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Clinical outcomes of the neuroendoscopic far lateral supracerebellar infratentorial approach for resection of deep brain lesions

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Resection of deep cerebral lesions presents significant challenges for neurosurgeons. However, advancements in neuroendoscopic techniques have led to the adoption of endoscopic surgery via the supracerebellar infratentorial approach for addressing deep cerebral lesions located in the petroclival region, cerebellopontine angle, and pineal region. The aim of this study was to explore the curative effects and analyse the characteristics of the neuroendoscopic far-lateral supracerebellar infratentorial approach for treating these lesions. Sixteen cases of deep cerebral lesions treated with this method were reviewed, and the surgical outcomes and patients' postoperative conditions were assessed to evaluate the approach's effectiveness. Among the 16 patients, ten were diagnosed with petroclival region meningiomas, two with epidermoid cysts in the cerebellopontine angle, two with germ cell tumours in the pineal region, one with a trigeminal schwannoma, and one with a thalamic haematoma. Notably, only two patients (12.5%) experienced postoperative complications, and during follow-up, three patients (18.6%) exhibited no symptom improvement. These findings indicate that the neuroendoscopic far-lateral supracerebellar infratentorial approach enhances lesion exposure, improves the surgeon's view of the surgical field, minimizes the risk of intraoperative injury, and reduces the risk of postoperative complications, demonstrating significant potential for the clinical treatment of skull base lesions due to its effectiveness and safety.

Keywords Neuroendoscopic far-lateral supracerebellar infratentorial approach, Brain tumours, Neuroendoscopic surgery, Surgical outcome, Deep brain lesions

Lesions in deep brain regions, such as the petroclival region, cerebellopontine angle area and pineal region, are usually in close proximity to the surrounding nerves and blood vessels, making them difficult to completely resect. Since Stein improved and promoted the supracerebellar infratentorial approach (SCITA) in 1971[1], this approach has become one of the classic approaches for treating posterior fossa lesions. However, the narrow operating space and complex surrounding structures are sources of major concern for surgeons.

In recent years, many scholars have increasingly attempted to perform the neuroendoscopic SCITA for pineal lesions under the guidance of endoscopy[2]. In the process of practical operation, we found that the neuroendoscopic far-lateral SCITA is not only suitable for pineal tumours but is also significantly advantageous for lesions in the cerebellopontine angle (CPA) area and lesions in the petroclival region. In this study, we analysed the surgical data and postoperative recovery of patients who underwent the neuroendoscopic far-lateral SCITA for lesion removal and summarized the intraoperative precautions and characteristics of this approach.

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Methods and materials
Patient cohort and evaluation
Between January 2022 and December 2022, a total of 16 patients with deep cerebral lesions underwent surgery at the Department of Neurosurgery, The First Affiliated Hospital of Nanjing Medical University. All procedures were performed by the senior author, Professor Zhao. This retrospective study was approved by the Ethics Committee of the First Affiliated Hospital of Nanjing Medical University. Written informed consent was obtained from all patients, and the studies were performed in accordance with the recognized ethical guidelines of the Declaration of Helsinki. Informed consent was obtained from all participants for the publication of identifiable information and images in this open-access journal.

Imaging and assistant examination
Magnetic resonance imaging (MRI) and computed tomography (CT) were utilized for preoperative diagnosis and assessment of postoperative outcomes. In all 16 patients, MRI was performed to evaluate the position and size of the lesions, as well as oedema, brain shift, calcifications, and involvement of the cranial nerves and cerebral vessels. Pathological results served as the final means of diagnosis.

Operation
Fifteen patients underwent neuroendoscopic resection via the far lateral supracerebellar infratentorial approach, and in one patient with a CPA epidermoid cyst, a combined posterior sigmoid sinus approach and a far lateral SCITA were used. Preoperative lumbar drainage (LD) was performed in patients without obstructive hydrocephalus to facilitate intraoperative CSF drainage and brain relaxation, optimizing surgical exposure, as reported in previous studies[3].

The patient was positioned in a lateral or park bench position, similar to the traditional far-lateral approach. The head was fixed in a three-pin skull fixation device. The head was elevated, flexed forwards, and rotated backwards to ensure appropriate selection of the surgical incision site.

Endoscopic monitoring and intraoperative neuromonitoring were performed at the patient's head. The pneumatic mechanical manipulator was installed in front of the patient, with the surgeon standing behind the patient and the assistant standing on the opposite side.

In these operations, a straight vertical incision approximately 5–6 centimetres long was made 4–5 centimetres behind the ear to allow exposure of the lateral part of the transverse sinus. The edge of the sigmoid sinus and the junction of the transverse sinus and sigmoid sinus are helpful to the surgeon. A hole was made at the lower edge of the transverse sinus, and the bone flap was expanded to 3 cm × 3 cm. During the craniotomy, careful attention was given to protecting the sinus. The dura mater was then opened in an arc shape away from the side of the transverse sinus, and dural traction points were placed.

When the endoscopic instruments were introduced, bridging veins obstructing the pathway were observed in some patients. After these veins were disconnected, the arachnoid attachments to the tentorial surface were also separated. The operator could then further dissect and separate to observe various unknown lesions, using a pneumatic mechanical manipulator to stabilize the neuroendoscope and allowing both hands to participate in the surgery. Intraoperative neurophysiological monitoring was used to ensure that cranial nerve function was not impaired. The lesions, including those extending to the Meckel cave and the edge of the lateral crest, were identified and removed.

