Operative Technique

To repeat or to recreate: A contralateral posterior interhemispheric transfalcine transprecuneus approach for recurrent meningiomas at the trigone of the lateral ventricle

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A B S T R A C T

Surgery in the trigone of the lateral ventricle remains a challenge for neurosurgeons. In recurrent trigonal meningiomas (RTM), the disturbance of normal anatomic structures and adhesion due to previous surgeries, significant oedema, and their malignant properties heighten the difficulties associated with their surgical removal. This report presents two patients with recurrent meningiomas with anaplastic transformation at the trigone of the lateral ventricle who were successfully treated with contralateral posterior interhemispheric transfalcine transprecuneus (CITT) surgeries. The primary tumours were both completely removed through a transparietal approach in previous surgeries, but both patients experienced hemianopsia postoperatively. The second surgeries resulted in the complete resection of the recurrent tumours without any new-onset neurological dysfunction. The CITT approach suits most trigonal lesions with advantages of optic radiation preservation, reduction of retraction, improved exposure, and navigation accuracy, and because it addresses the origin of the trigonal lesion. Although the characteristics of RTM heighten the difficulty associated with their surgical removal, these challenges highlight the advantages of the CITT approach. In conclusion, the CITT approach is a safe and effective procedure for the removal of RTM.

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1. Introduction

Intraventricular meningiomas comprise 0.5–3.7% of intracranial meningiomas, and most intraventricular meningiomas arise in the trigone of the lateral ventricle [1]. In most cases, trigonal meningiomas are benign, and surgical resection leads to a cure or satisfactory control, but a small portion recur after surgery and require further treatment. Surgery at the trigone of the lateral ventricle remains a challenge for neurosurgeons due to: its deep location; the important neural structures around the area or along the surgical corridor to the area, (optic radiation, fornix, and eloquent areas in the dominant hemisphere); and its close relationship to critical vascular structures, such as the choroidal arteries and the deep venous system [2,3]. In addition, the disturbance of normal anatomic structures and adhesion due to previous surgeries, significant oedema, or the malignant properties often observed in recurrent trigonal meningiomas (RTM) heighten the difficulties associated with their surgical removal. We previously reported the treatment of primary trigonal meningiomas through a contralateral posterior interhemispheric transfalcine transprecuneus (CITT) approach [4]. In this manuscript, we present two patients with recurrent meningiomas with anaplastic transformation at the trigone of the lateral ventricle who were treated with CITT surgeries. The primary tumours were both completely removed using a transparietal approach in previous surgeries, and after serious consideration, we decided to create a new surgical corridor rather than to repeat the previous approaches.

2. Case presentation

2.1. Patient 1

A 38-year-old woman underwent transparietal surgery for a lesion in the trigone of the right lateral ventricle in June 2009 (Fig. 1A). The tumour was completely removed (Fig. 1B). Histopathological examination indicated fibroblastic meningiomas (World Health Organization [WHO] grade I). The surgery left her with permanent left hemianopsia.
After she had suffered from a headache for more than 20 days in March 2012, a cranial MRI was performed, and the results demonstrated a recurrent tumour in the right trigonal region (Fig. 1C). CITT surgery was performed to resect the recurrent meningioma. The specimens showed histopathological features of anaplastic meningioma (WHO grade III). The patient was headache-free after the surgery. The postoperative course was uneventful, and no surgical complications were observed with the exception of the pre-existing hemianopsia, which did not worsen after the CITT surgery. She received radiotherapy and has been closely followed up. An MRI scan obtained 12 months after the second surgery showed no signs of a residual or recurrent tumour (Fig. 1D).

2.2. Patient 2

A lesion was found in the trigone of the right lateral ventricle of a 44-year-old man in July 2009 (Fig. 2A). Transparietal surgery was performed, the tumour was totally resected (Fig. 2B), and the pathological findings revealed transitional meningioma (WHO grade I). Postoperatively, the patient developed left homonymous hemianopsia. In addition, he suffered from seizures two to three times a year and required carbamazepine over the long term. In February 2013, he presented with fatigue and somnolence. An MRI showed a recurrent tumour in the right lateral ventricle (Fig. 2C), and the CITT approach was chosen to remove the recurrent tumour. The histopathology showed anaplastic meningioma (WHO grade III). The patient’s consciousness returned to normal, the homonymous hemianopsia did not progress, and no neurological dysfunction was caused by the second surgery. He received radiotherapy after discharge. An MRI obtained 3 months after the second surgery showed that the tumour was completely excised (Fig. 2D).

