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RESEARCH HIGHLIGHT

Important role of endoscope in tuberculum sellae meningioma resection via supraorbital keyhole approach

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Abstract

Background Tuberculum sellae meningiomas pose a surgical challenge due to the tumor adhesion to vital structures. In many cases, tumor residue and dural tail sign may contribute to an opportunity for future recurrence.

Methods In this study, we introduced endoscopic technique in supraorbital keyhole approach to further resected residual tumor and dural attachments that are traditionally difficult to detect under microscopic surgery, and finally achieved Simpson Grade II resection.

Conclusion The use of endoscopy offers enhanced visualization and ensures more reliable Simpson Grade II resection outcomes for tuberculum sellae meningiomas.

Keywords Endoscopy-assisted supraorbital keyhole approach · Tuberculum sellae meningioma · Simpson grade II resection · Dural tail sign

Relevant surgical anatomy

The gold standard for the treatment of anterior skull base meningiomas is surgical resection. Since the extent of tumor resection correlates closely with recurrence rate and survival prognosis, the surgical objective is to maximize tumor removal. Within anterior skull base meningiomas, tuberculum sellae meningioma represents one of the most challenging subtypes which can invade the planum sphenoidale anteriorly and skull base inferiorly, extend laterally to involve the optic nerve and the carotid artery, and posteriorly may affect the pituitary stalk and diaphragm sellae. As the tumor enlarges, it can progressively compress the optic nerves or chiasm leading to visual disturbances. The tumors' ability to invade these critical neural and vascular structures not only poses significant surgical challenges for dissection but also increases the risk of postoperative complications arising from injury to these structures including visual disturbances, hypopituitarism, diabetes insipidus, cerebrospinal fluid rhinorrhea, infection, hemorrhage, etc. It is reported that 57.1% of visual impairments can be improved, 7.5% will have diabetes insipidus, 3.6% will have hypopituitarism [5], with an overall complication rate of 23.9% [4].

To safeguard these critical structures, tumor residue and insufficient dural tail sign removal are often inevitable. Literature reports that gross total resection (GTR) rate for tuberculum sellae meningioma is around 80% [1]. However, GTR encompasses Simpson Grades I, II, and III resections. According to Simpson, recurrence rates vary across different Simpson Grade classifications [8]. Therefore, Simpson grade II resection should be the ultimate goal for surgeons which means intraoperative assessment of the tumor residue and its dural tail signs assume paramount importance.

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To achieve this objective, this study elaborates on the application of endoscopy during tuberculum sellae meningioma resection via the supraorbital keyhole approach, renowned for its excellent cosmetic outcomes and broad applicability [2, 3, 7]. By compensating for the limited view of the microscope, endoscope reveals the residual tumors and suspicious dural tail signs which were hard to be identified under the microscope. This enables further precise resection and coagulation to achieve minimally invasive Simpson Grade II tumor resection, and finally decrease the long-term recurrence rates. The immense value of endoscopy in such surgical procedure is well demonstrated.

Description of the technique

Following general anesthesia, the patient was positioned in the supine position with the head fixed in a three-pin Mayfield headholder. The head was then retroflexed 15° and rotated 20° to the right. The incision was planned on the lateral aspect of the left eyebrow, extending medially until the supraorbital incisura. After making the initial skin incision, the subcutaneous tissue was meticulously dissected. The skin flap was gently retracted superiorly with spring hooks. Approximately 3 cm above the orbital rim, the frontal muscle was incised parallel to the orbital margin, extending medially to just the supraorbital incisura and laterally along the temporal line. The frontal muscle flap was mobilized and retracted downward with holding sutures and the temporal muscle was retracted laterally to exposure the MacCarty keyhole. After a single burr hole was made using a highspeed drill, a frontal keyhole craniotomy measuring about 3×2.5 cm was performed. Subsequently, the dura mater was opened in a C-shaped flap and retracted in a basal direction [6].