Outcome measures
Perioperative measures, including the intraoperative blood loss volume, lesion resection rate, duration of postoperative hospitalization, and incidence of complications, were recorded. We also evaluated facial nerve function according to the House–Brackman facial paralysis scale and assessed hearing impairment.

Regarding prognosis, we followed up within 1–3 months after the operation and performed regular outpatient reexaminations at 3 months and 1 year after discharge. The follow-up measures included the incidence of recurrence, which was evaluated by cranial MRI, as well as the incidence of cranial nerve damage complications and the degree of improvement in preoperative symptoms.

Results
Among the 16 patients, 10 patients were confirmed to have petroclival region meningiomas on the basis of postoperative pathology. Two patients were diagnosed with CPA epidermoid cysts, two patients had germ cell tumours (mature teratomas) in the pineal region, and one patient was diagnosed with trigeminal schwannoma. Only 2 patients (12.5%) experienced postoperative complications: one with transient facial numbness and the other with preexisting pulmonary inflammation that worsened after the operation. Additionally, there was one patient with a thalamic haematoma caused by spontaneous cerebral haemorrhage, for whom we successfully performed surgical removal via the neuroendoscopic far-lateral supracerebellar infratentorial approach, achieving excellent therapeutic outcomes. The preoperative characteristics and outcome measures of the patients are shown in Table 1.

During the follow-up, only 3 patients (18.6%) exhibited no improvement in their symptoms. One patient presented with diplopia, while the other had tinnitus and facial numbness. Both of these patients had meningiomas, which were considered to be caused by long-term cranial nerve damage. The patient with a thalamic haematoma still exhibited mild limb movement disorders, although his symptoms significantly improved. The following are two representative cases that illustrate the application and outcomes of the neuroendoscopic far lateral supracerebellar infratentorial approach.

Parameters	Value
Age (years)	45.8 ± 16.9 (6–75)
Sex (male/female)	12/4
Disease duration (months)	5.4 ± 8.4 (0.4–24.0)
Diagnosis	
Meningioma	10
Epidermoid cyst	2
Trigeminal neurinoma	1
Thalamic haematoma	1
Mature teratomas in pineal region	2
Primary/relapsed	15/1
Maximum tumour diameter (mm)	26.2 ± 10.4 (13–45)
Involving Meckel's cave	12 (75%)
Preoperative cranial nerve symptoms	9 (6.3%)
Combined chronic diseases	6 (7.5%)
Intraoperative blood loss (ml)	118.8 ± 79.32 (50–300)
Extent of resection (total/almost total)	15/1 (93.8%)
Incidence of new complications	2 (12.5%)
Facial nerve damage (House–Brackman IV, V, VI)	0
Hearing impairment	0
Facial sensory disorders	1
Disturbance of consciousness	0
Nervous system infection	0
Pulmonary infection	1
CSF fistula	0
Postoperative hospitalization duration	6.8 ± 2.0 (4–11)
Recurrence	0
Long-term cranial nerve damage	3 (18.6%)
Degree of symptom improvement	
Complete improvement	13 (81.3%)
Partial improvement	3 (18.6%)
Not improving or worsening	0

Table 1. Preoperative characteristics and outcome measures.

Patient 1

A 6-year-old male presented with a 1-month history of headache and projectile vomiting. MRI revealed a 2.4 × 1.5 × 1.3 cm highly vascularized pineal region mass, which was suspected to be a germ cell tumour or vascular lesion, with associated hydrocephalus and cerebral oedema (Fig. 1A–C). The tumour was accessed and resected via a neuroendoscopic far lateral SCITA (video 1). The quadruple pool was opened, allowing direct exposure and dissection of the tumour from surrounding vascular structures (Fig. 1G–J). Postoperative MRI on the same day confirmed complete resection with no residual mass (Fig. 1D–F). The patient experienced an uneventful recovery, with transient fever but no significant complications. He was discharged on postoperative day 7. Histopathological analysis confirmed the diagnosis of a mature teratoma.

Patient 2

A 32-year-old male was referred to our institution after undergoing external ventricular drainage for thalamic haemorrhage one and a half months prior, with no symptom relief. On admission, the patient presented with a temperature of 38 °C, altered consciousness, unequal pupils, no reflexes on the right side, increased muscle tone in both upper limbs, and spastic paralysis with sustained flexion of the left upper limb. An external ventricular drain was noted in the right lateral ventricle. Following imaging studies (Fig. 2) to confirm the location and volume of the haematoma, we used an endoscopic supracerebellar infratentorial approach to evacuate the haematoma from the posterior thalamus (video 2) (Fig. 3). Additionally, we conducted an endoscopic third ventriculostomy to relieve obstructive hydrocephalus. The external ventricular drain was removed, and cerebrospinal fluid drainage was redirected to the lumbar cistern, accompanied by antibiotic therapy. Postoperatively, the patient showed improvement in consciousness. By the fifth week after surgery, he was able to ambulate independently and perform activities of daily living.

