Neurol Med Chir (Tokyo) 54, 991–998, 2014

doi: 10.2176/nmc.st.2014-0135
Online November 29, 2014

Special Theme Topic:
The 20th Annual Meeting of the Japanese Society for Neuroendoscopy

Transoral vs. Endoscopic Endonasal Approach for Clival/Upper Cervical Chordoma

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Abstract

The surgical results of 18 cases of clival/upper cervical chordoma treated in the last decade via the endoscopic endonasal approach (EEA, 9 cases) and the transoral-transpalatal approach (TO-TPA, 9 cases) were compared. Each group showed the same incidence of subdural invasion, with 5 cases each. The superior (frontal base) and lateral surgical fields were wider by EEA, but the inferior view lower than the cranio-vertebral junction (CVJ) was wider by TO-TPA. Gross total removal was achieved in 3 cases in the EEA group, but in only 1 case in the TO-TPA group. Differences in radicality might be due to the extent of the lateral and subdural overview. However for large tumors extending below the CVJ, TO-TPA was the only viable approach for surgical removal. Surgical complications were higher in the EEA (4 cases) than the TO-TPA group (1 case), and were mainly caused by aggressive management of subdural invasion in the EEA group. Post-operative oral intake was earlier and the operative time was shorter in the EEA group. The surgical results were more radical and less invasive in the EEA group than the TO-TPA group. However in tumors extending below the CVJ, the surgical field in EEA was limited, indicating the need to use the transoral route or a combination of routes. A higher complication rate following subdural management was a negative factor that requires improvement in the EEA group and two-staged EEA followed by a transcranial approach may be considered for the cases with subdural invasion.

Key words: cranio-vertebral junction, endoscopic endonasal approach, transoral approach, transpalatal approach

Introduction

Arising from notochord remnants such as the clivus, retropharyngeal space, and the ventral part of the cranio-vertebral junction (CVJ), chordoma has been considered a clinically malignant tumor because of its active biological nature. Maximal resection of the tumor is required because these tumors have high recurrence rates, and controversially, the surgical treatment should be minimally invasive to maintain the patient's activities of daily living (ADL).[1–5] Gross total resection is difficult because of tumor extension and surgeons should select the most suitable approach. Historically, various midline anterior approaches to the CVJ have been employed. The transoral approach (TOA) is one of the midline anterior approaches, and provides a direct extradural route without brain retraction around the CVJ. Surgical exposure via the TOA is limited by the extent of the patient's mouth opening, and TOA has been modified in various ways to extend the surgical field for caudal and rostral tumor extension. These modifications include the transpalatal approach (TPA), the transmaxillary approach, and the mandibular swing-transcervical approach.[6)] TPA can offer a TOA surgical field for rostral tumor extension by removal of the hard palate. However, these approaches are invasive and reconstruction takes many hours. The recently developed endoscopic endonasal approach (EEA) is useful for treating lesions not only in the sella

Received April 21, 2014; Accepted August 11, 2014

turcica but also around the clivus. This approach is considered minimally invasive to neurovascular structures, changing the history of treatment of skullbase tumors.[7–16] However, removal of lesions around the CVJ is difficult even when using the EEA, because the hard palate is located at the same level as the CVJ, and the surgical view of lesions around the CVJ when using the EEA is obstructed by the hard palate.

The present study is a retrospective analysis of chordomas operated in a single institution and resected by EEA or transoral-transpalatal approach (TO-TPA) during the period 2002–2012. The study aimed to compare the surgical results and find a suitable approach for clival and upper cervical chordomas.

Patients and Methods

Between 2002 and 2012, 18 patients—11 females and 7 males—aged 10–78 years (mean 43.5 years), underwent EEA or TO-TPA. Each approach was performed on nine patients. We started using the EEA in conjunction with the Department of Otolaryngology in 2008. Subsequently, the transnasal approach with a microscope was replaced with endoscopy. TO-TPA was performed in conjunction with the Department of Plastic surgery. The patients' symptoms, upper and lower limits of surgical location, extent of resection, incidence of cerebrospinal fluid (CSF) leakage and complications were analyzed. The upper and lower margins of the tumor were confirmed by pre-operative magnetic resonance imaging (MRI). The degree of resection was classified as gross total removal (GTR, confirmed by surgical observation and MRI after surgery), subtotal removal (STR, more than 90%), or partial removal (PR, less than 90%). Operative time, pre- and post-operative Karnofsky performance status (KPS) scores, and hospitalization were analyzed in both groups. Post-operative KPS was evaluated at discharge. Hospitalization does not include the stay for post-operative radiation therapy.