During the microscopic procedure, cerebrospinal fluid (CSF) of the suprasellar cistern was successfully released, resulting in satisfactory control of intracranial pressure. After gently retracting left frontal lobe, optic chiasm and the tumor were exposed. The tumor was soft with moderate vascularity, primarily originating at the tuberculum sellae. After excising the base, the tumor was removed piecemeal until the complete removal of the tumor was achieved. Then the endoscope was introduced from the keyhole bone window to the first gap. Under direct visualization, a suspected thin layer of residual tumor tissue was identified near the right internal carotid artery (ICA). Additionally, a small amount of dural tail sign was noted lateral to the right optic nerve. Both residues were subsequently excised under endoscope and microscope. Final endoscopic inspection confirmed Simpson grade II gross total resection, with complete coagulation of the dural tail sign. From the endoscopic view, tumor base did not involve the diaphragm sellae or pituitary stalk, and both bilateral optic nerves, chiasm, and left olfactory nerve

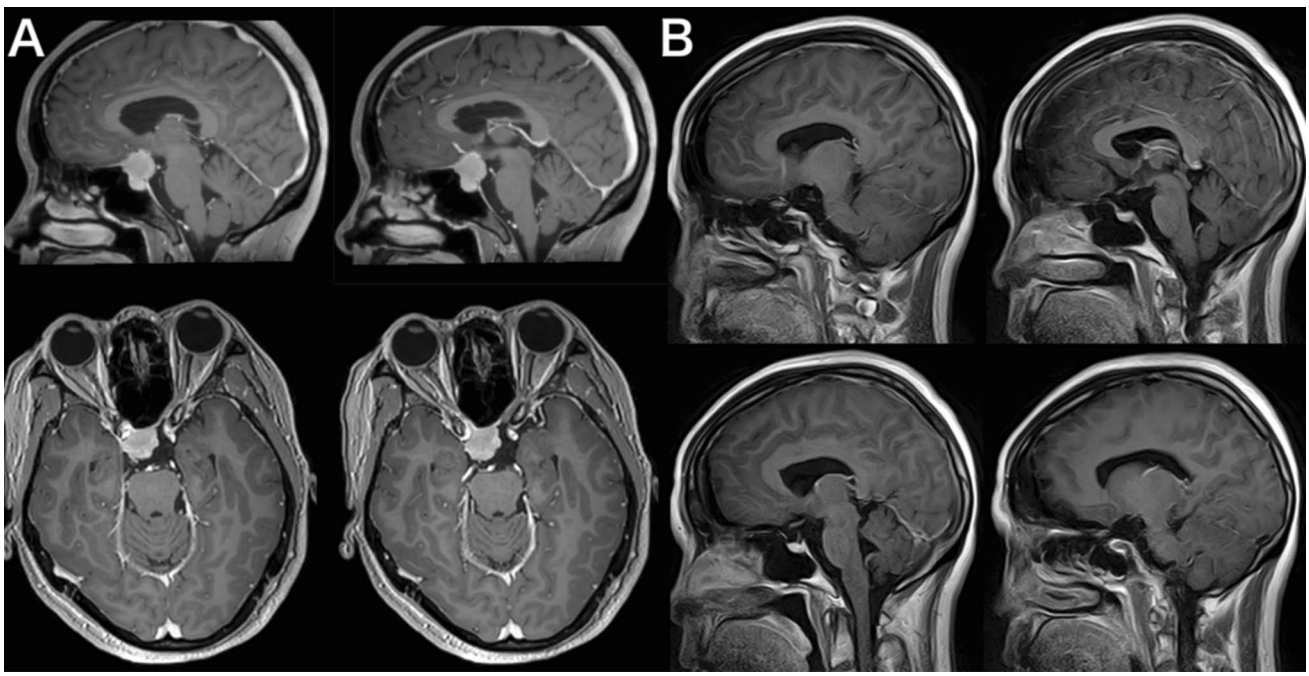

Fig. 1 Pre-operative and post-operative MRI showed tuberculum sellae meningioma was totally removed

