Endolymphatic duct and sac decompression: A new technique for Ménière’s disease treatment

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INTRODUCTION

Ménière's Disease (MD) is an idiopathic pathology of the inner ear clinically characterized by spontaneous and recurrent episodes of dizziness, vertigo, fluctuating neurosensory hearing loss, tinnitus, and ear fullness. Years before the episodes of vertigo, the patient can experience tinnitus, ear fullness, and hearing loss of the affected ear. Hearing loss is associated with episodes of vertigo in 77% of patients. It appears fluctuating and, in the first period of the disease, reversible after a...
Surgical technique

DASD is performed in substitution of plain endolymphatic sac surgery (ELSS). The technique is not limited to sac decompression but extended to duct decompression. To get around the difficulty of recognizing the endolymphatic sac, it is mandatory to drill out all the bone over the dura, from the superior petrosal sinus to the superior limit of the jugular bulb. To decompress the ED with reasonable certainty, the dura has to be exposed as far as the arch of the posterior semicircular canal, where the ED passes. The bone-pate-surgical bone dust mixed with fibrin glue-is then positioned superiorly and inferiorly to the area, where the ED resides [Figure 1]. Physiologically, the obstruction of the ED can hinder the success of any technique, it is therefore important to include this fundamental anatomical structure in the decompression zone.\(^{[14]}\)

In consideration of the rounded-up intraosseous ES average length of 15 mm,\(^{[12]}\) the duct average length of 1.64 mm,\(^{[13]}\) and the MD ED average volume of 0.34,\(^{[17]}\) the authors can demonstrate the height of bone paté necessary to decompress the ED.

Considering the ED as a cylindrical geometric figure:

For diameter \(= 2 \cdot r = 2 \cdot \sqrt{V/\pi} = 2 \cdot \sqrt{0.34/3.14} = 1.64 = 0.48\)

Considering [Figure 2a]

\(y_1 = 15\) mm ES length
\(y_2 = 15\) mm + 1.64 mm = 16.64 = decompression zone length (length ES + length ED)
\(z_1 = 0.48\) = minimum height to be reached at the level of the duct (point P) considered as the diameter of the cylinder.

\(z = \text{decompression zone height (bone-paté)}\)

For \(l = y_2 - y_1\)

\[ Z = y_2 \cdot \tan \alpha = y_2 \cdot \left( \frac{z}{l} \right) = \frac{y_2}{y_2 - y_1} \]

\[ z_1 \cdot \left( \frac{1}{y_2 - y_1} \right) = 0.48 \cdot \left( \frac{1}{1-1.5/16.64} \right) = 4.8\ mm \]

The authors hypothesize that to decompress the ED (P), it is necessary to have a height of about 4.8 mm of bone-pate to be placed between the posterior semi-circular canal and the upper extremity and dura mather (z). Using the currently available data in the literature regarding the ES,\(^{[14]}\) its maximum intraosseous length has been considered 15 mm. It is important to report that an excessive bone-paté height constitutes a risk for CSF fistula.

Furthermore, by arranging bone-paté in two points, beyond ES cranial margin, and beyond ES caudal margin (x), it is possible to include these structures in the decompression area. The authors have identified a prismatic area that represents the approximate decompression zone [Figure 2b].

MATERIALS AND METHODS

The observational self-controlled case study was conducted retrospectively at the Otolaryngology Department of the Campus Bio-Medico University on patients that underwent DASD. All the patients who met the criteria for MD according to the Classification Committee of the Bárány\(^{[16]}\) were subject beforehand to medical treatment (vestibular suppressors, diuretics, betahistine, and diet) without benefits for at least 6 months.

Exclusion criteria for DASD are patients older than 75 years (due to meningeal fragility), patients that cannot sustain general anesthesia, or suffering complete hearing loss of the affected ear. All patients underwent an ear Computed Tomography scan (CT scan) and brain magnetic resonance imaging to exclude inner ear pathologies and APC expansive formations.
Two patients showing signs of chronic otitis media will first undergo tympanoplasty and then DASD; the presence of a not well-pneumatized mastoid increases the difficulty of the intervention but does not represent a criterion of exclusion.

