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TECHNICAL NOTE

Endoscopic endonasal removal of laterally extended clival chordoma using side-viewing scopes

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Abstract
Background The transsphenoidal approach provides a straight and direct route to the clival chordoma, but has limitations for removing the tumor compartment extending laterally into the space posterior to the paraclival internal carotid artery. To overcome the limitations, a side-viewing endoscope and malleable/steerable instruments were employed.
Methods Four clinical cases with clival chordoma extending into the retro-carotid space were analyzed for extent of resection, complications and clinical outcome.
Findings The retro-carotid tumor compartment was removed in all cases under 30- and 70-degree side-viewing endoscopes using a malleable dissector and/or steerable forceps, resulting in gross total removal of the entire tumor. Single cases were complicated by transient abducens nerve palsy and cerebrospinal fluid leakage, which required surgical revision. All patients have been symptom free without tumor recurrence during the mean postoperative follow-up of 21.3 months.
Conclusions Though a longer follow-up is needed to evaluate its effectiveness in long-term tumor control, the surgical maneuver using the side-viewing endoscope is effective for removing laterally extended clival chordomas.

Keywords Chordoma · Clivus · Endonasal · Endoscopy · Skull base · Petrous bone

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Introduction

The clival chordoma still presents management challenges in the modern era of neurosurgery. Among diverse skull base approaches, the anterior approach provides the most direct route to the lesion without crossing major neurovascular structures [2, 18, 21]. The disadvantage of the approach is, however, the lateral limitation because of the carotid arteries [4]. An approach to the space behind the upper paraclival carotid artery, into which the clival chordoma often extends, mandates adoption of or combination with lateral approaches [18].

The evolution of endonasal endoscopic surgery has widened its indication to a variety of parasellar and paraclival lesions [13, 15, 22, 23, 26–28]. There are also some reports about endoscopic removal of the clival chordoma with promising results [7, 9, 11, 14, 24]. If the tumor invades laterally, however, visualization and management of the tumor in the retro-carotid space under the straight view endoscope become restricted [3, 7, 8, 11, 23, 28]. To overcome the limitation, we applied a side-viewing endoscope and added surgical maneuvers with malleable and/or steerable instruments in four patients with clival chordoma. The surgical technique and feasibility of the approach are demonstrated.

Clinical materials

Among 13 patients harboring clival chordoma treated from March 2005 to August 2010, four patients were thoroughly treated under the endoscope via the transnasal route. Three were recurrent cases and had been treated previously by the microscopic transsphenoidal approach. The demographic

data of the patients are listed in Table 1. The tumor in all cases demonstrated lateral extension into the space just behind the paraclival internal carotid artery.

Surgical procedure

After induction of general anesthesia, a lumber drain was placed in the patient with obvious intradural tumor extension. A binostril endoscopic transseptal approach was performed under navigational guidance (Vector Vision Compact, Brainlab AG, Germany). Bayonet-style rigid lens scopes with 4.0-mm diameter and 0-, 30- and 70-degree viewing directions were used (Fig. 1). Scopes were attached to the specially designed pneumatically driven holding system (EndoArm, Olympus Co, Tokyo, Japan) enabling the bimanual surgical maneuver by a single surgeon [6, 19]. In the initial nasal phase, the 0-degree endoscope was employed. The middle turbinate was partly resected, and wide sphenoidotomy was performed to expose the vidian canal and paraclival carotid artery on the side, to which the tumor demonstrated lateral extension. The micro-Doppler probe was used for accurate identification of the carotid artery. The major compartment of the tumor and the granulomatous tissue, if present in the recurrent case, were removed with the regular surgical instruments. For visualization of the residual tumor within the space posterior to the paraclival carotid artery, 30- and 70-degree side-viewing endoscopes were introduced. The endoscope was placed at the contralateral edge of the upper clivus with the lens directed to the lesion side (Fig. 2). A subsequent surgical maneuver under the side-viewing endoscope was performed using various modified instruments with malleable/steerable tips. The tumor was dissected from the clival dura and surrounding bone in a semi-sharp fashion. The remnant in the deepest part attached to the medial cavernous sinus wall was grasped and removed gently using the steerable forceps, the tip of which can be bent and rotated at an arbitrary angle [17]. Essentially, the bimanual maneuver was the principle method. The curved suction tube held in the left hand supported the dissection and grasping maneuver performed with the right hand. In the patient with prominent intradural tumor extension resulting in a large dural defect, the reconstruction was performed with the multilayer technique applying the abdominal fat and fascia as an inlay graft covered by the vascularized septal mucosal flap, which was held in place by the sinus balloon (Fuji Systems Corp., Tokyo, Japan) for 5 to 7 days. In other patients, the septal mucosa was placed back in its original configuration.

