The Journal of Laryngology & Otology

cambridge.org/jlo

Triple semicircular canal occlusion: a surgical perspective with short- and long-term outcomes

G Kontorinis and G Thachil

Department of Otorhinolaryngology – Head and Neck Surgery, Queen Elizabeth University Hospital, Glasgow, Scotland, UK

Abstract

Objective. To determine the short- and long-term outcomes of triple semicircular canal occlusion as a potential alternative for patients with intractable Ménière's disease.

Methods. A retrospective case series was performed in university settings, enrolling patients with intractable Ménière's disease with previous maximum treatment, who underwent transmastoid, triple semicircular canal occlusion. The study documented: pre- and post-operative Dizziness Handicap Inventory scores at six weeks and one year post-treatment, pure tone audiometry, and surgical aspects.

Results. Two female patients, aged 42 and 65 years, underwent unilateral three-semicircular-canal occlusion. Their respective Dizziness Handicap Inventory scores improved from 88 to 68 and 54 to 30 at six weeks post-operatively, with scores of 66 and 0 at one year post-treatment. The one patient with pre-existing functional hearing maintained her hearing threshold post-operatively.

Conclusion. Triple semicircular canal occlusion is a safe, hearing-preserving, extracranial alternative technique that can control rotatory vertigo in patients with intractable Ménière's disease, when other measures have failed.

Main Article

Mr G Kontorinis takes responsibility for the integrity of the content of the paper

Cite this article: Kontorinis G, Thachil G. Triple semicircular canal occlusion: a surgical perspective with short- and long-term outcomes. *J Laryngol Otol* 2022;**136**:125–128. https://doi.org/10.1017/S002221512100387X

Accepted: 8 June 2021
First published online: 29 November 2021

Key words:
Dizziness; Inner Ear; Endolymph; Semicircular Canals; Vertigo

Author for correspondence:
Mr Georgios Kontorinis,
Department of Otorhinolaryngology – Head and Neck Surgery,
Queen Elizabeth University Hospital,
1345 Govan Road, G51 4TF, Glasgow,
Scotland, UK
E-mail: gkontorinis@gmail.com

Introduction

Following the wider utilisation of semicircular canal obliteration for persistent benign paroxysmal positional vertigo and superior semicircular canal dehiscence, we have gained a better understanding of the surgical outcomes and the reaction of the inner ear to surgical manipulations.[1,2] Such knowledge has led to the development of novel treatment methods for dealing with patients with intractable vertigo.

Over 10 years ago, Yin *et al.* introduced three-semicircular-canal obliteration as an alternative method for managing patients with Ménière's disease.[3] The promising initial results, showing good control of vestibular symptoms and hearing preservation in most patients, were further supported by the promising long-term outcomes of a recent large retrospective series.[4]

However, the available information on three-semicircular-canal obliteration remains limited, and a detailed description and demonstration of the surgical technique are lacking. The current work aimed to demonstrate the surgical technique of three-semicircular-canal obliteration, highlighting key aspects and surgical considerations.

Materials and methods

Settings and patient selection

A pilot case series with prospectively collected data was performed in a tertiary, university centre between January and December 2019. The local ethical board approved this study as an audit.

Two patients with intractable Ménière's disease scheduled to undergo elective three-semicircular-canal obliteration were enrolled. They had both previously received intratympanic steroid and gentamicin injections, with additional vestibular physiotherapy, without any definite control of their vertiginous symptoms. Following detailed consultation about the available options, the patients were scheduled for the above procedure.

The present study focused on the surgical technique, including the duration of the procedure, any complications and side effects, and the length of in-patient stay.

Pre- and post-operative average pure tone audiometry thresholds (in accordance with the American Academy of Otolaryngology and Head and Neck Surgery minimal reporting standard for audiometric data in clinical research) and Dizziness Handicap Inventory scores were also included, to assess the outcome. Morbidities that could affect the outcome were additionally recorded.

All patients had undergone pre-operative magnetic resonance imaging to rule out a retrocochlear pathology and computed tomography of the temporal bone to assess the bony anatomy.

