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ORIGINAL ARTICLE

Clinical analysis of repeat microvascular decompression for recurrent hemifacial spasm

Wei Shu[1] · Hongwei Zhu[1] · Yongjie Li[1] · Ruicun Liu[1]

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Abstract
The aim of this study was to investigate the effects of repeat microvascular decompression (MVD) for recurrent hemifacial spasm (HFS). The clinical features, surgical findings, outcomes, and complications of 13 patients who underwent MVD with a history of prior MVD in Xuanwu Hospital between January 2010 and May 2017 were analysed retrospectively. All patients were successfully treated for their HFS but experienced recurrent symptoms and received repeat MVD. Teflon felt factors (9/13, 69.2%) and vascular changes (4/13, 30.8%) were the main reasons for recurrent HFS. With a mean follow-up of 34.6 months after surgery (ranging from 12 to 92 months), 11 (84.6%) patients achieved complete or major spasm alleviation and two patients (15.4%) achieved fair outcomes. Surgical complications included transited mild to moderate facial weakness in two patients (15.4%). None of the patients had serious surgical morbidities. Repeat MVD is an effective and safe treatment for recurrent HFS.

Keywords Hemifacial spasm · Failed microvascular decompression · Recurrent · Re-operation

Introduction

Hemifacial spasm (HFS) is characterized by involuntary, intermittent contractions of unilateral facial muscles innervated by the facial nerve. Its annual incidence is approximately 0.78 per 100,000 people, and its prevalence is 9.8–11 per 100,000 people [1, 2]. Although HFS is not medically dangerous, it is progressive and has considerable repercussions, affecting ordinary life, social relationships and work ability.

The current treatment of HFS consists of microvascular decompression surgery (MVD) and Botulinum toxin injections. MVD is preferred since the effects of botulinum toxin injections only lasts 3–6 months. Since the MVD operation was invented by the Jannetta in 1977, it has been widely performed to date [3]. Many studies have appeared describing the short- and long-term benefits of MVD [4–6]. Although the operations are mostly successful, 1–2.4% patients may experience recurrent spasms [4, 6, 7].

Management of recurrent HFS is controversial. Many clinicians are uncertain about the efficacy and safety of re-operation, and research evidence regarding this problem is rare. The aim of this study is to investigate the effect of re-operation for MVD in the recurrent HFS. Here, we reviewed our experience with re-operation for recurrent HFS and analysed the inducing factors.

Methods

The experience of re-operations for the HFS between January 2010 and May 2017 was reviewed at Xuanwu Hospital, Capital Medical University in Beijing, China. Thirteen adult patients who received a repeat MVD were enrolled. Selection for surgery was made according to the following inclusion criteria: (1) recurrent HFS after MVD; (2) spasm-free without facial palsy more than 6 months after surgery; (3) positive of abnormal muscle response (AMR); and (4) the

✉ Hongwei Zhu
zhangyuqinggnsw@126.com

Wei Shu
shuweiys@163.com

Yongjie Li
liyongjie1999@163.com

Ruicun Liu
liuruicun@163.com

1 Beijing Institute of Function neurosurgery, Xuanwu Hospital, Capital Medical University, 45 Changchun street, Beijing 100053, China

presence of vasculature adjacent to the facial nerve's root exit zone (REZ) on the MRI. Patients with symptomatic HFS secondary to anatomical mass lesions or unstable cardiac conditions were excluded. All patients were confirmed as surgical candidates by their physicians.

Preoperative magnetic resonance imaging evaluation

We performed a preoperative MR imaging using the 3D time-of-flight (TOF) MR angiography to evaluate the anatomical neurovascular relationship in the CPA cistern. In addition, we used conventional T1- and T2-weighted MR and flair images to study the posterior cranial fossa.