The authors administered the dizziness handicap inventory (DHI) questionnaire in an 82 patients consecutive cohort to evaluate postoperative and preoperative condition retrospectively. The DHI is a questionnaire validated in Italian\(^{[19]}\) including three scales: functional, emotional, and physical; it is used to assess the impact of vertigo and instability on the quality of life. Ear fullness and tinnitus were marked as “absent, reduced, unchanged, or worsened.” Preoperative and postoperative audiometric examinations were evaluated with 4-PTA (Pure Tones Average) (500Hz-1000Hz-2000Hz-4000Hz), the authors considered bone conduction average, the hearing threshold was considered stable with a ≤10-dB PTA improvement or worsening-based American Academy of Otolaryngology–Head and Neck Surgery (AAO-HNS = American Academy of Otolaryngology–Head and Neck Surgery) criteria for hearing level assessment. The age of the study population at the time of surgery ranged from 25 to 71, averaging 50.5 years, while the male/female ratio was 1.3:1. Of the 82 patients, 10.9% (9) presented the disease bilaterally, only one patient reported undiagnosed migraine, and one patient had a son with MD. The average time of the first vertiginous crisis was 8 (1–35) years earlier. Over the 6 months before the intervention, patients described the number of crises with wide variability 12 ± 10 (1–30).

The average follow-up from the intervention date is 14.96 months. Statistical analysis was carried out with GraphPad software Inc. and the Shapiro–Wilk test was used to evaluate the normality of the sample. Discontinuous variables are listed with median and range (IQR). The difference between the preoperative and postoperative values was analyzed with the Wilcoxon signed–rank test. The authors performed a comparison with the literature and found two publications, in which DHI was used to evaluate ELSS\(^{[1,2]}\) the T-test was performed to compare the data of these studies with those of this article.

In the case of the study by Bojrab et al., the authors do not report data on the standard deviations, these data were extracted from “Figure 2” of the Web Plot Digitizer program. We included patients with similar follow-ups. Statistical significance was considered for \(P < 0.05\).

RESULTS

The Wilcoxon signed–rank test showed that the scoring difference between the preoperative and the postoperative of each DHI question is statistically significant (\(P < 0.001\)) [Figure 3]. The average preoperative DHI score was 70 ± 15.19 against the postoperative one that turned out to be 18 ± 20 and the median score difference was 54 ± 18. The sub-scale comparison shows a preoperative average score of 24.9 against 6.52 in the postoperative for functional scale, 25.26 against 6.48 for the emotional scale, 19.8 against five for the physical scale. The postoperative situation shows fullness worsened in 4% of the case, unchanged 13% of the case, absent in 40% of the case, and reduced in 43% of the case. Postoperative tinnitus valuation worsened in 4% of the cases, unchanged in 36% of the cases, reduced in 38% of the cases, and absent in 22% of the cases.

Considering the follow-up obtained, 89% (73 of 82) of the patients achieved control of vertigo, 8% (7 of 82) underwent further surgery (neurectomy, Intratympanic Gentamicin), the remaining 3% (2 of 82) did not achieve symptoms control but refused to undergo further interventions. Among the residual symptoms, the “blocked crises” are reported: the patient experiences prodromal symptoms (tinnitus and fullness that increase in intensity) with brief light-headedness, without leading to vertigo. The comparison of the multi-frequency average of hearing thresholds is described [Figure 4]. In each DASD treatment, no paralysis of the facial nerve and no hearing loss were observed. The literature comparative results are presented [Table 1]; the baseline condition in DHI terms of the patients in this study is worse than in the patients of the other two studies that are considered; hence, it is not possible to draw a comparison without significant bias.

