior plane was 0, 0.03, and 0, respectively). The mean ocular and cervical myogenic potentials asymmetry varied as 9.65% and 18.39%, respectively.

CONCLUSIONS: The auditory performance improved in patients with MD similar to the general cochlear implant population. No major dysfunction of otolithic or semicircular canal function was demonstrated after the implantation surgery.

KEYWORDS: Cochlear implant, Meniere's disease, vestibular function, auditory outcome

INTRODUCTION

Meniere's disease (MD) is an inner ear disease characterized by cochlear and vestibular symptoms, including tinnitus, vertigo, and progressive sensorineural hearing loss (SNHL) [1]. The clinical course of MD varies among patients. Low-frequency SNHL may initially fluctuate with hearing loss affecting all frequencies as the disease progresses [2]. SNHL progresses to severe-to-profound in approximately 6% of patients diagnosed with MD [3]. These patients are candidates for cochlear implantation (CI) when hearing aids do not provide adequate hearing [4].

Among candidates for CI, vestibular injury is a concern that should be appropriately addressed during counseling. In particular, it should be a key point among patients with MD in whom the evaluation of vestibular function is of utmost importance considering the potential for associated disabilities. The prevalence of vestibular end organ functions in SNHL and estimates of vestibular dysfunction preoperatively range from 20% to 70% [5]. After CI in SNHL, late onset vestibular complaints range from 4.16% [6] to 45.4% [7]. To date, few studies have evaluated the vestibular symptoms after CI surgery as well as the presence of an added lesion to the vestibule [5].

To better understand the effect of CI on vestibular and auditory functions, 23 patients diagnosed with severe-to-profound SNHL due to confirmed MD were analyzed. The aim of the study was to measure auditory and vestibular outcomes in patients with MD who underwent CI.

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MATERIALS AND METHODS

Subjects

The inclusion criteria for this prospective study were as follows: "definite" MD according to the criteria described in the 1995 American Academy of Otolaryngology-Head and Neck Surgery guidelines for reporting results on the treatment of MD and severe-to-profound SNHL with speech discrimination below 40% with hearing aids [1, 2]. In total, 23 patients (15 males and eight females) with unilateral (n=10) or bilateral (n=12) MD were included. The mean age at implantation was 59 years [standard deviation (SD): 11 years], and the mean duration of hearing loss was 11 years (SD: 8 years). All but one patient in the MD group were unilaterally implanted. Patients underwent auditory and vestibular evaluations before and after CI. The auditory function was compared with that in a control group that included patients diagnosed with severe-to-profound SNHL who were CI recipients due to otosclerosis (n=29). Such an etiology was selected because no neural population damage has been depicted, and previous studies have supported that patients diagnosed with far-advanced otosclerosis have a good prognosis with CI that is comparable to others in whom postlingual implants are performed [8]. The control group comprised six males and 23 females having a mean age at implantation of 54 years (SD: 6 years) and a mean duration for hearing loss of 12 years (SD: 12 years). All study patients provided written informed consent to confirm their voluntary participation in the study. An ethics committee approval was obtained.

Study design

The surgical procedure was performed following soft-surgery principles as described by Friedland et al [9]. The standard CI surgery approach was implemented, and special attention was given to avoid the entry of blood into the scala tympani, the entry of bone dust in the cochlea, and perilymph leakage and suctioning.

Individual data sets were available for preimplant and post-treatment intervals 2 years after surgery and were used for comparative analysis. Audiometric testing (Audiotest, Equinox IEC 645-1/ANSI S3.6-1996 type I, IEC 645-2/ ANSI S3.6-1996 type B, Denmark) was preoperatively performed in the following conditions: unaided pure tone thresholds for frequencies 0.25, 0.5, 1, 2, 3, 4, and 6 kHz under headphones and unaided speech perception testing using recorded Spanish disyllabic words at 65 dB sound pressure level (SPL) at 0° azimuth in a quiet sound field. Both settings were performed with the contralateral ear masked using an ear mold (Moldex M1 6100, metric AG & co. KG, Walddorf, Germany). Postoperative audiometric testing included threshold testing with and without speech processor (unaided and aided) under the same conditions as those for preimplant measurements, including isolating the contralateral ear.