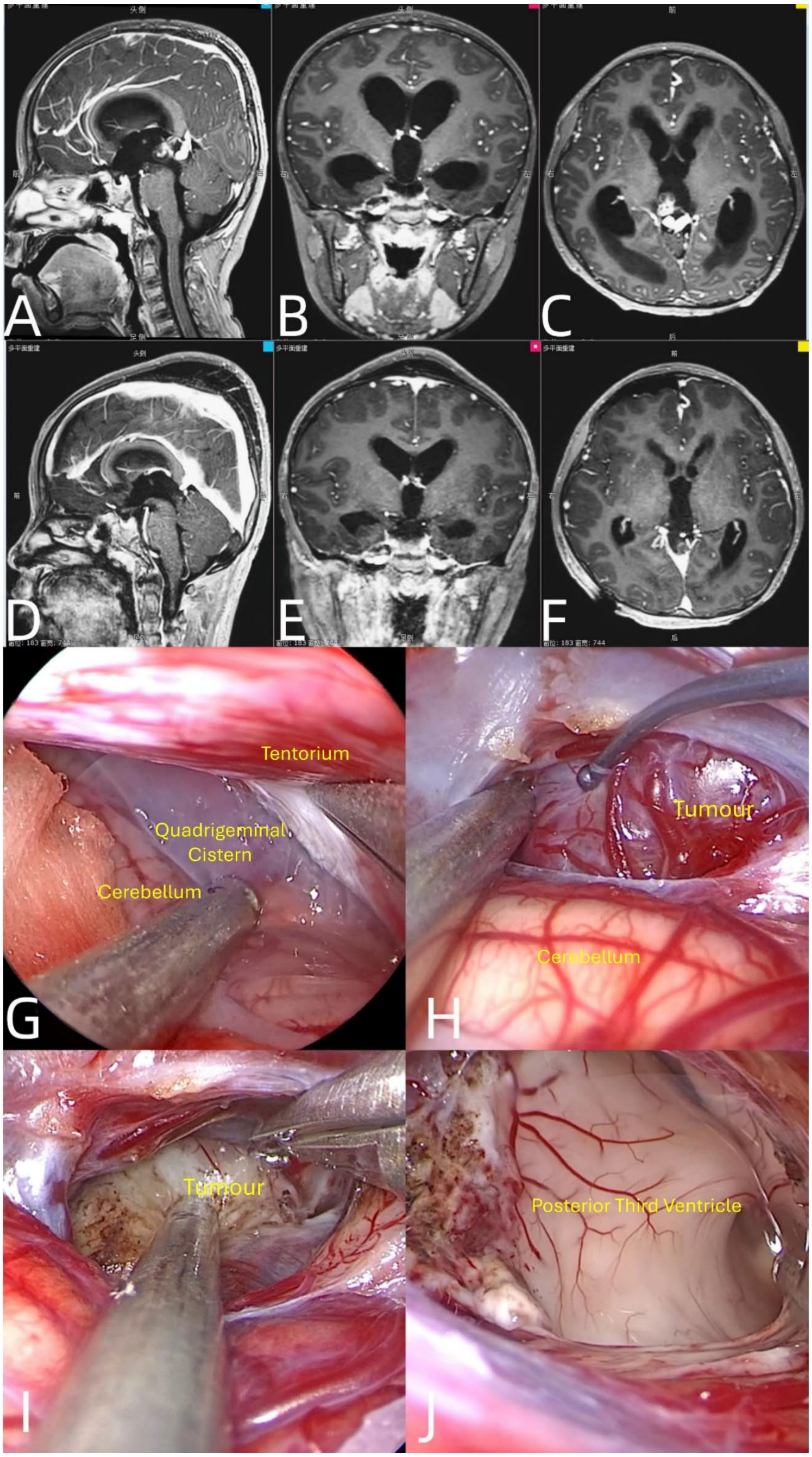

Fig. 1. Magnetic resonance imaging (MRI) and intraoperative images of pineal region tumours. (A-C) Preoperative MR image. (D-E) Postoperative MR image. (G) Opening of the quadruple pool. (H) Red tumours with a rich blood supply can be observed, and the tumours and surrounding tissues can be separated. (I) The blood vessels on the surface of the tumour were cauterized and removed. (J) No residual tumour was observed after resection.