DISCUSSION

The literature describes the different ELSS techniques: endolymphatic mastoid sac shunt and endolymphatic sac decompression without incision are described in some works.
Salvinelli, et al.: Ménière’s disease surgical treatment

with similar results among them. The different ELSS techniques are described by a meta-analysis that reported vertigo control in 81.6% of cases in 36-month follow-up regarding sac decompression surgery, and 75.7% regarding mastoid shunt. Furthermore, according to a review and a meta-analysis that did use the PubMed-NCBI database from 1970 to 2013, sac decompression and mastoid shunt are effective in controlling symptomatology with a 24-month follow-up in 75% of patients; the same studies reported better hearing performance without silastic application.

Failure of ELSS is related to the intrinsic intraoperative difficulty to recognize the endolymphatic sac; landmarks for its recognition are described in dissections of temporal bones reports.

The wide decompression of the sigmoid sinus is fundamental to allow vertigo control in 90% of cases. Other studies describe an improvement of the symptoms in 95% of cases or the significant improvement in the quality of life of the patient. According to the authors, the improvement of the technique involves meningeal decompression of the ED, as well as the endolymphatic sac and the coverage of the decompressed area with bone wax and temporal fascia graft to avoid bone regrowth in the decompressed area.

Considering the young age of many of the patients, despite the good results in the literature on intratympanic gentamicin administration (ITG), the authors prefer not to expose patients even to the related 10% risk of hearing loss. Studies report different percentages of symptoms control for ITG: 75–80–83.1% with a 24%,

Table 1: Literature comparison in ELSS techniques using DHI questionnaire results in patients with similar follow-up.

| PY | n  | FU          | Pre Average | Pre SD | Post Average | Post SD | Average variation | SD* |
|----|----|-------------|-------------|--------|--------------|--------|------------------|-----|
| Present data | 2021 | 15 | 10–14 months | 71.3 | 15.63 | 33.2 | 26.51 | −38.1 | 23.1 |
| Bojrab et al. | 2018 | 17 | 12 months | 60.5 | 6.89 | 25.8 | 18.52 | −34.7 | 16.2 |
| Difference | | | | 10.8 | 4.37 | 7.4 | 8.19 | −3.4 | 7.14 |
| t-test P | | | | 0.023 | 0.376 | 0.638 |

| PY | n  | FU          | Pre Average | Pre SD | Post Average | Post SD | Average variation | SD* |
|----|----|-------------|-------------|--------|--------------|--------|------------------|-----|
| Present data | 2021 | 69 | 12–28 months | 69.4 | 15.0 | 17.5 | 18.7 | −51.9 | 17.2 |
| Albu et al. | 2014 | 34 | 12–68 months | 52.2 | 11.2 | 41.6 | 17.5 | −10.6 | 15.4 |
| Difference | | | | 17.2 | 2.91 | −24.1 | 3.84 | −41.3 | 3.36 |
| t-test P | | | | <0.001 | <0.001 | <0.001 |

Figure 3: Comparison of total dizziness handicap inventory for each patient before and after surgery.

Figure 4: Four Pure Tone average (500 Hz-1000 Hz-2000 Hz-4000 Hz) before and after surgery.
The authors hypothesize that the technique failure is due to the lack of knowledge of the anatomical area that it is not exposed during surgery. Increasing accuracy and mastery of the anatomical area could improve the technique. To refute the hypothesis of symptoms worsening along the time, more than 2 years of follow-up will be performed.

CONCLUSION

DASD allows MD patients to obtain vertigo control, as well as improvement of the inner ear function. In addition, DASD helps to reduce ear fullness, with no relevant risk of hearing worsening in the postoperative time, lower rate of intraoperative complication, and shorter postoperative hospital stay and no irreversible vestibular deficits as expected from other techniques. DASD reduces the destructive effects of the MD on the cochlea and the labyrinths.

Declaration of patient consent

Institutional Review Board (IRB) permission obtained for the study.

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Conflicts of interest

There are no conflicts of interest.

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