Results

The retro-carotid tumor compartment was grossly removed in all cases under the 30- and 70-degree side-viewing endoscopes. The range of the maneuver reached the lateral border of the trigeminal impression. There was neither tight tumor adhesion to the carotid artery nor major arterial bleeding encountered in this series. Both patients presenting with abducens nerve palsy demonstrated full resolution of the symptom within 3 months. A single case was complicated by abducens nerve palsy (case 2), which resolved after 6-month follow-up, and another by cerebrospinal fluid (CSF) leakage, which required surgical revision (case 1). The latter was a recurrent case after linac-based stereotactic radiotherapy, and the impaired blood supply to the nasoseptal flap was considered the cause of the failure. There was no other morbidity or mortality. There has been no recurrence during the mean postoperative follow-up of 21.3 months, and all patients are symptom free.

Table 1 The demographic data of the patients

Case	Age/sex	Symptoms	Prev. OP/RT	Extent of resection	Complication	Follow-up (months)
1	64/F	CN VI palsy	+/Linac-SRT	Gross total	CSF leakage	30
2	56/F	None	-/-	Gross total	CN VI palsy	28
3	66/M	CN VI palsy	+/-	Gross total	None	14
4	41/M	None	+/Heavy P	Gross total	None	13

Prev., previous

OP, operation (microscopic transsphenoidal surgery)

RT, radiation therapy

CN, cranial nerve

Linac-SRT, linac-based stereotactic radiation therapy

CSF, cerebrospinal fluid

Heavy P, heavy particle-beam radiation therapy

Fig. 1 A photograph showing the bayonet-shaped configuration of the endoscope. Close-up view of the tip with 70-degree side-viewing lens is demonstrated in the inset

Illustrative case

This 66–year-old man presented with progressive paresis of the left abducens nerve. He had been treated for clival chordoma 4 years before with a microscopic endonasal transsphenoidal approach. The MRI demonstrated tumor recurrence at the lower clivus extending to the left upper paraclival area posterior to the carotid artery (Fig. 3a and b). He underwent a second surgery with an endoscopic endonasal approach. The middle turbinate was resected on the left side, and the sphenoid floor was widely drilled out.

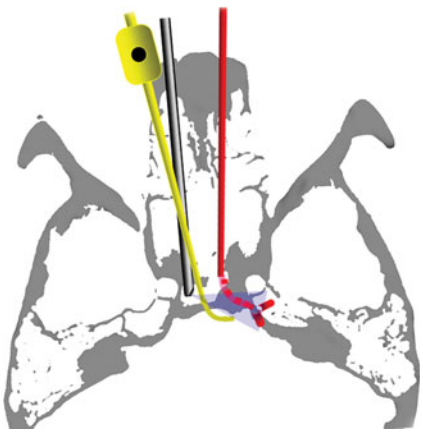

Fig. 2 Illustration demonstrating the operative setting for the surgical maneuver under the side-viewing endoscope. The endoscope (gray) was inserted in the patient's right nostril, keeping some distance from the target. The curved sucker (yellow) and dissector or forceps (red) were inserted in the left and right nostril, respectively

The left paraclival carotid artery was skeletonized with the drill and indentified with the micro-Doppler probe. After removing the granulomatous tissue within the sphenoid sinus with the ultrasonic aspirator, a grayish elastic soft tumor was encountered in the depth (Fig. 4a and b). The major compartment of the tumor was dissected from the clival dura and removed under the straight view endoscope, but the laterally extended tumor compartment could not be visualized. An endoscope with a 30-degree viewing direction was introduced at the right mid-clivus with the lens directed to the left. This clearly demonstrated the tumor confined in the space posterior to the carotid artery and medial to Dorello's canal (Fig. 4c and d). Using the malleable dissector, the tumor was dissected from the clival dura in a semi-sharp fashion. After the tumor had been freed from the surrounding structures, it was grasped and removed with steerable forceps in a piecemeal fashion. For removal of the most lateral tumor compartment, visualization with the 70-degree side-viewing endoscope was necessary (Fig. 4e and f). After the tumor had been totally removed, the medial cavernous sinus wall and petrous apex bone were evident (Fig. 4g and h). There was moderate venous bleeding encountered from the cavernous sinus, but this could be controlled with cottonoid plugging. The postoperative MRI demonstrated gross total removal of the tumor, including the retro-carotid compartment (Fig. 3c and d). The abducens nerve palsy disappeared immediately after surgery, and the postoperative course was uneventful.

