

Triple Semicircular Canal Occlusion Combined with Endolymphatic Sac Decompression: An Effective Surgical Strategy for Vertigo Control of Intractable Meniere's Disease

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Abstract

Objective: To investigate the symptomatic relief and functional preservation of a novel surgical strategy combined with triple semicircular canal occlusion and endolymphatic sac decompression in patients with intractable Meniere's disease. **Design:** Retrospective analysis. **Setting:** Patients with intractable Meniere's disease in the Department of Otolaryngology Head & Neck in the Second Affiliated Hospital of Nanchang University between July 2015 and June 2019. **Participants:** Data from 46 patients diagnosed with Meniere's disease, and underwent surgery **Methods:** Triple semicircular canal occlusion combined with endolymphatic sac decompression was performed in all patients with intractable Meniere's disease. Pre- and postoperative vertigo attacks, hearing levels, tinnitus, aural fullness, and equilibrium function rehabilitation were analyzed at defined time points during follow-up. **Results:** A significant vertigo control rate was observed in all patients postoperatively. The overall control rate of vertigo postoperatively was 100% in the entire follow-up, with a complete control rate of 97.8% and a substantial control rate of 2.2%. The rate of hearing preservation was 54.35%, and all patients suffering from hearing deterioration were at stages III and IV. The rate of tinnitus and aural fullness alleviation was 65.8% and 100%, respectively. Four patients failed to regain the equilibrium function postoperatively. **Conclusion:** Combining triple semicircular canal occlusion with endolymphatic sac decompression is an efficient strategy for vertigo control in patients with intractable Meniere's disease. Patients in advanced stages suffered more from hearing function deterioration. Hearing preservation and tinnitus alleviation warrant further investigation.

ABSTRACT

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Keywords: Semicircular canal occlusion; Endolymphatic sac decompression; Meniere's disease; Vertigo; Hearing Loss

Key points:

1. Triple semicircular canal occlusion an efficient strategy for vertigo control in patients with intractable Meniere's disease
2. The surgery can block the movement of endolymph in the canals to eliminate vertigo attacks induced by position changing
3. Advanced stage MD suffered more from hearing deterioration postoperative
4. The aural fullness remission was satisfactory postoperative
5. Rehabilitation of vestibular function is important to patients restoring equilibrium postoperative

INTRODUCTION

Meniere's disease (MD) is an inner ear disorder characterized by intermittent episodes of vertigo lasting from minutes to hours, incurring fluctuating sensorineural hearing loss, tinnitus, and aural pressure in the affected ear. Numerous treatment options are currently used with the aim of reducing the severity and incidence of vertigo attacks, preventing disease progression, and treating the effects of end organ damage such as hearing loss, tinnitus, and chronic imbalance, and providing symptomatic relief¹. Lifestyle modification and medical treatment were recommended as the first line of care provided to those patients. More than 85% of patients with MD are helped by such treatment strategies². However, vertigo persists despite an optimal conservative treatment in approximately 10% of cases. These cases are considered to have intractable MD³. The quality of life of these patients were seriously affected by the symptoms of the disease, especially during vertigo episodes. A common problem is the difficulty in controlling vertigo effectively while preserving hearing. To date, many different methods have been attempted to treat these patients, including a variety of surgeries. Endolymphatic sac surgery has been proven safe and effective in the alleviation of intractable vertigo in only 50% to 75% of patients⁴⁻⁶. However, Thomsen and colleagues concluded that endolymphatic sac surgery presented no advantages compared with a placebo operation⁷. Semicircular canal occlusion has been used as an alternative treatment in intractable benign paroxysmal positional vertigo with varying degrees of success. The surgery aims to ablate movement of the endolymph in the canals and therefore to eliminate vertigo attacks aroused by rotational movements. It is also a prospective method in vertigo management in patients with MD.

The aim of this study is to evaluate the effectiveness of triple semicircular canal occlusion (TSCO) combined with endolymphatic sac decompression (ESD) in controlling vertigo attacks, tinnitus, and aural fullness, and to evaluate its effect on hearing level and equilibrium function rehabilitation. Here, we present a retrospective analysis on 46 patients with MD who underwent TSCO combined with ESD. The analysis includes symptom control and management and markers of functional preservation.