3. Operative technique

Both patients had right-sided tumours. Under general anaesthesia, the patient was placed in the prone position with the upper body elevated 30 degrees and the head held by a Mayfield skull clamp. The head was rotated 15 degrees to the left such that the right hemisphere harbouring the tumour was at a higher position (Fig. 3). Registration of the image-guided system (Excelim-04 image-guide system; Fudan Digital Medical Company, Shanghai, China) was performed. An 8 cm long transverse skin incision inferior to the lambda was made on the left occipital region perpendicular to the superior sagittal fissure and crossing the midline. A left parieto-occipital parasagittal craniotomy approximately 4 × 5 cm was then created. The craniotomy crossed the midline and exposed the superior sagittal sinus. A semicircular parieto-occipital parasagittal craniotomy approximately 4 × 5 cm was then created. The craniotomy crossed the midline and exposed the superior sagittal sinus. A semicircular parieto-occipital dural incision, which was based on the superior sagittal sinus, was made, and the dura was reflected to the right. The parieto-occipital lobe of the normal hemisphere was retracted away from the falx by

Fig. 1. Radiological data from Patient 1. (A) T1-weighted enhanced axial MRI before the first surgery shows an enhancing lesion occupying the trigone of the right lateral ventricle. (B) Axial plain CT scan performed 7 days after the first surgery. (C) T1-weighted enhanced axial MRI obtained 32 months after the initial surgery reveals a large enhancing lesion occupying the trigone of the right lateral ventricle. Signs of the previous transparietal surgery can still be observed. (D) T1-weighted enhanced axial MRI obtained 12 months after the second surgery reveals no recurrence.

Fig. 2. Radiological data from Patient 2. (A) Enhanced axial CT scan before the first surgery shows a large enhancing lesion occupying the trigone of the right lateral ventricle. (B) T1-weighted enhanced axial MRI obtained 13 months after the first surgery reveals no recurrence. (C) T1-weighted enhanced axial MRI obtained 43 months after the initial surgery suggests that the meningioma has recurred. (D) T1-weighted enhanced axial MRI obtained 3 months after the second surgery reveals that the tumour has been completely removed.

Fig. 3. Illustration showing the prone position in which the patient is placed during the procedure. (This figure is available in colour at www.sciencedirect.com.)
gravity, and the cistern of the great cerebral vein was opened to release cerebrospinal fluid (CSF). The falx was then incised approximately 1 cm inferior to the lower border of the superior sagittal sinus. The incision was made in an arc-like manner parallel to the superior sagittal sinus. The precuneus gyrus of the target side was identified with neuronavigation and using the parieto-occipital gyrus as a landmark. A cortical incision in the right precuneus gyrus was then made to provide entry to the trigone of the right lateral ventricle, and the medial side of the tumour was exposed. After debulking and handling the arterial supply, the tumour was completely excised under a microscope. A neuroendoscope (Karl Storz, Tuttlingen, Germany) was used to evacuate the intraventricular clot and ensure that there was no residual tumour or active bleeding. The falx incision was sutured, and the dura mater, bone flap, galea, and skin were closed in layers (Fig. 4).

4. Discussion

4.1. Recurrence and progression

The two trigonal meningiomas described in this manuscript were both completely removed and diagnosed as benign meningiomas (WHO grade I) at the time of the initial surgeries, but then recurred. The recurrent tumours were surgically removed, and the pathological examination revealed anaplastic transformation. According to previous reports, the overall rate of progression from benign meningioma to a higher grade tumour ranges from 0.16–2%. However, 14–28.5% of recurrent benign meningiomas transform into atypical or malignant lesions, and the rate of progression from atypical meningioma to malignant forms at recurrence ranges from 26–33% [5,6]. The mechanisms underlying progression is not fully understood and warrants further study. Gains and losses on chromosomes 9, 10, 14, and 18 with amplifications on chromosome 17 have been found in cytogenetic studies of atypical and anaplastic meningiomas. However, no specific gene targets have been revealed in the majority of these chromosomal abnormalities [7]. According to the model of clonal evolution, as the tumour progresses to a more malignant stage, it accumulates mutations. It is believed that the progression from benign through to atypical to anaplastic meningiomas is a process in which many genetic aberrations are successively accumulated [1]. However, the study conducted by Al-Mefty et al. showed that the presence of a complex karyotype which could lead to malignant progression in benign meningiomas precedes the histopathologically confirmed progression [5].

4.2. Advantages and disadvantages of the CITT approach

The technical challenges presented by trigonal lesions have resulted in the development of various surgical approaches, each with specific advantages and disadvantages. Since 2011, we have been performing CITT surgeries for the treatment of trigonal lesions [4] and believe that the CITT approach suits most trigonal lesions for the following reasons.

1. Optic radiation preservation. The anatomical study conducted by Mahaney et al. suggests that the lateral wall of the lateral ventricle is covered by the optic radiation, and the medial wall of the lateral ventricle in the area of the trigone is entirely free of the optic radiation [8]. Therefore, interhemispheric approaches are much better than lateral or posterior transcortical

![Fig. 4. Intraoperative images. (A, B) Operating microscope views from Patient 1 show the cutting of the falx and the precuneus gyrus. (C) The tumour is well exposed after the cortical incision is made in Patient 1. (D) Intraoperative navigation image of Patient 2 shows the location of the precuneus gyrus and the venous sinus. Fa = falk cerebri, Pre = precuneus gyrus, T = tumour. (This figure is available in colour at www.sciencedirect.com.)](image-url)
approaches in terms of preserving the optic radiation. The two patients described in this manuscript underwent transparietal surgeries for the treatment of their primary tumours and were both left with left hemianopsia due to optic radiation damage.