Surgical technique and intraoperative monitoring

The MVD technique was similar to that devised by Jannetta et al. with some modifications. All of the operations were performed using a lateral retrosigmoid suboccipital approach with the patient in a park-bench position. After a typical retrosigmoid craniotomy was performed at the junction of the transverse and sigmoid sinus, the dura was opened. Subsequently, an intradural dissection was performed under the microscope to slowly withdraw the cerebral spinal fluid. To expose the cerebellopontine angle, we carefully dissected the adherent tissues, including the thick arachnoid membranes, cranial nerves and vessels. The Teflon sponge was resected by micro-scissors and extracted in pieces. Then, the surgeon re-explored the entire REZ area of the facial nerve, which is divided into the following four anatomical portions: the root exit point (RExP), the attached segment (AS), the root detachment point (RDP) and the cisternal portion (CP). When the compression factor and site were identified, they were detached, elevated or transposed from the REZ area. The transposition technique was adopted to introduce a Teflon ball as a cushion between the vessel and the brainstem. In addition, a gelatine sponge was employed to separate the implant from the REZ area (Fig. 1). When the facial nerve root was completely decompressed, the operation was completed with dural closure in a watertight fashion.

During surgery, AMR monitoring was performed, as Moller and Jannetta described. The disappearance of AMR was an indication of surgery's end-point (Fig. 2). In addition, facial electromyography and brainstem auditory evoked potentials were recorded [8].

Clinical assessment and follow-up review

We assessed outcome with Park YS grades measured at 4 weeks, 6 months, and 1 year by telephone or personal interview. The patients were classified into five groups. A grade of "excellent" was assigned if there was no residual spasm. A grade of "good" was assigned if HFS was resolved more than 90%. A grade of "fair" was assigned if HFS was resolved more than 50%. A grade of "poor" was assigned if HFS was resolved less than 50%. All other results were assigned a grade of "failure" [9]. In addition to the status of the HFS, we also documented complications of MVD. A follow-up telephone interview was attempted for all patients.

Results

Demographic data

A total of 13 patients with recurrent HFS were referred to our centre for MVD. At the time of surgery, the age range of patients was 25–62 years with a mean of 50.3 years. The study population had the mean symptom-free interval time of 26.3 months and a mean reoperation interval time of 46.3 months. Of these patients, 10 had received injections of botulinum toxin but discontinued its use due to insufficient control of symptoms. Their clinical characteristics are summarized in Table 1.

Recurrent factor

For all 13 patients included in our study, we found that the compression of the facial nerve was attributed to the culprit vessel, Teflon felt, or both. The culprit vessel was involved in all patients. One culprit vessel contacted the REZ area of the facial nerve in seven patients (53.9%, 7/13), and multiple culprit vessels did in five patients (38.5%, 5/13), including vertebral artery (VA), posterior inferior cerebral artery (PICA), anterior inferior cerebral artery (AICA) and vein. Definite vascular changes were considered to cause the HFS recurrent in four patients (30.8%, 4/13). The conflict site of them was the following: the root exit point in one patient (7.7%, 1/13), the distal cisternal segment in two patients (15.4%, 2/13) and the root detachment point in one patient (7.7%, 1/13).

Teflon felt was the probable reason for recurrent HFS in nine cases (69.2%, 9/13). Scarred implants between the vascular and nerve root were found in seven patients (53.9%, 7/13), and slippage of the Teflon felt was found in two patients (15.4%, 2/13).

In patients with severe, extensive scarred implants, it was difficult to distinguish the definite conflict site of REZ.

Surgical outcomes and complication

With a mean follow-up of 34.6 months after surgery (range 12–92 months), Excellent or good outcome were achieved in