Discussion

Surgical treatment of the clival chordomas still presents a challenge to the neurosurgeon despite the establishment of various skull base approaches to the clivus [1, 5]. With the recent technical advancements in endoscopic surgery, an endoscopic endonasal approach is becoming indicated for this lesion [7, 9, 11, 14, 23, 24]. The petrous apex behind the carotid artery, to which the clival chordomas frequently extends, is, however, often obscured, constituting the lateral limit of the approach [3, 7, 8, 11, 23, 28]. The endoscopic transpterygoid approach is a valid option for accessing such laterally extended tumor compartments [9, 13, 15]. However, if the tumor itself is not expansive, dislocating the carotid artery and providing enough space for the approach, resection of certain amount of the surrounding structures becomes mandatory. Even if this is done, the most lateral tumor compartment may be still obscured. Instead, the technique described in this case series follows the direction of the tumor extension, circumventing the carotid artery. In this way, the lesion can be followed without retraction of the carotid artery, allowing gross total removal of that particular compartment. Although the follow-up period is brief and a longer time is needed to

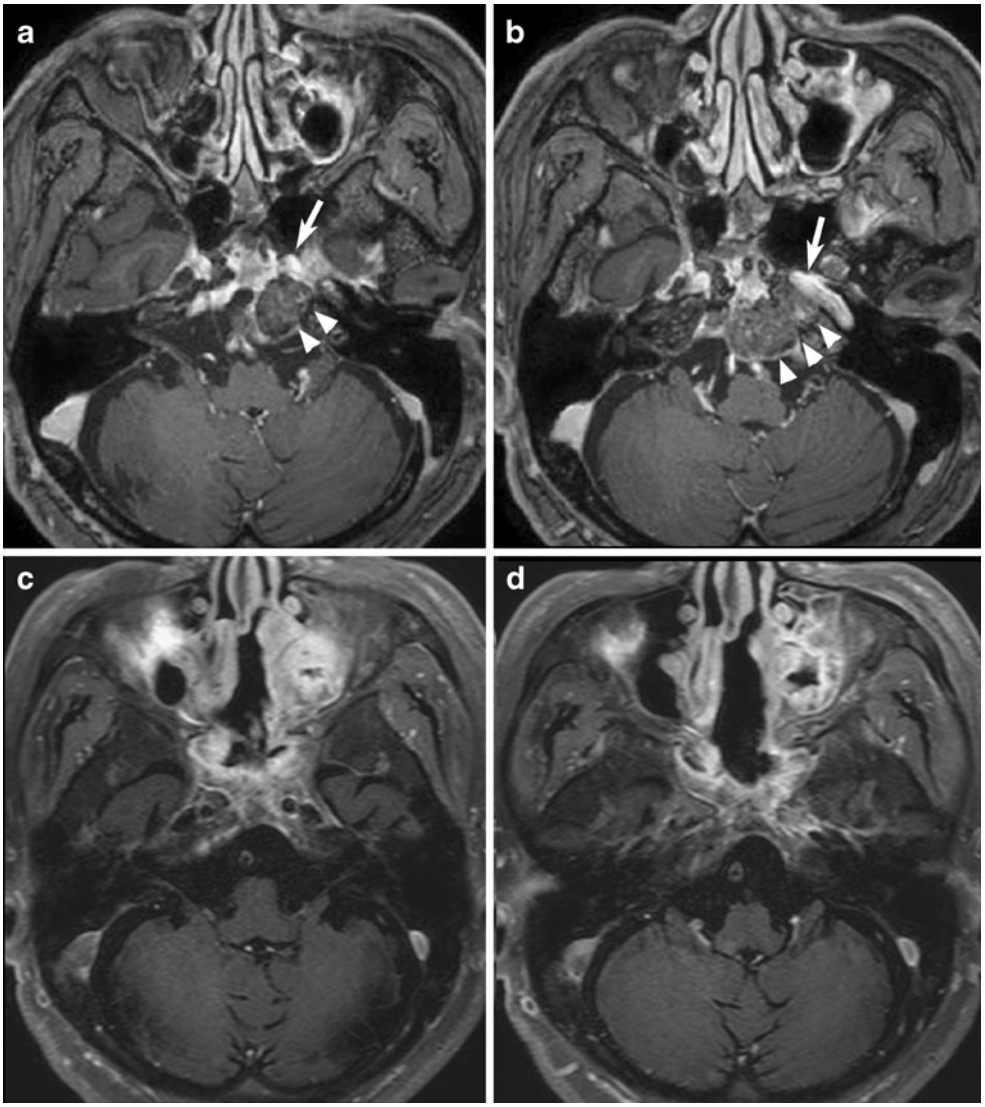

Fig. 3 Preoperative fat suppression Gd-enhanced MRIs of patient 3 (**a** and **b**) demonstrating a clival chordoma extending to the space posterior to the left carotid artery. Arrowheads indicate the lateral extension of the tumor, and the arrow indicates the course of the paraclival carotid artery. The postoperative MRIs (**c** and **d**) demonstrate gross total removal of the tumor. Note the complete removal of the tumor compartment from the space posterior to the left carotid artery

evaluate its effectiveness in long-term tumor control, this technique could provide a new dimension in the endoscopic management of the clival chordoma.