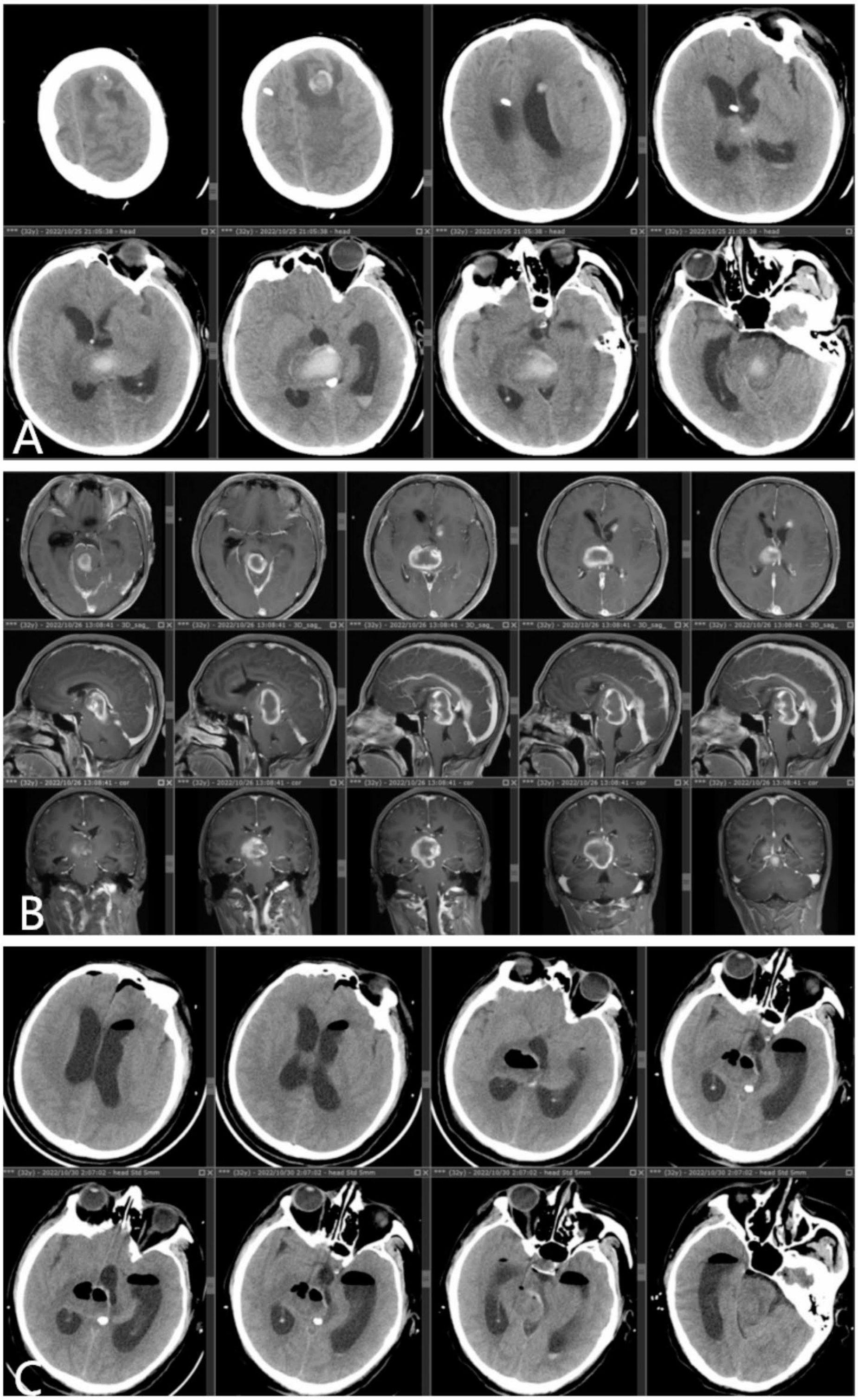

Fig. 2. Imaging data of patients with thalamic haematoma. (**A**) Preoperative cranial CT revealed a right thalamic haematoma and left frontal lobe haematoma. (**B**) Preoperative MR image. (**C**) Postoperative cranial CT revealed satisfactory clearance of the thalamic haemorrhage.

Patient 3

A 75-year-old male presented with a 3-month history of progressive right-sided facial pain. Initially intermittent, the pain worsened in frequency and intensity over time. His medical history included complete left bundle branch block and prior gastric cancer surgery. Neurological examination revealed no focal deficits. Preoperative contrast-enhanced MRI demonstrated a 3.8 × 2.5 cm mass in the right petroclival region, adjacent to the right