© The Author(s), 2021. Published by Cambridge University Press on behalf of J.L.O. (1984) LIMITED

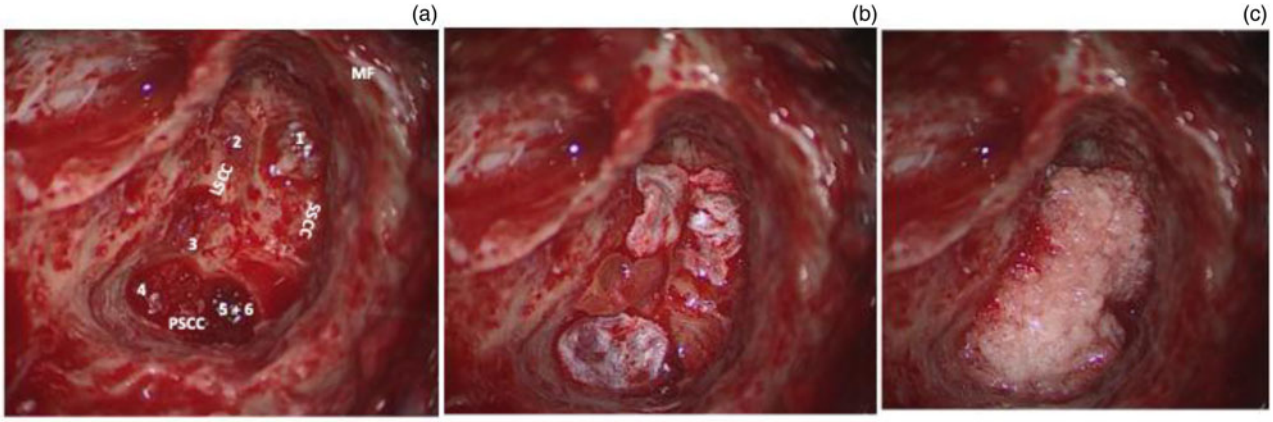

Fig. 1. The semicircular canal (patient one, left ear) opened and obliterated in two sites each (numbered), with two pieces of muscle occluding the lateral semicircular canal (LSCC), two occluding the posterior semicircular canal (PSCC) and two occluding the superior semicircular canal (SSCC) (a), covered by temporalis fascia (b) and bone pâté (c). MF = middle fossa

The post-operative data presented here are based on short-term (six-week or two-month) and long-term (one-year) post-operative assessment findings.

Surgical technique including surgical anatomy

Following a post-auricular approach and harvesting of little pieces of temporalis fascia and temporalis muscle, cortical mastoidectomy was performed; bone dust was harvested and mixed with a non-ototoxic antibiotic (bone pâté) for use as further graft material.

All three semicircular canals were gradually identified and carefully 'blue lined' until the endosteum was clearly visible, without disrupting its continuity, to prevent any perilymph leak and inner-ear trauma. After adequate exposure, the canals were plugged in very slowly with small pieces of muscle (as demonstrated in a short video, available on *The Journal of Laryngology & Otology* website; Appendix 1). The obliteration was subsequently covered by fascia and bone pâté (Figures 1 and 2).

In the first case, all three semicircular canals were 'blue lined' and obliterated with muscle in two different sites for each semicircular canal (Figure 1). However, in the second case, all three semicircular canals were 'blue lined' in one site only, with wider exposure of the membranous labyrinth, to achieve robust obliteration of the lumen (Appendix 1) (Figure 2).

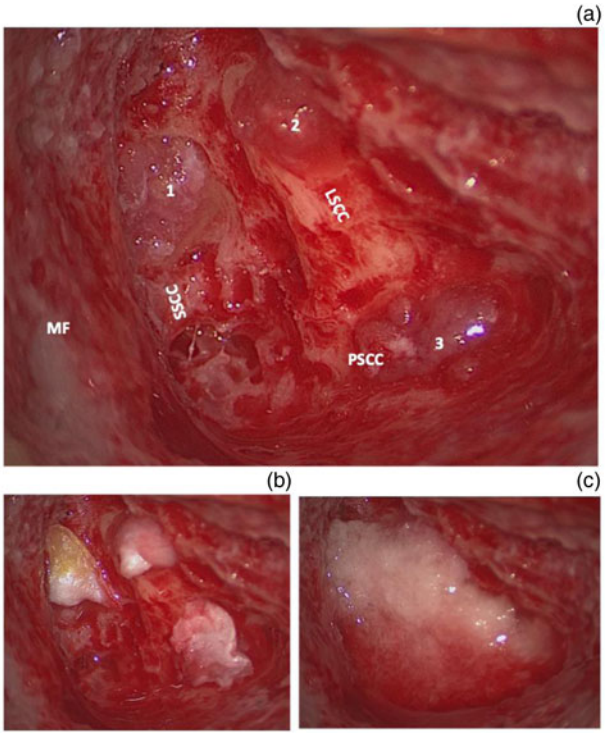

Fig. 2. All three semicircular canals (patient two, right ear) opened and obliterated in one site each (numbered) (part (a) shows a still from the video), covered by temporalis fascia (b) and bone pâté (c). LSCC = lateral semicircular canal; MF = middle fossa; SSCC = superior semicircular canal; PSCC = posterior semicircular canal

Results

Two female patients, aged 42 and 65 years respectively, were included. Both patients suffered from unilateral Ménière's disease, affecting the left ear (patient one) and the right ear (patient two) (Table 1).