PATIENTS AND METHODS

After obtaining institutional review board approval from the XXX, we carried out a retrospective analysis on 46 patients diagnosed with MD, according to AAO-HNS criteria⁸, who were treated by a surgical strategy that combined TSCO and ESD in the Department of Otolaryngology Head & Neck Surgery in XXX between July 2015 and June 2019. All information based on patients' medical records and follow-up interviews (telephone or questionnaire), including clinical symptoms, previous treatments, surgical procedures, and

control of vertigo attacks, tinnitus and aural fullness, preservation of hearing, rehabilitation of equilibrium function, postoperatively, was collected up until July 2020.

The inclusion criteria consisted of: only patients in the definite category of the MD, according to a diagnostic scale based on clinical criteria⁸; patients who underwent medical therapy and lifestyle modifications for at least 6 months without improvement and who had more than 6 vertigo attacks for the last 6 months before the surgery; patients who had a strong desire for surgery. The exclusion criteria were: (1) patients with intractable MD not responding to the inclusion criteria; and (2) patients with active mastoid or middle ear diseases.

Surgical protocol

All patients were placed under general anesthesia, and facial nerve monitoring electrodes were put in place. A standard mastoidectomy was performed through a postauricular incision, with decompression of the sigmoid sinus. The facial nerve and three semicircular canals were identified and skeletonized, after which the endolymphatic sac was identified posterior to the posterior semicircular canal, along the posterior fossa plate, below Donaldson's line. The bone over the sac was widely removed for decompression. A fenestration was made at a spot on the posterior canal as far as possible away from the ampulla, keeping the membranous labyrinth intact. Next, a small piece of soft tissue was filled into the fenestration to tightly block the membranous labyrinth over a short segment, after which, the fenestration was finally sealed with bone wax to further safeguard against perilymph leakage. Thereafter, the superior and horizontal semicircular canals were blocked using the same method.

Hearing evaluation

In this study, pure-tone average (PTA), calculated using 0.5-, 1-, 2-, and 3-kHz air conduction thresholds, was used to evaluate the hearing level of the patients. The 3-kHz threshold used in this study was interpolated by averaging the thresholds at 2 and 4 kHz, because the 3-kHz threshold is not routinely tested in China. The postoperative evaluation included three time points, at 6 months, 12 months and 18 months postoperatively. Hearing deterioration or improvement was assessed according to the *A New Standardized Format for Reporting Hearing Outcome in Clinical Trials*⁹. Hearing deterioration was defined as a PTA elevating ≥ 10 dB when compared with the hearing level preoperatively. The definition of stages was based on the hearing levels of patients pre-operatively¹⁰. In brief, a stage I corresponded to a PTA ≤ 25 dB HL, stage II corresponded to a PTA of 25 - 40 dB HL, stage III corresponded to a PTA of 41-70 dB HL and stage IV corresponded to a PTA ≥ 70 dB HL. The word recognition score cannot be reported in this study due to the variety of dialects. It is difficult to acquire reliable scores using a single standardization scale when evaluated patients speak different types of dialects.

RESULTS

In this study, the demographic and symptoms information on the patients undergoing TSCO combined with ESD are presented in Table 1. In brief, 19 male and 27 female patients (male: female ratio = 0.70: 1) were included. The mean age of these patients at the time of surgery was 58 years (ranging from 33 to 79 years). The duration of disease was 118.2 months (ranging from 48 to 360 months), and the vertigo episodes during the last 6 months occurred an average of 6.84 times (ranging from 2 to 42 times). All patients in this study complained of hearing loss, and most of them suffered from aural fullness and tinnitus, especially during the vertigo episode.

Post-operatively, all patients suffered from temporary vertigo and imbalance and presented with spontaneous nystagmus immediately post-operatively. Vertigo disappeared in all patients within 3 days, while the imbalance was alleviated in all patients within 4-5 days, and 30 patients totally recovered their balance within 2 months, with an average recovery time of 12.6 days. However, there were 4 patients who still felt unstable or like they were floating at the latest follow-up interview because none of them persisted with vestibular rehabilitation postoperatively. No patients had facial paralysis, cerebrospinal fluid leakage, infection, or other complications.