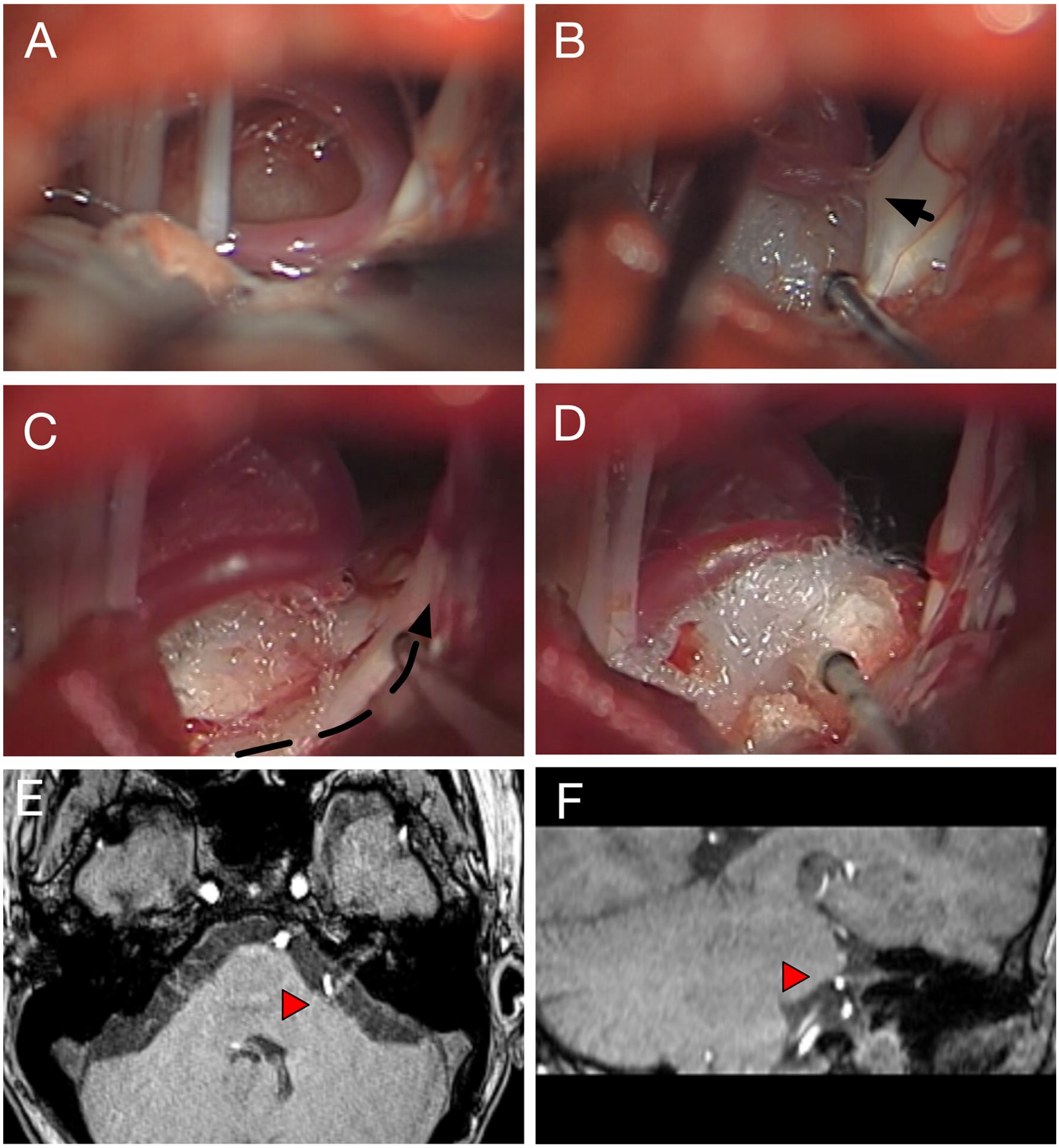

Fig. 1 A re-operation case of recurrent left-sided HFS. The result of the second preoperative MRI demonstrated the offending vessel (red arrowhead in **e**–**f**) compressed the left REZ of the facial nerve. Intraoperative microscopic finding (**a**–**d**) showed that the slipped Teflon felt could not afford the offending artery (arrow in **b**). After entire REZ zone of facial nerve (dashed line with arrow in **c**) was decompressed, the patient's spasm completely resolved without complication. (Color figure online)

11 patients (84.6%, 11/13). Fair outcome was achieved in two patients (15.4%, 2/13). During the study, two adverse events were reported in two patients. Mild to moderate facial weakness occurred in two patients (15.4%, 2/13), which resolved without treatment. There was no surgery-related death or severe permeant complication.