Vestibular function was measured on the basis of a video head impulse test (vHIT) and vibratory ocular and cervical vestibular evoked myogenic potentials (oVEMPs and cVEMPs, respectively). The follow-up was incomplete in seven patients because of the unavailability of the testing equipment during the evaluation.

Vestibulo-ocular reflex was evaluated using vHIT to register and measure the head and eye velocity during head impulse (GN Otometrics, Denmark). VEMPs were measured with 500 Hz vibration delivered using a Bruel & Kjaer minishaker to quantify otolithic function. Myogenic potentials were measured using an ICS Chartr EP 200 (GN Otometrics, Denmark) [7]. Based on our clinical experience, an inter-aural asymmetry ratio (IAAR) of >40% was considered abnormal.

Statistics

The outcomes were compared for all tests before and after CI. Patients with MD who were uni- or bilaterally affected were considered. A paired-sample t-test was conducted to compare bilateral statistical significance between both the control and MD groups. Significant values were set at $p<0.05$. Statistical analysis was performed using Statistical Packages for the Social Sciences (SPSS), version 20 (IBM Corp., Armonk, NY, USA).

RESULTS

A complete insertion and no surgical complications were achieved during the surgery. For the MD group, a round window approach was used in 13 patients and a promontory cochleostomy in 10 patients. A straight electrode array was inserted via the round window in nine of 12 patients and via the cochleostomy approach in three patients. A perimodiolar electrode array was inserted via the round window in four of 11 patients, and a cochleostomy approach was used in seven patients. For the control group, a straight electrode array was inserted in 13.8% (four patients), and a perimodiolar array was inserted in 86.2% (25 patients). Surgery was accomplished via a round window approach in two patients and via a promontory cochleostomy in 23 patients.

The auditory results are summarized in Figure 1. Preoperative mean pure tone average (PTA, 4-frequency) was 99 dB HL and 122.5 dB HL for the MD and control groups, respectively. One month after the surgery, hearing preservation was not observed in the MD group (median unaided PTA was 120 dB; IQR: 25; 75; 113;120 dB) despite soft CI surgery. CI-aided postoperative average thresholds were 33.75 dB and 38 dB for the MD and control groups, respectively; no statistically significant differences were observed. The speech perception scores, as demonstrated in Figure 2, yielded statistically significant differences between the groups (Meniere's, 80% and control, 72%, with p=0.036).

Semicircular canal function is shown in Figure 3. The mean follow-up was 9 months (range, 0-22 months). The time for testing was variable because of the inclusion of two patients almost at the end of the study, thereby shortening the follow-up period. The surgery did not provoke a significant deterioration in gains. Among unilateral MD (n=10), the anterior canal gain dropped from 0.65 to 0.38 after surgery (p=0.011). Utricular function, as measured by oVEMPs, yielded no response in seven of 16 patients. Further, the mean n10 latency was 14.87 mseg before the surgery and 11.24 after the surgery (p=0.251). Saccular function was measured using cVEMPs and yielded no response after

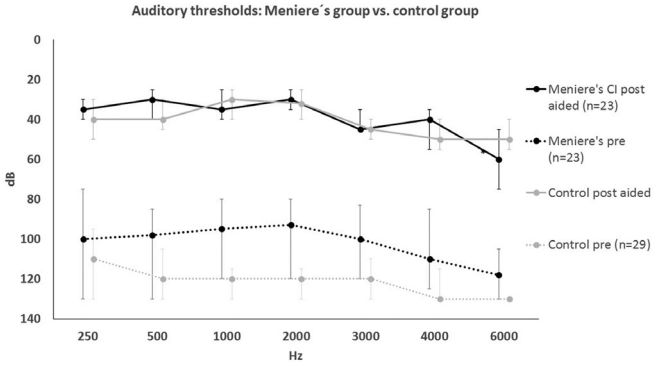

Figure 1. Pure tone auditory (PTA) thresholds for each frequency before and 2 years after CI for the MD and control groups. Mean PTA thresholds are higher for the control group. No statistically significant differences were observed between the MD and control groups.