The overall control rate of vertigo post-operatively was 100% in the whole follow-up, with a complete control rate of 97.8% (45/46) and a substantial control rate of 2.2% (1/46). The average numbers of vertigo attacks over the course of 6 months pre- and post-operatively was 6.727 ± 7.807 and 0.0625 ± 0.348 ($F = 499.67$, $p = 0.000$), respectively. Only one patient suffered from two vertigo attacks in the 6 months post-operatively (Table 2). However, the vertigo was alleviated when the patients took diuretics and betahistine, and never reoccurred over the course of the entire follow-up time. The number of patients suffering from aural fullness pre- and post-operatively was 44 and 0 ($p=0.000$), respectively (Table 2). Out of the 46 patients included in this study, 38 patients suffered from persistent or bothersome tinnitus preoperatively. However, this number was decreased to 12 ($X^2=21.959$, $p= 0.000$) postoperatively (Table 2). The tinnitus evaluation was carried out according to the *Clinical Practice Guideline: Tinnitus (2014)*¹¹.

According to the pre-operative staging of hearing, among these 46 patients, there were 2 in stage I, 11 in stage II, 21 in stage III and 12 in stage IV. Fifteen patients had unserviceable hearing pre-operatively (PTA more than 60 dB HL). No patients in stage I or II suffered from hearing deterioration postoperatively. However, 6 patients (6/21, 28.57%) in stage III presented with hearing deterioration 6 months postoperatively when compared with their preoperative state. That number increased to 9 (9/21, 42.86%) and 16 (16/21, 76.19%) at 12 months and 18 months postoperatively, respectively. Otherwise, patients in stage IV presented hearing deterioration were 2 (2/12, 16.67%), 3 (3/12, 25%), and 5 (5/12, 41.67%) at 6, 12, and 18 months postoperative, respectively. Finally, there was a total of 21 patients (21/46, 45.65%) suffering from hearing deterioration at 18 months postoperatively, and all patients suffering from hearing deterioration were at stage III and IV. The rate of hearing preservation was only 54.35% at 18 months postoperatively (Table 3). The overall PTA was 59.33 ± 17.2 dB HL and 68.28 ± 24.0 dB HL pre-operatively and post-operatively, respectively, which reflected a significant difference compared between pre- and postoperatively (Table 2).

DISCUSSION

The primary goals of numerous treatment options currently used for MD treatment are first to prevent or at least reduce the frequency and severity of vertigo attacks, and, secondarily, to prevent disease progression, treat the effects of end organ damage like hearing loss, tinnitus, and chronic imbalance, and provide symptomatic relief. A main consideration regard to the choice of treatment strategy is the patient's hearing status, and whether it is usable or not. Nonablative procedures have been advocated for patients with usable or serviceable hearing. Surgical procedures for the treatment of this disease can be classified into three categories. The first category, an ablative procedure, includes selective vestibular neurectomy or labyrinthectomy. Although vestibular neurectomy has a very high efficiency of vertigo control, the risk of operation is high¹², and it is only implemented in patients with total deafness² and with an intense desire to receive surgical treatment. The second category, a traditional functional preserved strategy, involves all types of endolymphatic sac surgeries (decompression and drainage). Endolymphatic sac surgery, as a conservative operation, was often used in intractable MD patients. The theory behind the surgery is to relieve the pressure of the endolymphatic fluid, thereby decreasing episodic vertigo attacks induced by endolymphatic hydrops^{13,14}. So far, endolymphatic sac surgery has been universally acknowledged and used, and has generally considered to be a safe surgical option because hearing is maintained postoperatively^{13,15}. However, many patients relapsed with episodic vertigo postoperatively, and the control rate of vertigo was only 60~80%; the benefit of this strategy is still under debate as it yields inconsistent results compared to placebo surgery^{16,17}.