Discussion

The pathophysiological features underlying HFS remain unclear. Some hypotheses, including the peripheral hypothesis and the central hypothesis, have been presented

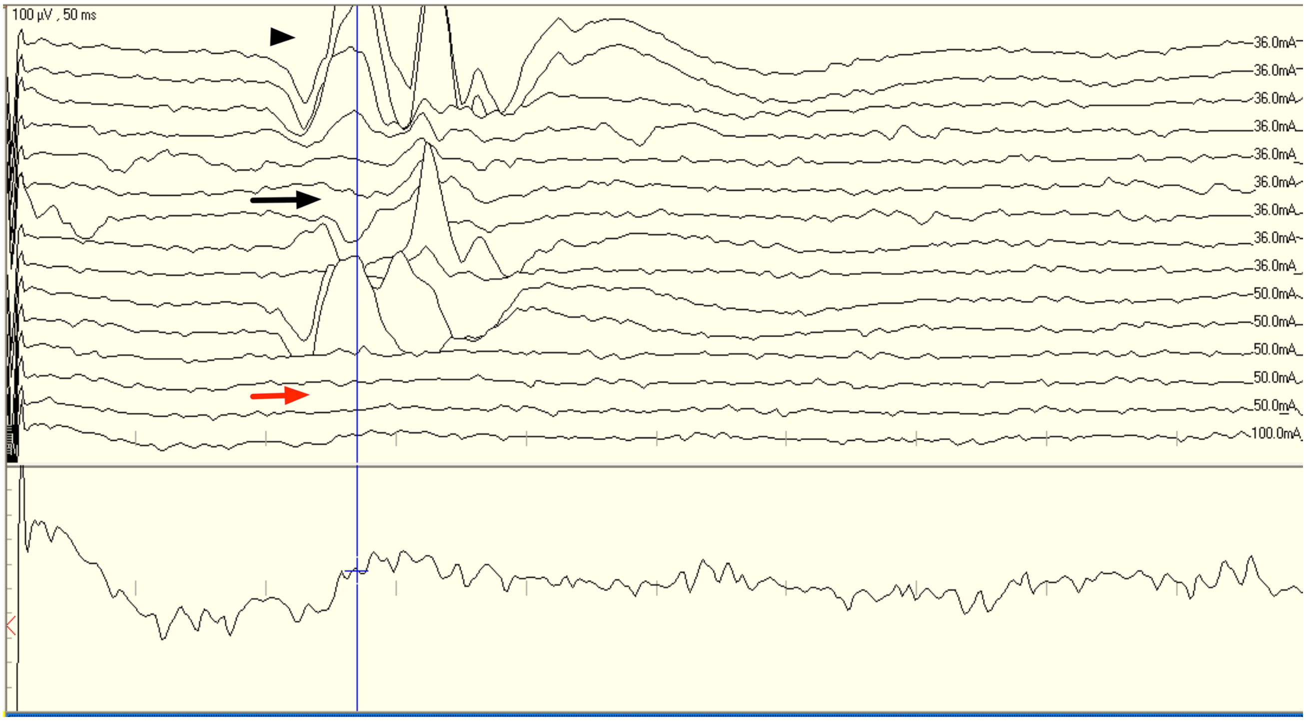

Fig. 2 Intraoperative electrophysiological recording. An abnormal muscle response (AMR) was recorded from the facial muscle (arrowhead). As the Teflon scar was removed and the vessel was detached, the AMR was alleviating (long arrow) and disappeared (red short arrow). (Color figure online)

to explain the mechanisms. Nonetheless, vascular compression has been regarded as a critical factor for spasm, and MVD has been widely accepted to decompress the REZ area of the facial nerve. Unfortunately, some patients showed failure or recurrence in spite of MVD's high success rate. Based on aforementioned hypotheses, re-operation should be considered as effective treatment. However, there exists controversy regarding the indication and time of re-operation for recurrent HFS.

Re-operation for recurrent HFS has been gradually accepted by the neurosurgeon. Kureshi and Wilkins, at first, did not recommend repeat MVD for persistent or recurrent HFS as they found 37.5% of negative exploration rate for persistent or recurrent HFS [10]. However, Li CS believed that it was not difficult to make the decision for re-exploration. They claimed that a second MVD is indicated for patients with later recurrence, showing significantly persistent or even worsened HFS after the first MVD [11]. In our study, a compression factor was found in all patients at the REZ area of the facial nerve, and 84.6% of patients achieved an "excellent" or "good" grade and the treatment effects were stable for 1 year.

