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Surgical labyrinthectomy in the treatment of unilateral Meniere disease: a Belgian retrospective study

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Abstract

Purpose Meniere's disease (MD) is a disabling condition with symptoms, such as hearing loss, dizziness, and tinnitus. Surgery is the last resort option for managing MD when other treatments are not effective. Surgical labyrinthectomy (SL) is less commonly performed than vestibular neurectomy or chemical labyrinthectomy. We sought to assess the efficacy and safety of the SL procedure.

Methods A retrospective study was carried out involving a cohort of 25 patients with disabling and drug-resistant MD, who underwent SL performed by the same surgeon at University Hospital UCL Namur between 2009 and 2019. All patients considered their hearing non-functional and requested a radical therapeutic option. We compared subjective and objective measures before and after surgery, retrieved from patient medical records.

Results The difference between the Dizziness Handicap Inventory scores before and after surgery was statistically significant ($p<0.01$). 81% of patients being satisfied with surgery. No post-operative complications occurred. Following SL, 14 patients evolved well, both subjectively and clinically, without any further vestibular workup required, which was offered to the other patients. All had a total deafness on the operated side, as expected, while four benefited from multidisciplinary rehabilitation because of persistent tinnitus. The scientific literature on this topic was reviewed, compared, and discussed.

Conclusions Based on our results, SL represents an efficient and safe approach to achieve vestibular deafferentation in patients with unilateral, disabling, and treatment-resistant MD, with non-functional hearing.

Keywords Meniere's disease · Surgical labyrinthectomy · Dizziness · Hearing · Vertigo · Vestibular dysfunction

Introduction

Meniere's disease (MD) is an inner ear disorder that causes fluctuating hearing loss, tinnitus, regular episodes of dizziness lasting more than 20 min, and sensations of fullness in the ear [1]. These symptoms usually begin between 30 and 60 years of age. MD is more common in elderly, white, and female patients, with reported prevalence rates ranging from 3.5 to 513 per 100,000 people [2]. The symptoms result from endolymphatic accumulation in the inner ear, known as endolymphatic hydrops [3]. Several etiopathological hypotheses have been formulated, with genetic and environmental factors likely to play a role [3]. The precise cause of MD is still unknown.

Treatment is mostly symptomatic. Patients are advised to adopt a low salt diet, avoid caffeine and stress, and practice good sleep hygiene. Drug treatment is typically the next step, comprising corticosteroids, diuretics or betahistine [4]. If the disease is drug-resistant, conservative surgery aimed at curing the patient's vertigo is the last therapeutic approach. Surgery encompasses several procedures, such as vestibular neurectomy, chemical labyrinthectomy using gentamicin injection, surgical labyrinthectomy (SL), or sacculotomy [5]. Though secure and efficient, SL is less commonly performed, the main reason for this being the inevitably resulting total deafness. Yet, this treatment option becomes reasonably feasible in the case MD is associated with severe hearing loss.

This retrospective study involved a cohort of 25 patients with unilateral, disabling, and drug-resistant MD, who underwent SL performed by the same surgeon between 2009

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and 2019. We compared subjective and objective measures before and after surgery to assess the procedure's efficacy and safety, and we related our findings with published reports using the same or different approaches.

Methods

Study design and patient population

This retrospective study was approved by the Ethics Committee of the CHU UCL Namur. We retrieved medical records of 25 patients who underwent surgical labyrinthectomy due to definite, unilateral (at surgery), disabling, and treatment-resistant MD. All patients were operated on by the same surgeon at University Hospital UCL Namur between 2009 and 2019. This procedure primarily sought to obtain immediate, total, and definitive unilateral vestibular deafferentation to activate central compensation mechanisms.