Patient one had no measurable hearing prior to the operation in the affected ear; she was also suffering from degenerative lower spine changes with disc prolapse (lumbar spine vertebrae L4/L5) and anxiety. Her Dizziness Handicap Inventory score improved to 68 following the obliteration procedure (*vs* a score of 88 pre-operatively). She had a 3-day in-patient stay in light of balance disturbances following the surgery. One year following the surgery, her symptoms were stable, with a Dizziness Handicap Inventory score of 66. Additionally, she had managed to come off antidepressant medication, which she had required prior to surgery for a prolonged period of time.

The post-operative disequilibrium in patient one led the surgeon to obliterate each semicircular canal through one site only in patient two. This latter patient spent 1 day in the hospital post-operatively. Patient two had an average hearing threshold of 82.5 dB pre-operatively, which was preserved after surgery (her post-operative hearing threshold was 85 dB). Her Dizziness Handicap Inventory score improved from 54 pre-operatively to 30 following the three-semicircular-canal obliteration. One year following the surgery, she was completely asymptomatic, with a Dizziness Handicap Inventory score of 0.

There were no surgical complications in either case.

Discussion

Surgical considerations

The present study, which focuses on the surgical aspects of three-semicircular-canal obliteration, demonstrates vestibular

https://doi.org/10.1017/S002221512100387X Published online by Cambridge University Press

Table 1. Summary of demographics and recorded factors of enrolled patients

Pt no.	Gender	Age (years)	Surgery duration (mins)*	In-patient stay (days)	Average PTA (dB)†		Dizziness Handicap Inventory score			Co-morbidities
					Pre-op	Post-op	Pre-op	6 wk	1 year	
1	F	42	150	3	–	–	88	68	66	Lumbar disc prolapse with spinal degenerative changes, anxiety
2	F	65	120	1	82.5	85	54	30	0	Autoimmune arthritis

*Duration of operation refers to 'skin-to-skin' (entire surgery) duration, with the cortical mastoidectomy performed by a supervised resident. †Pure tone audiometry threshold in accordance with American Academy of Otolaryngology and Head and Neck Surgery minimal reporting standard for audiometric data in clinical research. Pt no. = patient number; mins = minutes; PTA = pure tone audiometry; pre-op = pre-operative; post-op = post-operative; wk = weeks; F = female

symptom improvement in patients with intractable Ménière's disease who underwent this procedure. There are two main noteworthy surgical aspects: (1) the 'blue-lining' and occlusion of the semicircular canal in one site only, instead of the two-site approach, which has commonly been utilised in cases of benign paroxysmal positional vertigo (posterior semicircular canal) and superior semicircular canal dehiscence;[1,2] and (2) the obliteration material (muscle supported by fascia and bone pâté).

With respect to 'blue-lining' and obliterating the semicircular canal only in one site, this appears to provide adequate exposure of the lumen, allowing the advance of the obliterating material into the semicircular canal. The initial case series of three-semicircular-canal obliteration, reported by Yin *et al.*, also described a one-site fenestration only.[3] However, the authors recommended a small fenestration (1 mm) to avoid inner-ear trauma.[3] In the present work, the surgeon used a wider fenestration, taking care not to breach the membranous labyrinth. This aspect was helpful, as it facilitated trouble-free advancing of the muscle and occlusion of the lumen. The post-operative recovery period and the surgery duration were shorter when 'blue-lining' all three semicircular canals only in one site. Although the number of cases reported here is minimal, the recovery and the previously reported larger series[3,4] indicate that fenestrating only one site in each canal in the three-semicircular-canal obliteration technique is preferable to fenestration and obliteration of each canal in two sites.

The number of reported cases is very limited, but the findings indicate that three-semicircular-canal occlusion can be a viable alternative for selected patients. Gill *et al.* recently reported the promising outcomes of three cases, based on class of vertigo and pure tone thresholds. Of note, we did aim to collect data from additional patients, but the current pandemic prevented this; we hope to collect these data in the near future.

In this study and in the initial description of three-semicircular-canal plugging,[3] temporalis muscle was used as an occlusion material. Despite the utilisation of bone pâté in previous series, targeting either the superior or the posterior semicircular canal,[1,2] the authors are sceptical about the direct application of bone pâté in the inner ear, in case the continuity of the membranous labyrinth has been disrupted. However, to date, there is no evidence against the usage of bone pâté. The temporalis muscle has been utilised by the surgeon without any issues in a series of superior semicircular canal obliteration cases (unpublished data). In addition to the muscle, the overlying temporalis fascia and bone pâté, which can support the obliteration and prevent any perilymph leak, is an important detail.