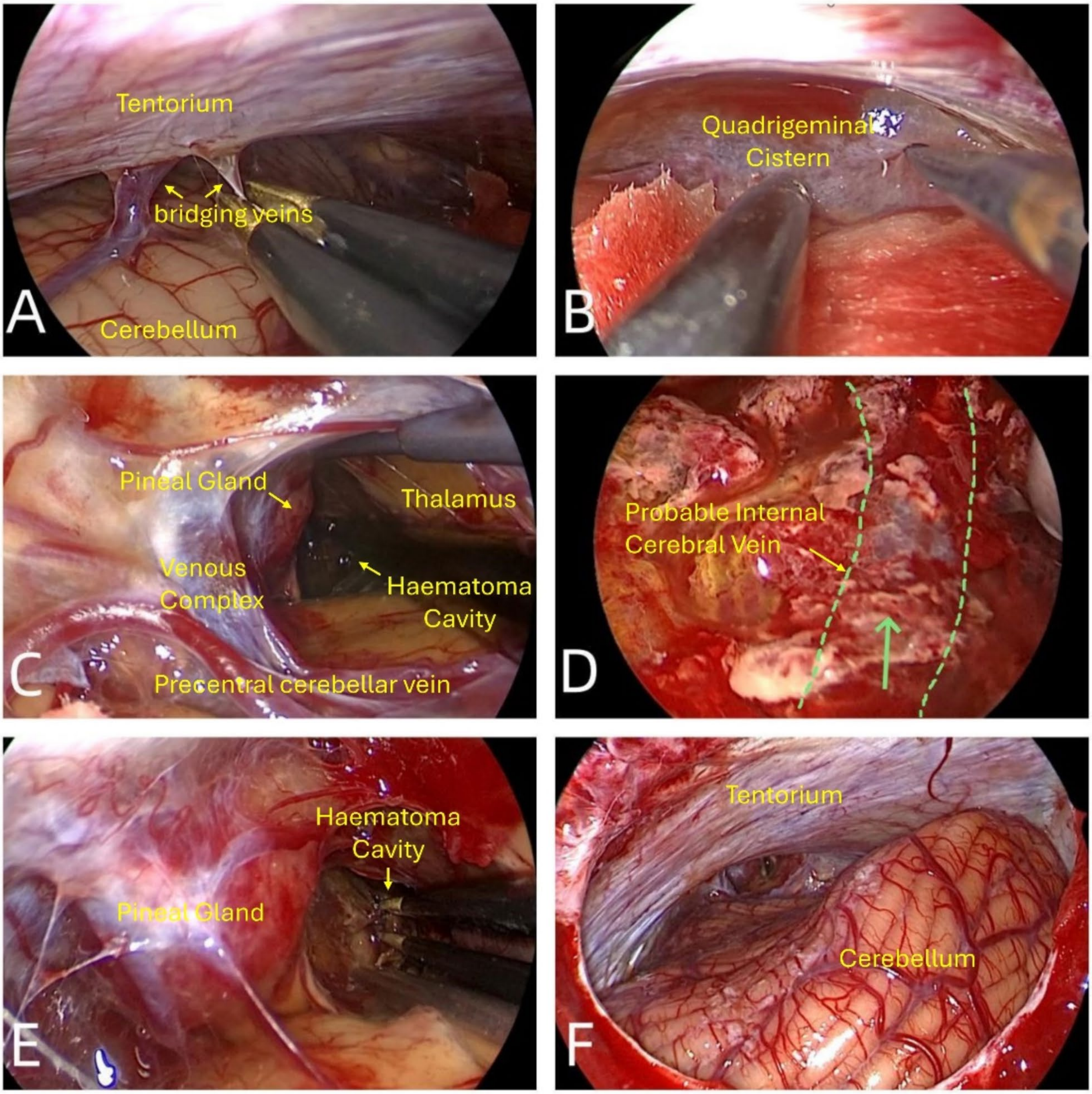

Fig. 3. Intraoperative images of patients with thalamic haematoma. (**A**) Electrocoagulation and devascularization of the bridging vein. (**B**) Opening of the arachnoid. (**C**) Thalamic haematoma. (**D**) After the haematoma content is removed, the internal cerebral vein can be vaguely observed under the remaining haematoma tissue. (**E**) Endoscopic third ventriculostomy. (**F**) Satisfactory intraoperative haemostasis and unobstructed cerebrospinal fluid drainage.

vertebral and basilar arteries, suggestive of a meningioma (Fig. 4A). Given his cardiac comorbidity, a temporary pacemaker was placed preoperatively.

The patient underwent neuroendoscopic resection via the supracerebellar infratentorial approach (video 3). Intraoperatively, a firm, pinkish tumor was identified at the petrous apex, extending into Meckel's cave and the clivus. The trigeminal nerve was encased by the tumor, necess meticulous microsurgical dissection under endoscopic visualization. The tumor within Meckel's cave was carefully debulked using forceps. Critical neurovascular structures, including the trigeminal, facial, and oculomotor nerves, were anatomically preserved (Fig. 4C–F). Postoperative MRI on day 1 confirmed gross total resection without residual tumor (Fig. 4B). The patient experienced transient drowsiness but no cranial nerve deficits or other complications. He was discharged on postoperative day 9. Histopathological analysis confirmed a World Health Organization (WHO) grade I meningioma.