The MD diagnostic criteria of 'Committee on Hearing and Equilibrium Guidelines for the Diagnosis and Evaluation of Therapy in Meniere's Disease' were applied [6], i.e., (i) two of more definitive spontaneous episodes of vertigo lasting 20 min or longer, (ii) audiometrically documented hearing loss on at least one occasion, (iii) tinnitus or aural fullness in the treated ear, (iv) other causes excluded. The disabling nature of disease was assessed according to the number of monthly attacks as defined by those guidelines [6], 'Dizziness Handicap Inventory' (DHI), and 'Functional Level Scale' [6]. The inclusion criteria were: definite, unilateral, and disabling MD, with a major impact on quality of life; non-functional preoperative hearing with or without hearing aid, according to the American Academy of Otolaryngology–Head and Neck Surgery (AAO–HNS) criteria [6]; classical drug treatment failure; normal magnetic resonance imaging (MRI) or endolymphatic hydrops; ability to undergo vestibular rehabilitation; patient seeking a radical solution and being fully informed about alternative treatments. According to the AAO–HNS criteria, patients were classified into the following classes depending on their mean pure tone threshold: Class A: < 25 dB, Class B: from 26 to 40 dB, Class C: from 41 to 70 dB, and Class D: > 70 dB[6]. The exclusion criteria were: bilateral or unconfirmed MD; functional hearing with or without hearing aid; contraindication to general anesthesia; significant psychological disorder. All patients previously provided informed consent for the surgery.

Data collection

A preoperative workup was systematically conducted for all patients ($n = 25$), including pure tone and speech audiometry, videonystagmography (VNG), brain MRI, and temporal bone computed tomography (CT). Among these patients, 10 additionally underwent cervical Vestibular Evoked Myogenic Potential (cVEMP), with three benefiting from preoperative video head impulse testing (VHIT).

Owing to imaging advances, it is possible to assess hydrops on MRI using two sequence types [7]: (1) without contrast, the T2 inframillimetric sequence in three Tesla MRI (3DT2) is instrumental in measuring the saccule's size, shape, and signal. The saccule's size is known to correlate with the pressure pathology, consisting of a hydrops if the saccule's height is > 1.6 mm and its width > 1.4 mm; (2) With contrast, the FLAIR sequence taken 4 h after intravenous gadolinium injection (3D FLAIR) enables differentiating perilymph from endolymph, with perilymph containing structures appearing as hypersignal (white), versus those containing endolymph in black. The membranous labyrinth pertaining to vestibule, cochlea, and ampulla of semicircular canals can be visualized. The DHI questionnaire was filled in by all patients before surgery.

Following the surgical intervention, all patients underwent pure tone and speech audiometry to confirm the total deafness. Only a patient subset benefited from vestibular explorations, because they still complained about residual imbalance after surgery: 10 patients underwent post-operative VNG, three cVEMP, and four VHIT.

The DHI was filled in by 21 patients after surgery. Post-surgery DHI scores from four patients were missing. From medical records, one of these died 5 year post-surgery for reasons unrelated to MD while presenting a delayed central compensation; another one was asymptomatic 8 month post-surgery; a third one reported no longer experiencing any vertigo with still fluctuating instability complaints; the last one, followed-up elsewhere, was asymptomatic 2 year post-surgery. The data concerning the patients' daily life activities were collected.

Surgical procedure

SL is aimed to remove the neuroepithelial components of the semicircular canals and vestibule, resulting in permanent vestibular deafferentation. Dizziness is provoked by a lack of corroboration between left and right labyrinth inputs. SL can be performed using two different surgical approaches: the transcanal or transmastoid approaches [8]. At University Hospital UCL Namur, the transmastoid approach is usually selected to lower meningitis risk, with the oval window more exposed than the semicircular canals in case of otitis media. The transcanal approach is more often the preferred option in France [9].

Overall, 24 patients were operated on using the transmastoid approach, as follows: complete mastoidectomy, lateral and posterior semicircular canal with abundant irrigation with saline solution at high pressure, which were then filled with bone pâté. The transcanal approach was applied on the remaining patient, owing to a major dehiscence of the tympanic tegmen and high sigmoid sinus, detected upon preoperative CT. In this case, the surgery was performed through the external auditory canal via tympanic membrane incision, stapes bone removal, and wide oval window opening. The middle ear was then filled. This technique is commonly called 'labyrinthectomy', yet 'labyrinthotomy' would be more appropriate anatomically.

Patients were allowed to leave the hospital after the procedure once they were able to eat and walk without much difficulties.

Data analysis

Statistical analyses used the JMP software, Version 15.2.0. Data were expressed as means and standard deviations (SD), as relevant ($n > 8$). The differences between pre- and post-operative means were assessed using non-parametric Wilcoxon test. Statistical significance was set at $p < 0.05$.