Surgeons should be aware of the delayed cure phenomena when making the decision for the time of repeat MVD. A total of 8–33% of patients showed delayed disappearance of symptom after MVD and experienced spasm relief within 6 months [7, 12]. For these patients, invasive treatment should be reconsidered, as they may be in delayed cure period and the time course of symptom relief varies. Some researchers recommend that the patient should be observed for 12 months after the operation, but others believe that the failed MVD should be re-explored in the early stage [6]. For recurrent patients, we prefer observation at least for 6 months. When the botulinum toxin therapy failed, surgical approaches was considered.

The REZ zone was involved in the neural compression of all patients, suggesting its role in recurrent HFS. The REZ zone of the facial nerve, where the transition between central oligodendrocyte-derived and peripheral Schwann cell-derived myelin occurs, is divided into four anatomical portions: RExP, AS, RDP and CP. The AS segment was typically the most common neurovascular compression location in MVD [13]. For the adhesion structure in repeat MVD, it is difficult to distinguish the specific segment. Therefore, surgeon should carefully explore the entire REZ zone. In some cases, even the release of the facial nerve is needed. Finally, the REZ zone's length of facial nerve is often varied or may sometimes be extended, whose pressure may increase via the nerve trunk's tension. For this study, Teflon felt and vascular changes play important roles in neural compression in the REZ zone.

Table 1 Findings of the 13 patients with repeat microvascular decompression for recurrent hemifacial spasm

No	Age (years)	Side	Sex	Symptom-free interval (month)	Interval period (month)	Culprit vessel	Conflict site	Failure reason	LSR after MVD	Outcome	Complication
1	41	L	M	12	24	VA, PICA	REZ	Adhesion	Disappeared	Excellent	–
2	47	L	F	24	60	VA, AICA, PICA	REZ	Adhesion	Disappeared	Excellent	–
3	62	R	F	6	37	PICA	REZ	Adhesion	Disappeared	Excellent	–
4	52	R	F	12	39	VA, AICA, PICA	REZ	Adhesion	Disappeared	Excellent	Transient facial palsy
5	60	L	F	36	84	AICA	CP	Slippage of Teflon	Disappeared	Excellent	–
6	60	R	F	18	19	AICA	CP	Vascular changes	Disappeared	Fair	–
7	56	L	F	12	24	AICA, PICA	RExP	Vascular changes	Disappeared	Excellent	–
8	53	R	F	24	42	VA	REZ	Adhesion	Disappeared	Excellent	–
9	53	L	M	120	121	PICA	REZ	Adhesion of Teflon	Disappeared	Excellent	–
10	39	R	F	63	75	AICA	REZ	Vascular changes	Partially relieved	Excellent	Transient facial palsy
11	50	R	M	7	17	VA, PICA	REZ	Slippage of Teflon	Disappeared	Fair	–
12	55	R	M	9	12	PICA	REZ	Adhesion	Disappeared	Excellent	–
13	25	L	M	6	48	AICA, vein	TZ	Vascular changes	Partially relieved	Excellent	–

L left, *R* right, *M* male, *F* female, *AICA* anterior inferior cerebral artery, *PICA* posterior inferior cerebral artery, *VA* vertebral artery, *V* vein, *REZ* root exit zone, *RExP* root exit point, *AS* attached segment, *RDP* root detachment point that corresponds to the TZ, *CP* distal cisternal portion

During the re-operation, the Teflon felt was found to be a frequent reason for recurrent HFS. Teflon felt has been widely adopted in MVD since 1990 due to its non-absorbable nature and relatively morphological plasticity compared with muscle, cotton and other material [14]. However, the adhesion of Teflon felt may cause new neurovascular conflicts, which are often induced by improper insertion of the Teflon felt, including its size, shape and placement. Inappropriate size and unsuitable shape of the Teflon sponge may cause it to slip or be unable to withstand the pressure of vessels over time. Teflon adhesions and secondary granulomas may distort nerves and cause compression again, resulting in the recurrent symptoms [15]. Thus, the transposition technique was considered to be superior to the interposing technique as it could separate the conflicted vessels from the REZ and implant the Teflon felt between the nerve and the brainstem to avoid secondary compression by the Teflon felt.