Finally, with respect to pre-operative diagnostic methods, we found the computed tomography scan very useful in determining pneumatisation of the temporal bone and the accessibility of all three canals. In patients with superior semicircular canal dehiscence, the temporal bone is well pneumatised;[5] however, in patients with Ménière's disease, this may vary.

Technique strengths and limitations

The three-semicircular-canal obliteration technique is associated with high rates of hearing preservation.[3,4] This provides us with a good alternative to labyrinthectomy (essentially three-semicircular-canal occlusion is a selective, partial, hearing-preserving labyrinthectomy). It also helps us to improve our understanding of the inner ear's tolerance to surgical trauma. Being able to obliterate and bypass part of the inner ear without causing deafness opens up new ways of accessing deeper areas such as the petrous apex, in a less invasive, more sophisticated way.

Previous experimental three-semicircular-canal occlusions in guinea pigs showed promising results in managing rotatory dizziness with hearing preservation.[6] In a similar fashion, the first animal study on three-semicircular-canal occlusion also showed superior outcomes compared to labyrinthectomy.[7] Despite the differences between animal and human models, the reported outcomes in humans support the use of such a technique. As the semicircular canals control angular accelerations, in cases where rotatory dizziness is intractable, selective obliteration of the semicircular canals – the part of the vestibular organ responsible for such symptoms – should be considered a worthwhile treatment method.[3,4,8] This was also highlighted in a recent study focusing on long-term, symptom-centred, positive outcomes, further supporting the current findings;[8] unfortunately, that study lacked surgical details.

In the currently described surgical technique, a cautious, step-by-step approach is essential to avoid inner-ear trauma. During and after the 'blue-lining' of all three semicircular canals, economy of movements and avoidance of excess manipulations are crucial. Should a leak occur, additional care should be taken to avoid inner-ear trauma.

- Triple semicircular canal occlusion is a feasible, hearing-preserving surgical option for patients with Ménière's disease resistant to less invasive treatment
- Three-semicircular-canal obliteration targets the angular acceleration (controlled by semicircular canals), and can eliminate rotatory vertigo
- So far, outcomes indicate that such 'selective labyrinthectomy' techniques can be used to access deeper lesions, with hearing-preserving intent
- An atraumatic technique, with semicircular canal 'blue-lining' and careful occlusion of all canals, is crucial in hearing preservation

https://doi.org/10.1017/S002221512100387X Published online by Cambridge University Press

In conclusion, the three-semicircular-canal obliteration technique is a useful treatment option for selected patients with intractable Ménière's disease, as it can safely control rotatory vertigo. 'Blue-lining' of each semicircular canal in one site, and occlusion with temporalis muscle supported by fascia and bone pâté, is a safe technique.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S002221512100387X.

Competing interests. None declared

References

1 Beyea, JA, Agrawal SK, Parnes LS. Transmastoid semicircular canal occlusion: a safe and highly effective treatment for benign paroxysmal positional vertigo and superior canal dehiscence. *Laryngoscope* 2012;**122**:1862–6

2 Deschenes GR, Hsu DP, Megerian CA. Outpatient repair of superior semicircular canal dehiscence via the transmastoid approach. *Laryngoscope* 2009;**119**:1765–9

3 Yin S, Chen Z, Yu D, Wu Y, Shi H, Zhou H *et al*. Triple semicircular canal occlusion for the treatment of Ménière's disease. *Acta Otolaryngol* 2008;**128**:739–43

4 Zhang D, Lv Y, Han Y, Li Y, Li X, Wang J *et al*. Long-term outcomes of triple semicircular canal plugging for the treatment of intractable Meniere's disease: a single center experience of 361 cases. *J Vestib Res* 2019;**29**:315–22

5 Tikka T, Kontorinis G. Temporal bone anatomy in superior semicircular canal dehiscence: a case control study on bone pneumatization and the level of middle cranial fossa. *Otol Neurotol* 2020;**41**:e334–41

6 Yin S, Yu D, Li M, Wang J. Triple semicircular canal occlusion in guinea pigs with endolymphatic hydrops. *Otol Neurotol* 2006;**27**:78–85

7 Gianoli GJ, Duff B, Kartush JM, Bouchard KR. Triple semicircular canal occlusion versus labyrinthectomy in the cat. *Am J Otol* 1997;**18**:74–8

8 Gill C, Muzaffar J, Kumar R, Irving R. Triple canal occlusion for the treatment of intractable Menière's disease. *Otol Neurotol* 2021;**42**:116–20

Appendix 1. Supplementary video material

A short video, demonstrating the 'blue-lining' of all three semicircular canals in one site (right ear), and subsequent occlusion with temporalis fascia, is available online at *The Journal of Laryngology & Otology* website, at https://doi.org/10.1017/S002221512100387.

https://doi.org/10.1017/S002221512100387X Published online by Cambridge University Press