There have been some sporadic presentations about the use of the side-viewing endoscope during the endoscopic endonasal approach [3, 10, 15]. The details of the surgical maneuver, however, have seldom been described. Simple suctioning with a curved suction tube and curettage may be the most feasible and frequently used technique. For appropriate management of the tumor with a certain consistency, however, a more sophisticated surgical maneuver with specially designed instruments is necessary. Forceps with a steerable tip (Flexible Curette Forceps, Mizuho Co., Tokyo, Japan) and malleable dissectors were the most regularly used instruments in this series. Even in the retro-carotid space near the lateral border of the trigeminal impression, the surgical maneuver with these instruments can be performed with enhanced safety and certainty under visual control provided by the side-viewing endoscope [25]. The armamentarium, however, is still not satisfactory, and further development of steerable instruments with various types of tips is an urgent requirement. Moreover, some form of curved drill would be helpful for cases with prominent tumor invasion into the petrous apex bone.

The major concern when performing surgery under the side-viewing endoscope is bleeding management. We usually reduce the risk by performing a bimanual surgical maneuver similar to that performed under the surgical microscope. In this way, certain kinds of bleeding can be managed properly by compression and/or cauterization of the responsible vessels [16]. Profuse arterial bleeding from the carotid artery, however, would be more formidable, and if a such situation is highly indicated, the proximal carotid artery should be secured in advance at the lower paraclival level or even at the cervix. For possible profuse retrograde flow, the exposure of the distal carotid artery in the cavernous sinus would also be necessary. Fortunately, as