Vasculature changes are also a frequent causative factor in HFS recurrence. VA, multiple-offend vessels and veins are more common in patients who underwent re-operation. For the VA, adequate decompression is difficult since the tissue cannot often sustain the increased strength to compress the REZ and Teflon, which may lead to recurrence. Some surgeons employ the fibrin glue, sling technique or the double-stick tape technique to secure the VA or large vessel away from the implantation site [5, 16–18]. For multiple-offend vessels and veins, surgeons should be aware that they may be new compression factors during the second operation. Preoperational MRI and intraoperative AMR were effective tools for this situation, which were also important in making the decision for re-exploration [9].

For patients with HFS despite a prior MVD, a combination of 3D-TOF MRA and high-resolution conventional brain MRI is recommended in our centre. Although the surgical outcomes of MVD were not well correlated with the postoperative image, they could provide surgeons with potential reasons for failed MVD. First, 3D-TOF MRA could reveal the unaddressed neurovascular compression [19, 20]. Moreover, high-field conventional MRI could reveal more accurate details of the neighbouring structures of the facial nerve REZ and operative approach, including the cerebellar cortex, scarring, the Teflon sponge and small veins [19, 21]. In some cases, 3D constructive interference in steady-state MR imaging and 3D-TOF MR angiography was helpful to identify neurovascular contacts at both the RExP and AS of the facial nerve, especially for the deep-seated RExP in the pontomedullary sulcus [9, 22].

Abnormal muscle response is an effective intraoperative tool to help the surgeon to ensure adequate decompression of the facial nerve, as it provides the real-time response. When one branch of facial nerve was electrically stimulated in HFS patients, the muscle innervated by a different branch of facial nerve would also show response. This abnormal phenomenon has been termed the “abnormal muscle response” or “lateral spread response”, which is a hallmark of facial electromyography monitoring in HFS. Although the mechanism of the AMR remains controversial, several studies have suggested that the disappearance of AMR intraoperatively could effectively predict the short-term outcome [6, 23, 24]. In this study, the AMR was detected in all patients since it was an indication to re-exploration in this study. We found that AMR disappeared or decreased in accordance with the degree of decompression. Due to the limited number of cases, the AMR has not shown significant correlation with the clinical outcome. However, we believe that it is a useful intraoperative indicator for MVD. As the multiple vessels and Teflon adhesions was common in the recurrent hemifacial spasm, AMR provides assurance for an adequate decompression [23, 25, 26]. Additionally, AMR could change with the degree of decompression, which helps the surgeon to decide when to finish surgery.

Compared with the primary MVD, the secondary MVD is more difficult and the complication rate is higher. In this series, transited postoperative facial weakness was observed in two patients (15.4%), as compared with 0.6% facial palsy in regular MVD [27]. The extensive adhesion is the crucial reason. The key to minimizing complications is to create sufficient operative space, which was usually limited as the arachnoid layers adhering the dural, cortex and VII/VIII cranial nerve would hold the CSF. The craniectomy should be made larger to allow easier access with minimal cerebellar retraction. Researchers have suggested that the bony window should be as large as the condylar fossa laterally and as large as the foramen magnum caudally. Microscissors are preferred to dissect the adhering tissue sharply. The facial and acoustic nerve is more sensitive to the retraction since the arachnoid layers and the Teflon create tension in the surrounding area. Unlike MVD for TN, it is unnecessary to dissect the arachnoid membrane around the internal acoustic meatus, which may confer additional risk. Rough, direct cerebellar retraction may cause stretching injury of the cranial nerve and lead to impaired hearing and facial palsy. The caudorostral direction perpendicular to these two cranial nerves is ideal to observe the root exit zone clearly and minimize the complications. For complex compression, a high intraoperative definition endoscope used to observe may be helpful [21].

Conclusions

Re-operation for recurrent MVD was successful by standard outcome measures. Detailed imaging and intraoperative AMR are useful tools to determine whether sufficient decompression was made for adhesion structure and vascular changes. Gentle perpendicular cerebellar retraction and sharp dissection were also helpful to minimize complications.

Compliance with ethical standards

Conflict of interest None declared.

Informed consent Informed consent was obtained from all individual participants included in this study.

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