2. Reduced retraction with improved exposure. Based on their anatomical study, Wang et al. proved that the CITT approach can expose the trigone with a wider surgical angle compared with the conventional ipsilateral approach \[9\]. In the CITT approach, the patient is placed in a prone position, and the head is rotated such that the hemisphere harbouring the tumour is at a higher position \[4\]. As a result, the contralateral hemisphere falls away from the falx due to gravity. In addition, CSF is released from the cistern of the great cerebral vein to provide further space. Therefore, instead of intensive retraction of the swollen hemisphere harbouring the tumour, almost no retraction of either hemisphere is required. In this sense, the more oedematous and swollen the hemisphere harbouring the tumour, the greater the benefit of the CITT approach over the ipsilateral posterior interhemispheric parieto-occipital approach. In addition, during the process of resection, as the medial part of the trigonal tumour is removed, the lateral part will be pulled downward by gravity and pushed to the midline by the swollen hemisphere, which facilitates further removal.

3. Navigation accuracy. For transparietal or transtemporal approaches, significant retraction is usually required for adequate exposure, resulting in shift and inaccurate navigation. In our own practice, when we attempted to treat trigonal or parietal lesions using the ipsilateral interhemispheric parieto-occipital approach, we frequently found that the shift due to brain retraction was so large that it hindered the surgical procedure, particularly in the treatment of small lesions that were difficult to locate. In the CITT approach, however, the structures of the hemisphere harbouring the lesions do not shift before the ventricle is opened, which leads to accurate navigation.

4. Dealing with “root”. Intraventricular meningiomas arise from the tela choroidea and choroid plexus stroma \[1\], which are located closer to the midline than to the lateral cortex. Therefore, the “root” of the intraventricular meningiomas can be approached more directly and excised more radically through a medial interhemispheric approach compared with a lateral transcortical one. Thus, in theory, a medial approach such as CITT may help prevent recurrence by addressing the origin of the tumour more thoroughly.

There are two major disadvantages of CITT. Occipital lobe retraction may lead to postoperative visual field deficits, and entering the interhemispheric fissure as well as cutting the falx may jeopardise the integrity of the venous structures, including the venous sinuses and bridging veins \[9\]. By rotating the head so that the retracted hemisphere falls away from the falx, releasing CSF from the cistern of the great cerebral vein, and performing gentle manipulation during surgery, we have avoided postoperative visual field deficits due to occipital lobe retraction. Care should be taken when entering the interhemispheric fissure and cutting the falx to preserve the venous structures. In our practice, we have not encountered large bridging veins draining to the superior sagittal sinus such that the exposure of the interhemispheric fissure is limited or serious venous sinus damage occurred, leading to neurological deficits. We use magnetic resonance venography (MRV) in some of our patients to evaluate venous structures preoperatively, as in Patient 2. In our most recent patients with trigonal lesions, we integrated data from an MRV scan into the navigation system to precisely locate the venous structures and thereby reduce the risk of venous damage. In addition, during the treatment of lesions that are too large and too close to the midline, the exposure of the part that adjoins the falx and is beyond the boundary of the falcine incision is limited.

4.3. To repeat or to recreate

Surgeons tend to repeat previous surgical procedures for the treatment of recurrent lesions. To our knowledge of all the reports on RTM, only three discuss both of the surgical approaches used for the treatment of the primary and recurrent tumours, and all three surgical teams chose to repeat the approach used for the primary tumour when resecting the recurrent tumour \[10–12\]. However, we chose to create another surgical corridor using the CITT approach after taking the following factors into account. First, the disturbance of normal anatomic structures and adhesions due to previous surgeries make it more difficult to repeat a previous approach. Second, visual field deficits can be worsened by further transparietal surgeries. Third, although the often malignant properties and significant oedema of RTM heighten the difficulties associated with their surgical removal, these challenges actually highlight the advantages of the CITT approach for reduction of retraction, improved exposure, and navigation accuracy. The complete resection and absence of complications achieved by CITT surgery in the treatment of these RTM supports our choice of approach.

5. Conclusions

The CITT approach suits most trigonal lesions with advantages for optic radiation preservation, reduction of retraction, improved exposure, navigation accuracy and because it addresses the origin of trigonal meningiomas. Although the characteristics of RTM heighten the difficulty associated with their surgical removal, these challenges actually highlight the advantages of the CITT approach. The CITT approach is a safe and effective procedure for the removal of RTM.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

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