Results

The 25 patients all met the inclusion criteria, presenting a disabling MD, defined by the MD diagnostic criteria of the 'Committee on Hearing and Equilibrium Guidelines for the Diagnosis and Evaluation of Therapy in Meniere's Disease' [6], with their baseline characteristics presented in Table 1. Their mean patient age was 53 (27–78) years; there were 10 women and 15 men; the mean disease evolution was 5 (1–8) years; the left side was more commonly impacted than the right (15/10). In all cases, classical conservative treatments had failed. Heavier medical treatments had previously been administered to some patients, including tympanostomy tube, chemical labyrinthectomy using transtympanic gentamicin injection, and endolymphatic decompression surgery, which all failed or only temporarily alleviated symptoms**.** The pre- and post-operative data are summarized in Table 2.

Table 1 Demographic and medical patient characteristics

Baseline patient characteristics ($n = 25$)	
Gender (n, female/male)	10/15
Side impacted by MD (n, left ear/right ear)	15/10
Age (mean years [range])	53.32 [28–76]
Disease evolution (mean years [range])	5 [1.25–8] *Tumarkin crises ($n = 2$)* *No Lermoyez syndrome*
Treatment history (n)	
Classical treatments	25
Tympanostomy tube	18 *(temporary helpful in 15 patients)*
Chemical labyrinthectomy	5
Decompression surgery	3

Objective data

During the pre-surgery workup, all patients displayed strongly impaired pure tone (AAO–HNS Class C for 6 patients and Class D for 19 patients) and speech audiometry results, and they considered their hearing non-functional. Pre-operative VNG was performed in all patients, yet values were missing for two, as the examinations were conducted elsewhere. Pre-surgery VNG enabled us to verify contralateral external semicircular canal reactivity, which was good for all.

The CT and brain MRI examinations were instrumental in verifying cerebellopontine angles and internal auditory canals, without any inner ear malformations recorded. A Grade 1 schwannoma (Koos classification) of cochleovestibular nerve was detected in one patient, concomitantly to a homo- and unilateral endolymphatic hydrops. This patient benefited from chemical labyrinthectomy using gentamicin injections, but the post-procedurally performed VNG highlighted areflexia with persistent vertigo attacks.

Following surgery, 14 (56%) patients evolved well subjectively and clinically, with central compensation attained, without any vestibular workup post-surgery. The remaining 11 (44%) still presented residual instability complaints, or reported a recurrence of instability complaints after a clear transient improvement. They underwent further vestibular examinations. Of these 11, one patient decided to pursue medical care in another institution. The remaining 10 underwent post-surgery VNG. In one of them, postoperative VNG showed 84% hyporeflexia with central compensation. cVEMPs were absent on the operated side. After a few sessions of physiotherapy, the complaints improved. We believe there may have been artifacts during the examination, as some eye movements are counted by the software as nystagmus. Analysis of the tracings suggests a stronger hyporeflexia than that calculated by the computer. The nine others presented complete areflexia, which was compensated in five patients and uncompensated in four patients (Table 2).

Of the four patients with uncompensated areflexia, two progressively developed bilateral MD, as reported later, one patient had a strabismus that decompensated postoperatively. He underwent eye surgery and the vertigo complaints ceased after. The last one initially refused to undergo vestibular rehabilitation after the surgery, but he eventually agreed to it and his complaints strongly improved. The etiology of the instability complaints was studied for patients with compensated areflexia. They underwent brain MRI and an ophthalmological, neurological, and cardiological check-up. One of the five patients

Table 2 Pre- and post-surgery data

	Pre-operative	Post-operative
Dizziness Handicap Inventory	($n=9$)	($n=21$)
Score (mean ± SD)	71.9 ± 15.2 *Severe handicap*	30 ± 29** *Mild handicap*
Vocal and tonal audiometry	($n=25$)	($n=25$)
Group C: 41–70 dB (n)	6	–
Group D: > 70 dB (n)	19	–
Cophotic (n)	–	25
Videonystagmography	($n=25$)	($n=10$)
Absence of hyporeflexia (n)	4	–
20–40% hyporeflexia (n)	7 *Compensated ($n=3$)* *Uncompensated ($n=4$)*	–
41–60% hyporeflexia (n)	5 *Compensated ($n=5$)*	–
61–80% hyporeflexia (n)	5 *Compensated ($n=1$)* *Uncompensated ($n=4$)*	–
> 80% hyporeflexia (n)	2	1
Areflexia (n)	–	9 *Compensated ($n=5$)* *Uncompensated ($n=4$)*
cVEMP	($n=11$)	(n = 3)
	Absent at 90 and 70dB (n = 4) Bilateral at 90dB but asymmetrical ($n=7$)	Absent at 90 and 70dB ($n=3$)
VHIT	($n=3$)	($n=4$)
	–	Collapsed gain for the three semicircular canals (n = 4) Collapsed gain for the contralateral anterior and posterior canals ($n=1$)