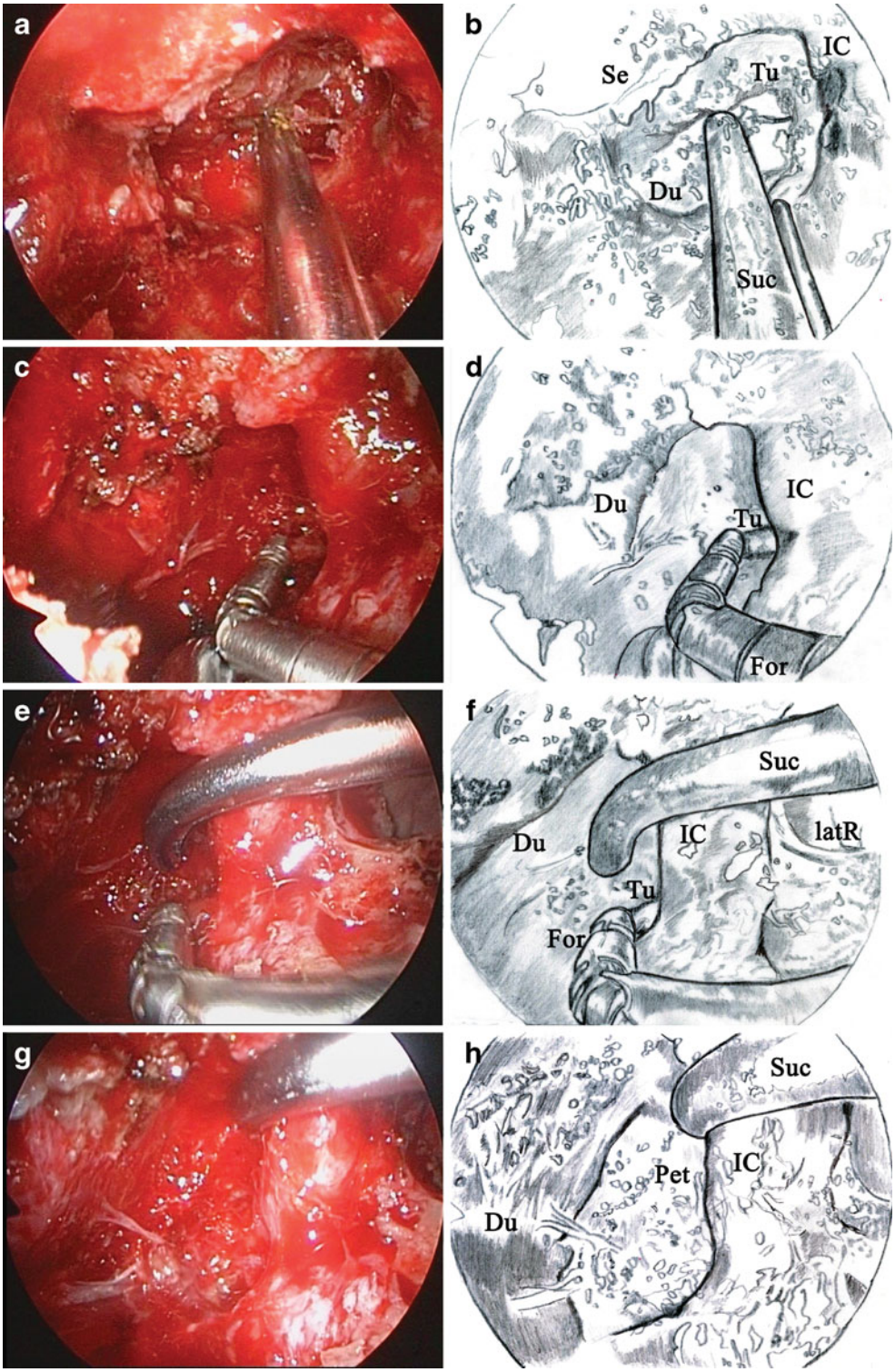

Fig. 4 Intraoperative photographs and illustrations of the endoscopic endonasal approach to the clival chordoma in patient 3. The tumor is removed using a 0-degree endoscope (**a** and **b**). With the 30-degree side-viewing endoscope, the tumor compartment posterior to the left carotid artery becomes visible and is removed with the steerable forceps (**c** and **d**). The most lateral tumor compartment just behind the carotid artery is removed under the 70-degree side-viewing endoscope (**e** and **f**). After gross removal of the tumor, the petrous apex bone is exposed (g and h). IC: paraclival internal carotid artery, Tu: tumor, Se: sellar floor, Du: clival dura, Suc: suction tube, For: steerable forceps, latR: lateral recess of the sphenoid sinus, Pet: petrous apex bone

the clival chordoma rarely invades the carotid artery, dissecting, grasping and piecemeal removal of the tumor adjacent to the artery can be accomplished relatively safely [12, 20]. In malignant or recurrent cases, however, the surgeon should always be prepared for possible carotid invasion and serious injury during the dissection.

Conclusion

The recent endoscopic endonasal approach provided promising results in treating the clival chordoma. The lateral access, however, is often limited by the presence of the paraclival carotid artery. With the application of the side-

viewing endoscope, the lesion behind the carotid artery became accessible, and the surgical maneuver could be accomplished with specially designed instruments. Though longer follow-up is needed to confirm its long-term efficacy in tumor control, this technique may become one option for the treatment of clival chordoma.

Conflicts of interest None.

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