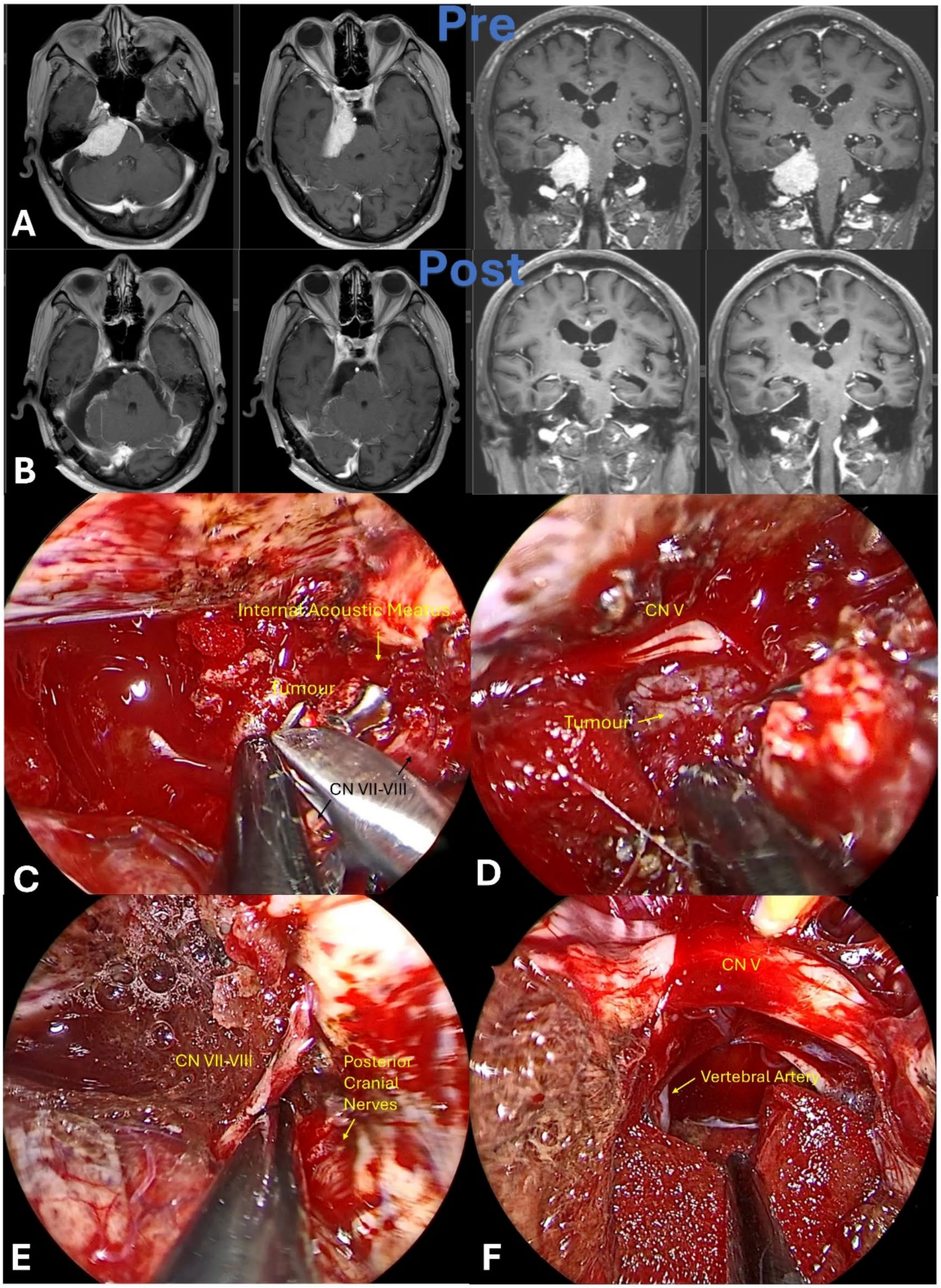

Fig. 4. Magnetic resonance imaging (MRI) and intraoperative images of petroclival meningioma. (**A**) Preoperative MR image. (**B**) Postoperative MR image. (**C**) The tumor encircles the acoustic-facial bundle and invades the internal acoustic meatus; careful dissection is performed using forceps for removal. (**D**) The tumor wraps around the trigeminal nerve and is removed in segments, ensuring the nerve is carefully preserved. (**E**) The tumor is completely excised, and the acoustic-facial bundle are preserved. (**F**) The trigeminal nerve is adequately protected during the procedure.

Discussion

Advantages of the neuroendoscopic far lateral SCITA

Compared with traditional surgical methods, the neuroendoscopic far-lateral supracerebellar infratentorial approach has the following advantages:

Minimally invasive: This procedure is minimally invasive, thus reducing the likelihood of severe damage to the scalp, bones, and soft tissues owing to small incisions and the use of a neuroendoscope. As a result, it reduces surgical trauma, shortens the postoperative recovery time, and lowers the risk of postoperative complications.

Refined Manipulation: Neuroendoscopy is flexible and allows surgeons to utilize more precise instruments for performing accurate manipulations in confined spaces. This facilitates the careful handling and removal of brain tissue and lesions while maximizing the protection of the surrounding neural structures and blood vessels.

Enhanced Visualization: The neuroendoscope provides a bright and wide field of view as the light source is directed into the surgical area. This enables the operator to directly observe lesions in hard-to-reach areas obscured by the brainstem, cerebellum, and nerve structures[4,5]. This capability aids in accurately locating lesions, protecting surrounding structures, and minimizing surgical risks[6]. Furthermore, this surgical approach allows surgeons to bypass the obstruction of the petrosal vein during intracranial access, thereby enhancing the visualization of the surgical field.

Reduced Risk of Complications: Due to minimal trauma, a clear field of vision, precise manipulation, and the assistance of navigation and imaging techniques, the neuroendoscopic far-lateral supracerebellar approach can decrease the risk of complications commonly associated with some traditional open surgeries, such as infection, bleeding, and tissue damage.

The retrosigmoidal approach remains the most classic surgical route for skull base tumors, and the integration of neuroendoscopy has further enhanced its ability to expose midline structures, facilitate anatomical identification, and minimize incision size, as supported by prior studies[7]. However, to the best of our knowledge, no direct comparisons between the endoscopic far-lateral SCITA and the endoscopic retrosigmoidal approach have been reported in the literature. Based on our institutional experience, we observed that far-lateral SCITA offers a simplified craniotomy procedure compared to the retrosigmoidal approach, as it requires exposure of only the transverse sinus extending laterally to the sigmoid sinus, which may render the craniotomy faster and safer. Post-craniotomy, far-lateral SCITA provides a larger operative working space by utilizing the natural anatomical corridor between the tentorium and cerebellum. Importantly, while the retrosigmoidal approach necessitates manipulation and retraction of the acousticofacial and trigeminal nerve complexes, far-lateral SCITA avoids direct contact with these nerves, thereby offering superior anterior exposure and enhanced contralateral visualization of critical regions such as Meckel's cave. Conversely, the retrosigmoidal approach demonstrates distinct advantages in accessing inferomedial regions, including deeper exposure of the jugular foramen and even the foramen magnum, whereas far-lateral SCITA's smaller bone window limits its ability to visualize inferolateral areas. Ultimately, the choice between these approaches should be guided by lesion location, balancing anatomical accessibility and procedural risks.

Application for germ cell tumors in the pineal region

The pineal gland region is one of the first skull base areas where the SCITA has been applied. The use of microsurgical techniques for the infratentorial supracerebellar approach was revisited in the 1990s. With the advancement of endoscopic technology, neuroendoscope-assisted microsurgery and total endoscopic supratentorial cerebellar approaches have gradually emerged. In 2008, Gore reported the world's first case of pineal cyst removal via a total endoscopic superior cerebellar approach[8].

Compared with those encountered during the posterior median supratentorial cerebellar approach, the drainage veins above the inferior cerebellum encountered during the distal lateral supratentorial cerebellar approach are significantly smaller and shorter. Once the endoscope is placed with the support of a pneumatic arm, we can clearly identify structures such as the cerebellar fissure vein, internal cerebral vein, and Galen's vein, allowing us to operate from the intervenous space. Special attention must be given to protecting the Galen venous system during the procedure. Giordano suggested that imaging techniques can clearly display the vein of Galen and its branches, aiding in both preoperative planning and intraoperative navigation[9].