cVEMP cervical vestibular evoked myogenic potential, *VHIT* video head impulse test, *DHI* dizziness handicap inventory

** $p < 0.01$ between pre- and post-operative DHI mean scores

had vestibular migraines, others orthopedic problems or an emotional fragility requiring pharmacological treatment. Of note, one of the patients was hospitalized in psychiatry.

Besides the two patients who developed bilateral MD and another one who developed vestibular migraine, none of the other patients displayed post-surgery vertigo attacks. Interestingly, complaints of residual imbalance were noted as futile by some patients but disabling by others, highlighting the subjective perception of surgical outcomes, and the relevance of psychological states. While temporary instability was sometimes reported, it was primarily associated with central decompensation and possibly stress- or fatigue-induced. The post-operative VNG, VHIT, and cVEMP examinations confirmed the vestibular deafferentation (Table 2). Hence, the SL procedure was considered successful.

Subjective data

A significant decrease in mean DHI scores between pre- and post-operative questionnaires occurred, switching from a severe to mild handicap (Table 2). Patient quality of life improved, while their complaints greatly decreased or totally disappeared. Post-surgery DHI scores were additionally analyzed as a function of age and gender, without any significant differences observed. Post-operative satisfaction was notably better for the 51–60-age group, yet without statistical significance, possibly on account of low statistical power.

Surgery was considered satisfying by 17/21 (81%) patients. Of these, 14 were completely satisfied post-surgery, their mean DHI ± SD being 14.2 ± 18.2. Three patients would reiterate the surgery, yet with a stronger psychological support, their mean DHI being 58.7. The remaining

Table 3 Summary of subjective and objective data collected post-surgery

Impact on daily life activities ($n = 21$)	
Social activities	
Normal	14
Minor limitations	3
Strong limitations	4
Sport activities	
Normal	14
Minor limitations	5
Strong limitations	2
Work activities	
Retired or housewife	11
Normal	7
Strong limitations	3

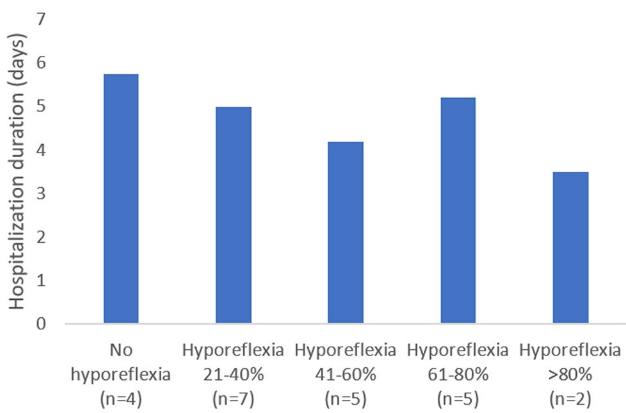

Fig. 1 Mean hospitalization length according to pre-surgery hyporeflexia

four were disappointed with the surgery, their mean DHI being 64. Of note, the patient who underwent transcanal labyrinthectomy did not report vertigo attacks post-surgery, with an excellent post-operative DHI score of 2.

The surgery's impact on patients' social, sport, and work activities is provided in Table 3. In brief, 58% fully recovered in social and sport areas, while 70% of those who had a job returned to normal professional activity. Residual tinnitus complaints were common after surgery, yet mostly (81%) well-tolerated. The remaining four patients already experienced tinnitus before surgery. They considered it disabling, with great impact on their quality of life. These patients were redirected to University Hospital's audiophonology department. No pre- or post-operative complications occurred, such as hemorrhage, hematoma, infection, facial paralysis, meningitis, or cerebrospinal fluid (CSF) leakage.