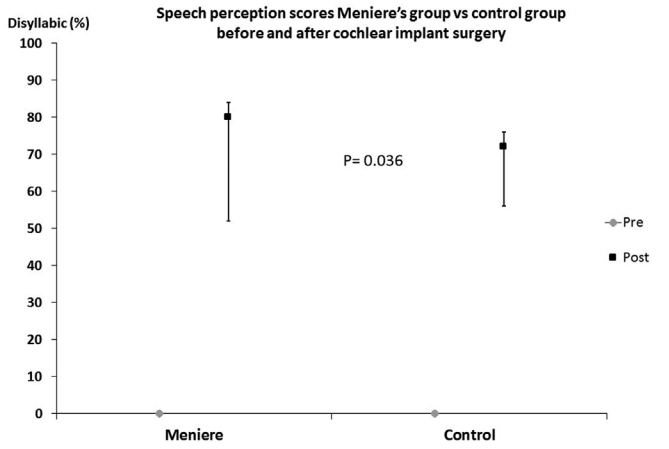

Figure 2. Speech perception scores (% disyllabic at 65 dB in quiet sound field) before and 2 years after CI for the MD and control groups. Statistically significant differences are seen postoperatively (p=0.036).

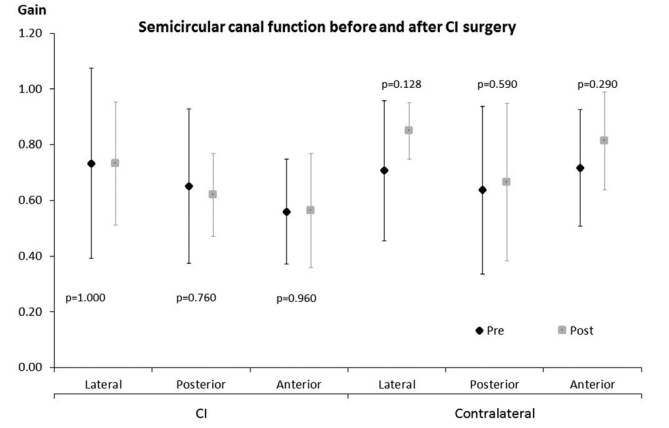

Figure 3. Mean semicircular canal gain among patients with MD before and after CI surgery. The left side of the graph represents implanted ear, and the right side represents contralateral ear. A comparison before and after CI surgery for each plane (lateral, posterior, and anterior) is performed on the implanted ear and also on the contralateral ear to rule out MD activity within the study period.

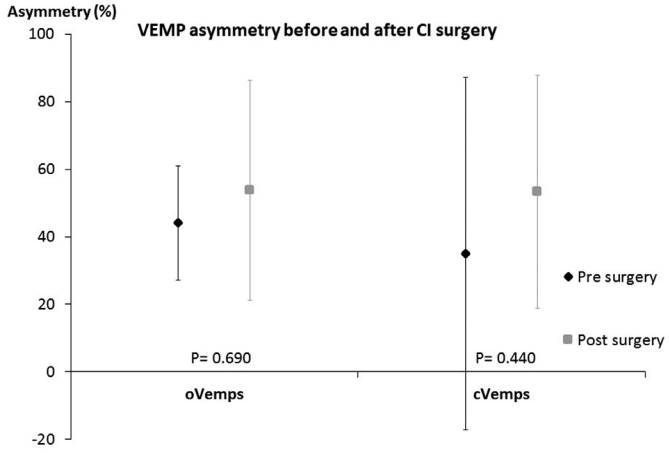

Figure 4. oVEMP and cVEMP asymmetry summary before and after surgery. P values reveal no statistical differences.

operation in seven of 16 patients. Moreover, the mean p13 latency before and after the surgery was 17.01 and 15.65 mseg, respectively (p=0.401), and the mean n23 latency before and after the surgery was 24 and 23 mseg, respectively (p=0.331). The otolithic function based on IAAR is summarized in Figure 4. There was a tendency to increase the asymmetry for both oVEMPs and cVEMPs, although no statistical significance was observed. No differences in asymmetry were observed when uni- and bilateral MD were compared.