Neuroendoscopic posterior third ventriculostomy can be performed simultaneously[10]. However, in some patients, due to the opening of the posterior part of the third ventricle and the relief of compression of the midbrain aqueduct, obstructive hydrocephalus can be relieved after the operation.

Application for petroclival region meningiomas

Compared with the retrosigmoid approach, the neuroendoscopic far-lateral SCITA better prevents the petrosal vein from obscuring the surgeon's vision during surgery and facilitates the entry of surgical instruments into the petroclival area for tumour removal. Meningiomas extending into the sellar region can also be clearly exposed and resected via endoscopy, and the optic chiasma and pituitary stalk can be clearly observed.

Meckel's cave is a common site for the growth of petroclival meningiomas, and these tumours are typically challenging to manage via the retrosigmoid approach under a microscope. Through extensive practice, we have shown that neuroendoscopic far-lateral SCITA offers a direct view of the upper medial aspect of Meckel's cave, which can be accessed naturally by the surgeon without the need for any bone resection[2].

Application for CPA epidermoid cysts

Epidermoid cysts are the third most common type of tumour in the cerebellopontine angle area and can present as extensive lesions that intricately involve critical neurovascular structures[11,12]. CPA epidermoid cysts often adhere strongly to the surrounding cranial nerves (CNs), brainstem structures, and blood vessels[13], significantly increasing the difficulty of safely and completely removing the tumour during surgery. The neuroendoscopic far-lateral SCITA can effectively address this challenge, enabling the surgeon to separate the tumour from these important structures more intuitively and clearly. In cases where tumours extend into the internal acoustic meatus and Meckel's cave, this approach allows for more intensive and deeper exploration and separation.

Application for trigeminal schwannoma
There are many complex vascular and nerve structures surrounding the trigeminal nerve, which should be preserved as much as possible during surgery. The neuroendoscopic far-lateral SCITA allows the surgeon to minimize traction on these blood vessels during the procedure, thereby reducing the risk of injury and minimizing postoperative complications. Chen et al. recently demonstrated the efficacy of a similar endoscopic far-lateral approach for dumbbell-shaped trigeminal schwannomas, achieving favorable resection rates with minimal cranial nerve deficits[3], aligning with our emphasis on nerve preservation and reduced complications. Protecting the function of the trigeminal and facial nerves is critical, and intraoperative electrophysiological monitoring further mitigates postoperative cranial nerve dysfunction, as highlighted in both studies.

Application for thalamic haematoma
Among all intracerebral haemorrhage (ICH) cases, haemorrhage originating from the thalamus occurs in approximately 8.3–15% of patients[14,15]. These patients typically experience slower recovery and worse long-term neurofunctional outcomes than those with other types of ICH[16]. During the clinical treatment of a patient with thalamic haemorrhage, we chose to use neuroendoscopic far lateral SCITA for an exploratory surgical procedure. This patient presented with moderate disturbances of consciousness and limb movement disorders prior to surgery and had undergone external ventricular drainage at another hospital, after which there was no significant improvement for more than a month. However, after we removed the previous lateral ventricular drainage tube and performed surgery via the neuroendoscopic far lateral SCITA, the patient's prognosis improved significantly. By the fifth week posttreatment, he was able to move independently and regain the ability to care for himself.

Application in other pathologies
Beyond the pathologies described, the neuroendoscopic far-lateral SCITA has shown promising applications in other skull base lesions. Han et al. successfully resected an upper-middle clival chordoma via neuroendoscopic far-lateral SCITA, achieving gross total resection with preserved neurovascular structures and no postoperative CSF leakage, underscoring its utility in complex midline lesions[17]. Similarly, Yao et al. reported two cases of trigeminal neuralgia (classical and tumor-induced) treated via neuroendoscopic far-lateral SCITA, demonstrating immediate pain relief and zero complications, highlighting its versatility in managing neurovascular conflicts[18]. Although our study did not include clival chordomas or trigeminal neuralgia, these reports corroborate our findings that neuroendoscopic far-lateral SCITA enhances surgical exposure, minimizes neurovascular injury, and optimizes outcomes for deep-seated skull base pathologies, further advocating its clinical adoption.

Limitations and prevention of postoperative complications
First, there are high skill requirements for the operator. The operator needs extensive anatomical knowledge and experience in neuroendoscopic procedures, enabling them to accurately understand the anatomical relationships observed through the endoscope and operate skillfully along the endoscopic axis. Moreover, the operator must be able to adapt to the transformation.

between three-dimensional and two-dimensional images[19]. This is not a skill that can be mastered overnight; it requires training to achieve proficiency.

Second, this procedure also has the potential to cause damage to the surrounding tissues due to improper handling. When the lens is contaminated with blood during surgery, it needs to be wiped and repeatedly, and the operator should avoid damaging the surrounding tissues when moving the endoscope due to excessive concentration[20]. This issue can be mitigated by rinsing the lens with saline and securing the neuroendoscopic lens with a pneumatic mechanical manipulator, which enhances the stability of the endoscopic field, reduces the risk of accidental injury, and frees the operator's hands for better manipulation.

In addition, the lens of the neuroendoscope is prone to fog due to the temperature difference between the inside of the body and the external environment. We can reduce lens fog by soaking the lens in warm water to equilibrate the temperature.

We emphasize the need for additional osteotomy of the transverse sinus in far lateral SCITA, as this not only increases the degree of freedom for endoscopic fixation to avoid instrument conflicts but also facilitates the repair of the dura mater.

Although the application of this approach in patients with thalamic haematomas offers significant advantages and has great potential, an effective comparative analysis cannot be conducted at this time because of the limited number of cases.