Figure 1 illustrates the mean hospitalization durations according to pre-operative hyporeflexia. Shorter postoperative hospital stays were possible when pre-operative hyporeflexia was higher, yet without attaining statistical significance. The patients benefited from overall nine to 18 post-surgery vestibular rehabilitation sessions.

Case report of bilateral MD

The two patients who developed bilateral MD presented sudden significant hearing loss, six and 46 month post-surgery, respectively. They did not recover hearing after treatments, including urea syrup, systemic corticosteroids, piracetam, and hyperbaric oxygen therapy. Post-operative VNG revealed areflexia on the operated side, and hyporeflexia on the contralateral side. Vestibular symptoms were less marked than cochlear ones, as vertigo attacks were less intense than those before SL. Both benefited from ipsilateral cochlear implants on the same side as the surgery, obtaining tone audiometry around 25–30 dB with greatly satisfying procedural outcomes. It should be noted that the SL did not prevent the subsequent insertion of a cochlear implant (no extensive major fibrosis in the cochlea).

Discussion

Based on our data set, surgical labyrinthectomy is an effective, simple, and safe treatment for managing intractable vertigo in patients with unilateral MD, who have failed to respond to medical treatments. Nevertheless, this procedure causes an unavoidable total deafness and is only proposed to patients with non-functional hearing.

Surgical labyrinthectomy can be achieved via two different procedures: transcanal and transmastoid. At our institution, we definitely prefer performing the latter one. Indeed, with the former, the transcanal exposure is limited compared to that achieved in transmastoid labyrinthectomy. With the transcanal approach, labyrinthectomy may be incomplete, in the hands of unexperienced surgeons. Moreover, reaching the ampulla of posterior semicircular canal may prove difficult when using the transcanal method, this maneuver being performed with blind probing.

Regarding quality of life, Diaz et al. [10] in 2007 reported the results of a study similar to ours. Based on questionnaire analyses, the authors concluded that the quality of life of MD patients improved significantly following surgical labyrinthectomy, despite their inevitable total deafness.

A success rate $\geq 90.5\%$ following surgical labyrinthectomy was previously reported in terms of vertigo control [11].

Vestibular deafferentation can additionally be achieved using either vestibular neurotomy or chemical labyrinthectomy, with a priori hearing preservation. Badke et al. described a somewhat greater tendency for residual instabilities after surgical labyrinthectomy (20–78%) than vestibular neurotomy (14–20%) [12]. Conversely, Eisenman et al. reported no significant differences in central compensation, subjective complaints, and posturography data in vestibular neurotomy versus surgical labyrinthectomy patients [13]. Bremond et al. reported on a study involving 70 patients who underwent vestibular neurotomy [14]. Areflexia was obtained in 100% of cases, with 66 (94%) being cured of their vertigo. The vertigo cure was durable except for the rare cases of bilateral MD disease. Central compensation was obtained rapidly, even in > 65 years.

In 2005, Morel et al. published a first article[15] comparing vestibular neurotomy via retrosigmoid approach and chemical labyrinthectomy in disabling MD, followed by a second article in 2009[16], expanding on their findings. In their studies, vestibular neurotomy resulted in strong hyporeflexia in 90% of cases, and chemical labyrinthectomy in 86%. These figures are comparable to ours, with areflexia obtained in 90% of our cases (9VNG/10), along with a much lower surgical risk than for vestibular neurotomy. Subjectively, vestibular neurotomy displayed a better efficacy on the AAO–HNS scale versus chemical labyrinthectomy, yielding an improvement in 93% versus 81% in chemical labyrinthectomy patients, with non-significant between-group differences. Recurrences of rotatory seizures were less common after vestibular neurotomy than chemical labyrinthectomy, being 7% versus 11.4%, respectively. Accordingly, vestibular neurotomy offered better vertigo control than chemical labyrinthectomy. De Beer et al.[17] described the efficacy of chemical labyrinthectomy using transtympanic gentamycin injections, with vertigo control obtained in 80–90% of cases, in line with other authors [18]. According to Schmerber et al. [16], chemical labyrinthectomy led only to partial vestibular destruction, with partial hypovalence recovery on caloric tests. This may account for five of our patients who had previously undergone chemical labyrinthectomy, with three of them having improved post-procedurally, but only transiently. In his 'Vertigo' manual, Sauvage highlighted the capacity of cells injured following transtympanic gentamycin injection to spontaneously regenerate [19]. The author explained the frequency of residual instabilities by a dissociated effect on the semicircular canals and otolith maculae.