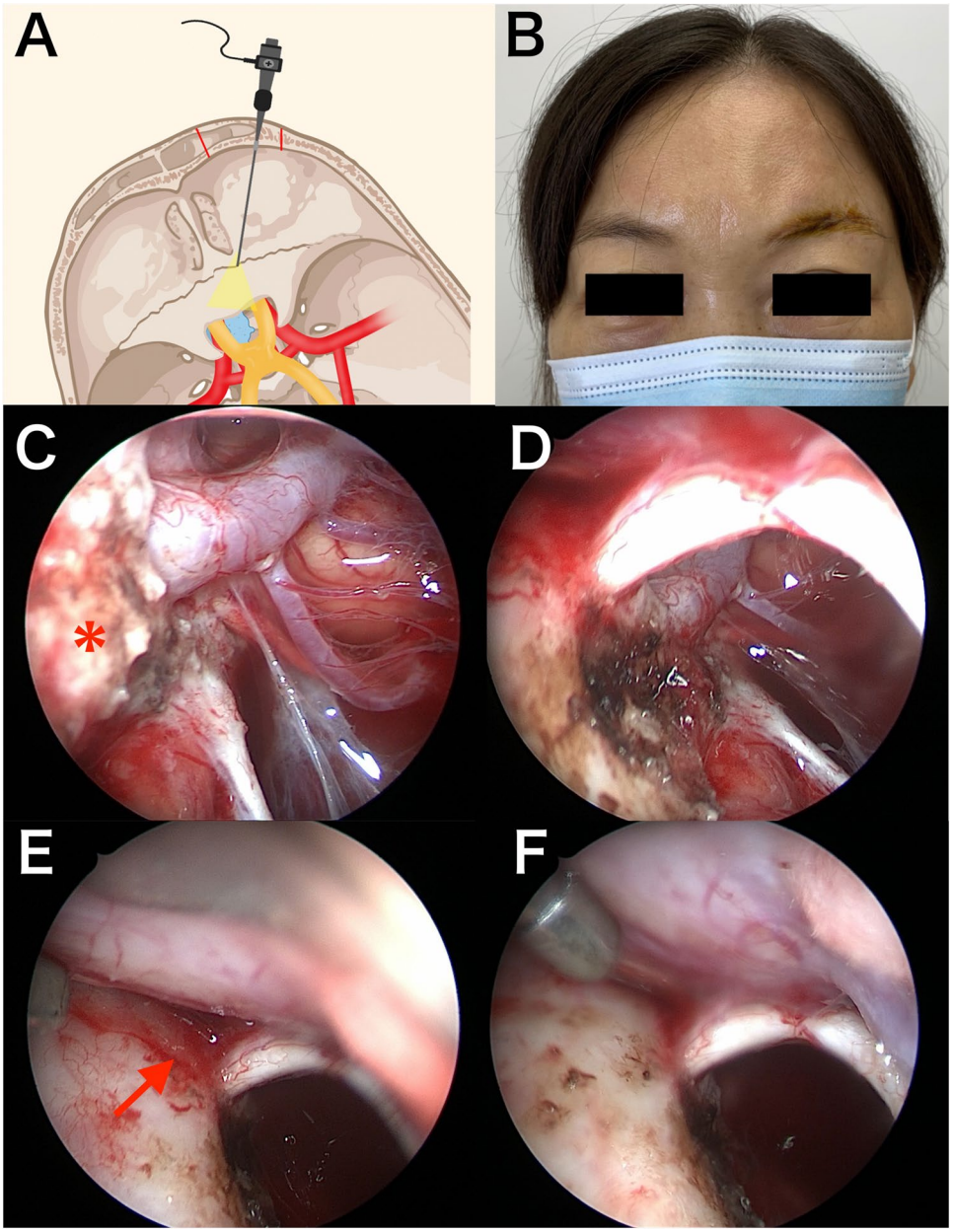

Fig. 2 Endoscopic view after total resection of tuberculum sellae meningioma under microscope. **A**. The illustration of endoscopy assisted supraorbital keyhole approach for tuberculum sellae meningioma. **B**. Cosmetic outcome after supraorbital keyhole surgery at one-month postoperative follow-up. **C**. Endoscopic view showed residual tumor was located near the right ICA. **D**. Residual tumor was resected totally and tumor base was precisely coagulated. **E**. Found extra dual tail sign near the right optic nerve. F. Total resection of extra dual tail sign and final achievement of Simpson Grade II resection. Asterisk: residual tumor. Red arrowhead: dural tail sign

were preserved intact. Artificial dura mater was used to repair the dural defect, followed by meticulous and cosmetical closure of the incision.