Conclusion
On the basis of our practical experience, we conclude that the neuroendoscopic far-lateral SCITA technique improves lesion exposure, enhances the operator's view of the surgical field, and reduces the risks of intraoperative injuries and postoperative complications. This technique has significant potential in the clinical treatment of skull base lesions because of its remarkable efficacy and safety, particularly in the management of petroclival meningiomas and thalamic lesions.

Data availability
All data used in this work can be acquired from the corresponding author upon reasonable request.

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References

1. Stein, B. M. The infratentorial supracerebellar approach to pineal lesions. *J. Neurosurg.* **35**(2), 197–202 (1971).
2. Xie, T. et al. Endoscopic far-lateral supracerebellar infratentorial approach for petroclival region meningioma: Surgical technique and clinical experience. *Oper. Neurosurg.* **22**(5), 290–297 (2022).
3. Chen, P. et al. Endoscopic far-lateral supracerebellar infratentorial approach for resection of dumbbell-shaped trigeminal schwannoma: Surgical techniques and preliminary results. *Acta Neurochir.* **165**(10), 2913–2921 (2023).
4. Vinchon, M. et al. Intradural epidermoid cysts of the cerebellopontine angle: Diagnosis and surgery. *Neurosurgery* **36**(1) (1995). (**52-6; discussion 56-7**).
5. Low, W. K. Enhancing hearing preservation in endoscopic-assisted excision of acoustic neuroma via the retrosigmoid approach. *J. Laryngol. Otol.* **113**(11), 973–977 (1999).
6. Giammattei, L., Borsotti, F. & Daniel, R. T. Extreme lateral supracerebellar infratentorial approach: How I do it. *Acta Neurochir.* **161**(5), 1013–1016 (2019).
7. Van Rompaey, J., Bush, C., McKinnon, B. & Solares, A. C. Minimally invasive access to the posterior cranial Fossa: An anatomical study comparing a retrosigmoidal endoscopic approach to a microscopic approach. *J. Neurol. Surg. Cent. Eur. Neurosurg.* **74**(1), 1–6 (2013).
8. Gore, P. A., Gonzalez, L. F., Rekate, H. L. & Nakaji, P. Endoscopic supracerebellar infratentorial approach for pineal cyst resection: Technical case report. *Neurosurgery* **62**(3 Suppl 1), 108–109 (2008). (**discussion 109**).
9. Giordano, M., Wrede, K. H., Stieglitz, L. H., Samii, M. & Ludemann, W. O. Identification of venous variants in the pineal region with 3D preoperative computed tomography and magnetic resonance imaging navigation. A statistical study of venous anatomy in living patients. *J. Neurosurg.* **106**(6), 1006–1011 (2007).
10. Daniel, R. T., Lee, G. Y. & Reilly, P. L. Suprapineal recess: An alternate site for third ventriculostomy? Case report. *J. Neurosurg.* **101**(3), 518–520 (2004).
11. Gopakumar, S., Srinivasan, V. M., Sharma, H., Cherian, J. & Patel, A. J. Fully endoscopic resection of an epidermoid cyst of the cerebellopontine angle: Bilateral resection via a unilateral approach. *Oper. Neurosurg.* **20**(2), E152–E155 (2021).
12. Samii, M., Tatagiba, M., Piquer, J. & Carvalho, G. A. Surgical treatment of epidermoid cysts of the cerebellopontine angle. *J. Neurosurg.* **84**(1), 14–19 (1996).
13. Hasegawa, H. et al. Long-term surgical outcomes of intracranial epidermoid tumors: Impact of extent of resection on recurrence and functional outcomes in 63 patients. *J. Neurosurg.* **136**(6), 1592–1600 (2022).
14. Lee, S. H. et al. Prognostic factors of clinical outcomes in patients with spontaneous thalamic hemorrhage. *Med. Sci. Monit.* **21**, 2638–2646 (2015).
15. Arboix, A. et al. Thalamic haemorrhage vs internal capsule-basal ganglia haemorrhage: Clinical profile and predictors of in-hospital mortality. *BMC Neurol.* **7**, 32 (2007).
16. Eslami, V. et al. Influence of intracerebral hemorrhage location on outcomes in patients with severe intraventricular hemorrhage. *Stroke* **50**(7), 1688–1695 (2019).
17. Han, S. et al. Endoscopic far-lateral supracerebellar infratentorial approach for resection of clival chordoma: Case report. *Front. Oncol.* **14**, 1448063 (2024).
18. Yao, H. et al. Fully endoscopic far-lateral supracerebellar infratentorial approach for trigeminal neuralgia: Illustrative case reports. *Chin. Neurosurg. J.* **10**(1), 1 (2024).
19. Kabil, M. S. & Shahinian, H. K. A series of 112 fully endoscopic resections of vestibular schwannomas. *Minim. Invasive Neurosurg.* **49**(6), 362–368 (2006).
20. Vaz-Guimaraes, F. et al. Endoscopic endonasal surgery for epidermoid and dermoid cysts: A 10-year experience. *J. Neurosurg.* **130**(2), 368–378 (2019).

Author contributions

PZ, ZL, and KD contributed to the design and conception of the study. ZL, KD, KC, KY, HX, HC and JL collected and assembled the data. ZL and KD performed the statistical analysis. ZL, KC, and KD wrote the first draft of the manuscript. JL and ZL revised the manuscript. All authors read and approved the submitted version.

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Declarations

Competing interests

The authors declare no competing interests.

Additional information

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