At the auditory level, profound deafness cases were described by most authors after chemical labyrinthectomy and vestibular neurotomy, without any predictive factors [16]. Some authors reported an average 5.4 dB decrease in both groups [15, 16]. Auditory changes were negligible in 65% of vestibular neurotomy and 73% of chemical labyrinthectomy, with auditory improvement noted in 11.3% and 11.4% of patients, respectively, and worsening in 24% and 14% of patients. Similarly, Colletti et al. suggested a more limited auditory risk following vestibular neurotomy versus chemical labyrinthectomy, with vestibular neurotomy displaying superior efficacy in suppressing vertigo attacks [20]. According to Alarcon et al., hearing loss following gentamycin injection occurred after 1 month in 80% of cases [17], with recovery recorded in 24.1%. Bremond et al. [14] published somewhat differing results: after vestibular neurotomy, compared to pre-operative tests, 24% of patients displayed improved hearing at 10 days postoperatively, 73% unchanged hearing, and 3% worsened hearing. However, at 1 year post-surgery, the hearing results had deteriorated: 10% had improved, 52% had similar hearing, and 38% had worsened hearing. In the authors' view, this hearing loss could be explained by a persistent hydrops with harmful effect on the cochlea. Vestibular neurotomy's positive effects on hearing appear controversial. Quaranta et al. compared the hearing of MD patients after vestibular neurotomy versus endolymphatic sac decompression [21]. With both approaches, a few cases of auditory improvement were reported postoperatively; yet, these were more likely related to the auditory fluctuations inherent to pressure pathology rather than surgery. In addition to these auditory variations, chemical labyrinthectomy may be complicated by persistent tympanic perforation requiring myringo-tympanoplasty. Vestibular neurotomy can be associated with more serious complications, including CSF leakage, facial paralysis, meningitis, brain abscesses, subdural hematoma, cerebral edema with even cases of death described [14]. Transmastoidal labyrinthectomy can be complicated by bleeding, infection, facial paralysis, or CSF leakage. These risks are those of a classic mastoidectomy, and they are extremely low in the hands of skilled surgeons.

This study has several limitations. First, it was performed in a tertiary academic reference center, with its inherent limitations, including its monocentric nature, small sample size, and retrospective design. Only a very small number of MD patients require radical surgery. It is thus difficult to attain a sufficiently critical mass to enable solid conclusions, especially in statistical terms. Moreover, in our study, the patient follow-up was quite heterogeneous, and a precise study of mid-frequency ($n = 4$, post-op VHIT), high-frequency vestibular (no bone vibration test performed), or otolith function ($n = 3$, cVEMP) was impossible. Postoperative VNG assessing low frequencies was performed for only 10 patients postoperatively. In addition, the DHI was employed—with its major drawback of not being able to differentiate between rotatory vertigo attacks and instabilities. Thus, some postoperative DHI scores can remain high, without any disabling attack recurrence. Besides, data on the postoperative rehabilitation duration required before attaining central compensation were unavailable. Given the small number of surgical labyrinthectomies performed per year, it is complicated to conduct such a study prospectively. Nevertheless, a prospective multicenter study on a Belgian scale based on a common protocol with pre-operative and post-operative vestibular examinations should be considered. Finally, we showed that postoperative DHI was not significantly different in elderly patients compared with younger patients. However, eligible patients were all deemed physically able to undergo vestibular rehabilitation after surgery and had no contraindications to general anesthesia, which may have induced a selection bias.

To conclude, SL appears to be an effective and low-risk treatment for patients with unilateral disabling MD, resistant to conventional medical treatments, and non-functional hearing. In our series, areflexia was obtained in 90% of cases, which is comparable with that obtained after vestibular neurotomy in the literature, but higher than obtained after chemical labyrinthectomy.

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Data availability The data that support the findings of this study are available from the corresponding author, VL, upon reasonable request.

Declarations

Conflict of interest The authors have no competing interests to declare that are relevant to the content of this article.

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