DISCUSSION

This study demonstrated that patients with MD who develop severe-to-profound SNHL can expect a hearing benefit from CI. Our audiological results demonstrate improved speech perception for disyllabic words at 65 dB SPL in a quiet sound field. Such results were not significantly different from those of the control group with respect to age, sex, or the type of device implanted. Similar findings have been described by Mick et al. [10] in which data support the use of CI in patients with MD who are audiological and surgical candidates. In contrast, McRackan et al. [11] concluded that hearing outcomes in a sample of 21 patients with MD were worse than those in the general CI population. However, our findings in speech perception support the reports by Vermiere et al. [12], which showed a tendency to achieve better results if severe-to-profound hearing loss was due to MD. The findings are best explained by the known pathophysiology of MD [13]. Histopathological analysis has demonstrated that extensive neuronal degeneration in the spiral ganglion is rare and that there is no correlation between the severity of hearing loss and the number of remaining hair cells and neurons seen [14, 15]. Histological studies have demonstrated that the spiral ganglion cell population is reduced but not eliminated by surgical trauma [16]. Such findings may explain the poor clinical outcomes of patients with MD with moderate HL treated using hearing aids. A retro-cochlear pattern may explain the fact that hearing performance in this group is worse than that for other etiologies. McRankan et al. [11] studied implant recipients who previously underwent ablative procedures for MD and found significantly better hearing outcomes in these patients than in those who had received only medical treatment. In our study, the median for disyllabic speech understanding after surgery was 78% for patients who underwent ablative procedure [gentamicin, n=2; surgical (labyrinthectomy, n=3 or endolymphatic sac drainage, n=3)] and 76% for patients who were only managed with medical treatment (p=0.975).

CI may cause trauma by either surgical maneuvers or electrode insertion. Electrodes may alter the inner ear fluid homeostasis and provoke inflammation and fibrosis with deleterious effects at different levels of the inner ear [17]. In our study, the damage was confined to the cochlea. Despite adherence to soft-surgery principles, a mean postoperative threshold difference of 24 dB was evident 1 month after the surgery, which shifted to 28.5 dB at the 2-year follow-up. This shift in the mean threshold suggests that trauma occurring during the surgery damaged the inner ear in patients with MD. Among the temporal bones of donors diagnosed with definitive MD [18], endolymphatic hydrops was found to occur in the cochlea. Whether this damage was localized or widespread to the rest of the structures of the inner ear is an issue still under investigation [19]. According to previous findings, VEMP abnormalities are frequently observed both for oVEMPs and cVEMPs; however, they are particularly observed when there is a radiological confirmation of endolymphatic hydrops [20]. In vHIT, the most frequent abnormalities are observed in the gains of the posterior semicircular canal in

the ipsilateral side [21]. The estimated incidence of vestibular impairment after CI (according to clinical follow-up or other procedures of testing) widely varies from 39% to 74% in patients with severe-profound SNHL with varying etiologies [22]. We observed that although head impulse gain yielded minor changes after CI surgery, the mean IAAR of oVEMPs and cVEMPs increased (became abnormal) by 15% and 25%, respectively, with no statistical significance. Such slight changes are consistent with the findings described by Buchman et al. [22], who found that significant adverse effects on the vestibular system were uncommon. In fact, around 70% of the vestibular symptoms associated with MD vanish over the long term, leaving only approximately 30% of patients with chronic dizziness [23]. Thus, vestibular symptoms after CI in patients with MD may be seen as a part of the ongoing disease itself. Results in our population with MD suggested no deterioration of otolithic or semicircular function before or after CI. Such differences are regardless of uni- or bilateral MD condition. However, our results for the VEMPs differ from those obtained in previous studies [24] wherein a disappearance and impairment of oVEMPs and cVEMPs after CI surgery has been reported. These authors suggest that some degree of damage occurs at the level of the utricle and saccule. Differences from our group might be mainly explained by differences in the methodology, patients' age, and the pathophysiology of MD.

Further studies are needed to measure vestibular function and corroborate the data. CI in patients with MD has opened a new avenue to understand the nature of hearing loss and the physiopathology of this disease. Our findings of the impact of surgery on residual hearing thresholds indicate that soft-surgery principles used for CI in patients with MD need to be reviewed and amended to include additional measures to further safeguard against potential damage in such patients.

CONCLUSIONS

CI is an appropriate treatment for severe-to-profound SNHL in patients with MD. The auditory performance is improved and is similar to that in the general CI population. However, hearing preservation is not achieved in patients with MD despite adhering to soft-surgery principles. No major dysfunction of the otolithic or the semicircular canal function was demonstrated after CI surgery.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of the University of Navarra Clinic on 2013.

Informed Consent: Written informed consent was obtained from patients who participated in this study.

Peer-review: Externally peer-reviewed.

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Conflict of Interest: No conflict of interest was declared by the authors.

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