Indications

1. Moderate tumor volume and controllable blood supply.
2. The tumor can be expected to achieve a Simpson Grade II resection.
3. The tumor invasion does not penetrate the anterior skull base and there is no need for reconstruction of the skull base.

Limitations

1. The small size of the keyhole bone window limits the space for endoscopy, necessitating care to prevent excessive retraction of the frontal lobe that could lead to direct injury of the brain tissue or tearing of the olfactory nerve.
2. When using the endoscope, it is crucial to pay attention to the optic nerves, arteries, and pituitary stalk, ensuring careful entry and exit to avoid iatrogenic injury.
3. The area beneath the optic nerve often represents a blind spot, requiring meticulous observation with the endoscope; a 30-degree angled lens may be employed if necessary.

How to avoid complications

1. The endoscope should be used after tumor removal when intracranial pressure has been adequately controlled.
2. Frontal lobe should be protected with brain cotton in case of scratch by endoscope.
3. Entry and exit with the endoscope should be gentle, maintaining close contact with the anterior skull base.
4. To minimize the visual blind spots typically found beneath the optic nerve, an alternative approach entering from the contralateral side can be adopted to enhance the vision.

Specific information for the patient

A 42-year-old female patient presented with a history of right-sided blurred vision for over two months. Neurological examination revealed right temporal hemianopia. Magnetic resonance imaging (MRI) demonstrated right tuberculum sellae meningioma. To achieve optimal cosmetic outcomes and ensure complete resection of the tumor, we decided to perform endoscopic-assisted supra-orbital keyhole approach. The surgical procedures may be associated with several potential complications as follows.

1. Injury of artery or optic nerve: if tumor was adherent to critical structures such as the carotid artery, optic nerves, or chiasm, forced dissection may risk damaging these structures, leading to massive bleeding, or further deterioration of visual acuity. Therefore, we opted for a left-sided approach which provided better visualization of the blind area below the optic nerve.
2. Bleeding, seizure, infection and brain edema: these complications also occurred in standard open craniotomy surgery. Careful intraoperative hemostasis, mild frontal lobe retraction, and attention to draining venous protection were emphasized.
3. Hypopituitarism and diabetes insipidus: injury of pituitary stalk or portal system may result in postoperative hypopituitarism and diabetes insipidus. Hormone replacement therapy may be required, and close monitoring of electrolyte disorder should be maintained.
4. Wound healing and cosmetic problems: postoperative care should include vigilant observation of wound healing, as mild effusion, swelling, or CSF leak may occur, requiring early detection and management.

Fortunately, the patient did not develop any of these complications and experienced excellent wound healing. Postoperative MRI confirmed GTR of the tumor. Follow-up evaluation of visual acuity revealed no change compared to preoperative status, while visual fields had returned to normal, and olfaction remained intact (Figs. 1, 2).

Key points

1. Endoscopic assisted supraorbital keyhole approach is an effective minimally invasive transcranial approach for tuberculum sellae meningioma.
2. Endoscopic visualization gives a direct view on tumor base and dural attachments.
3. Be careful and not retract frontal tissue too much in case of frontal contusion.
4. Gentle entry and exit of endoscopic instruments.
5. Keep high stability and avoid any iatrogenic injury of optic nerve pituitary stalk and arteries.
6. Protection of olfactory nerve during the operation.
7. Cosmetic closure technique should be performed in supraorbital keyhole surgery.
8. Contralateral approach is effective to minimize the blind area below optic nerve.
9. Dural tail sign is far more extensive than MR image showed or observation under a microscope.
10. Simpson Grade II resection is surgical goal for tuberculum sellae meningioma.

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Author contribution Zhifeng Shi and Chao Shen were responsible for the project administration and wrote the first draft of the manuscript; Chao Shen and Bojie Yang were in charge of the surgery and video.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethical approval All procedures performed in this study involving human participants were in accordance with the ethical standards of The Institutional Ethics Committee of Huashan hospital Fudan University and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Consent to publish Written informed consent for publication of patient's clinical details and clinical images was obtained from the patient.

Conflict of interest The authors declare no competing interests.

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