The third category is semicircular canal occlusion/plugging, a novel procedure proposed for the management of intractable peripheral vertigo by many specialists, which aims to block the movement of endolymph in the canals and therefore to eliminate vertigo attacks induced by position changing³. Since semicircular canal occlusion was first applied to treat intractable benign paroxysmal positional vertigo in 1990, many investigators have begun to apply this method for the treatment of intractable peripheral vertigo, with results showing that plugging surgery represents a safe option¹⁸. However, the investigation of semicircular canal plugging/occlusion applied to patients suffering from MD has scarcely been discussed to date. Yin et al¹⁹ applied TSCO to three patients with MD who underwent unsuccessful ESD or a mastoid shunt, demonstrating that two cases reached complete vertigo control with the other reached substantial vertigo

control. In this study, TSCO combined with ESD was applied to patients with intractable MD as the primary surgical strategy for the purpose of controlling vertigo. The overall vertigo control rate was 100%, with a complete control rate of 97.8% and a substantial control rate of 2.2%. The vertigo control rate was higher than the rate reported by Zhang et al^{20,21} and Charpiot et al²². All patients in this study were satisfied with the vertigo control postoperatively during the follow-up period. Our data directly suggested that combining TSCO and ESD is an efficient strategy for vertigo control in patients with intractable MD.

As a nonablative procedure, TSCO combined with ESD provided a satisfying vertigo control rate in this study. However, the total hearing preservation rate was 82.61%, 73.91%, and 54.35% at 6-months, 12-months, and 18-months postoperative, respectively. This was inconsistent with the data from Zhang²⁰, who reported a rate of 70.9% for hearing preservation in a 2-year follow-up. However, 76.19% of patients were in stage III (16/21) and 41.67% of patients in stage IV (5/12) with hearing loss, no patients in stages I or II pre-operatively (13 patients) complained of hearing loss postoperative. The results of this study suggested that patients in advanced stages (stages III and IV) suffered more from progressive hearing deterioration postoperatively as time elapsed, which suggested that vertigo control cannot simultaneously halt the progression of cochlear function deterioration. Although the group of patients suffered from hearing deterioration including 15 patients who presented with no serviceable hearing function pre-operatively (Table 4). However, this group of patients lost the opportunity to use the hearing aids to improve their social communication in daily life. Residual hearing preservation remains a significant challenge to address prior to the selection of an optimal strategy for intractable MD patients.

Why does hearing deteriorate over time? Animal studies demonstrated that factors such as lymph leak, bleeding into the inner ears, serous labyrinthitis, and infections were all considered to potentially induce hearing loss during surgery^{23,24}. Hearing loss caused by those factors is reversible²⁵. However, transaction of the membrane labyrinth intraoperatively usually causes irreversible hearing loss²⁵. Otherwise, in our study, all patients suffered from hearing loss postoperatively were in stages III and IV. In this case, it remains difficult to determine exactly what the factors affecting the auditory function directly are postoperatively. Our data do not support the notion that the surgery procedure itself, or the labyrinthitis postoperatively, directly deteriorated the hearing. Blocking the movement of endolymph in the canals can eliminate vertigo attacks induced by position changing but cannot halt the development of MD on cochlear function deterioration, especially at advanced stages. Whether surgery, disease stages, or other potential risks (such as aging and lifestyle) were factors directly inducing hearing loss over time postoperatively still needs to be further investigated. A long-term follow-up is necessary to investigate the auditory function postoperatively.

The aural fullness remission was consistent with the vertigo control in this study. The tinnitus control rate is 65.8%. Patients still bothered with persistent or bothersome tinnitus had severe hearing loss. However, this cannot rule out the possibility that tinnitus is related to auditory function damage in MD. In this study, 30 patients regained their balance within 2 months, with an average recovery time of 12.6 days. There were 4 patients who still felt unstable or like they were floating at the latest follow-up interview because none of these 4 patients persisted with vestibular rehabilitation postoperatively. Vestibular rehabilitation is important and effective for vestibular function compensation in patients postoperative. The vestibular dysfunction induced by TSCO and ESD is reversible, and vestibular rehabilitation should be recommended to all patients postoperative.

In conclusion, combining TSCO and ESD is an efficient strategy for vertigo control in patients with intractable MD. However, the hearing functions were deteriorating gradually postoperatively in patients at advanced stages. The hearing preservation and tinnitus relief still warrant further illumination.

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