Operative Procedures

I. Transoral-transpalatal approach

General anesthesia was performed using standard endotracheal intubation. The patient was positioned supine with the head down using a shoulder pad, without head fixation. A 2-cm incision was made in the mucosa of the midline gingivo-buccal sulcus and the anterior nasal spine was exposed. The submucosal nasal floor was dissected along the palate, and the nasal septum cut and freed from the palatal bone. After this procedure, a Crockard retractor was attached to open the mouth.

A U-shaped mucosal incision was made on the palate, along the maxillary alveolar process to the second/third molars (Fig. 1). A midline palatal incision was added along the palatine raphe, sparing the uvula, to form the muco-periosteal flaps, which were supplied by the palatal artery, and were retracted laterally using strings (Fig. 2). The exposed palatal bone was drilled and cut along the margin of the mucosal incision using a chisel, and the horseshoe-shaped palatal bone was removed. By retraction of the muco-periosteal flaps using the Crockard palatal arms, a long surgical field from the posterior nasal cavity to the pharynx was obtained (Fig. 3). In the middle surgical field, the pharyngeal tonsil was observed. The epidural tumor was exposed using

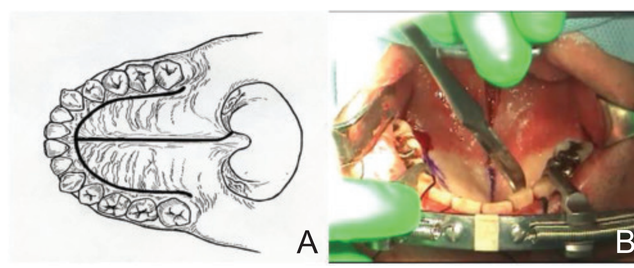

Fig. 1 **A U-shaped mucosal incision is made on the palate. A: A drawing of the mucosal incision. The midline incision is made on the palatine raphe, avoiding the uvula. B: A mucosal incision is made along the maxillary alveolar process to the second/third molars.**

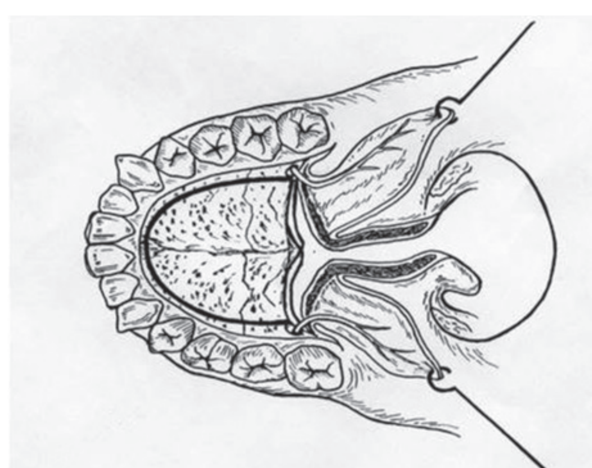

Fig. 2 **Muco-periosteal flaps are elevated from the palatal bone. The soft palate is divided along the midline, forming palatal flaps. The great palatine artery is preserved in the pedicle of the flap. The *solid line* shows the osteotomy line.**

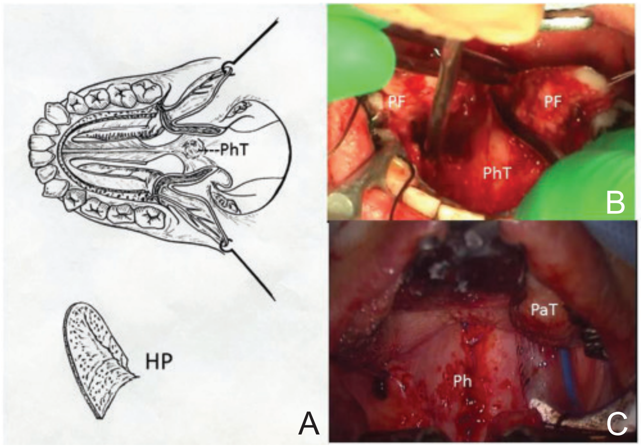

Fig. 3 After removal of the palatal bone. A: A drawing of the surgical field after the HP has been removed. Nasal septum is seen in the center. A long surgical field from the posterior nasal cavity to the pharynx is obtainable, by retraction of the palatal flaps bilaterally. B: A superior view of the naso-pharynx. C: An inferior view of the pharynx (Ph). HP: hard palate, PaT: palatal tonsil, PF: palatal flap, PhT: pharyngeal tonsil.

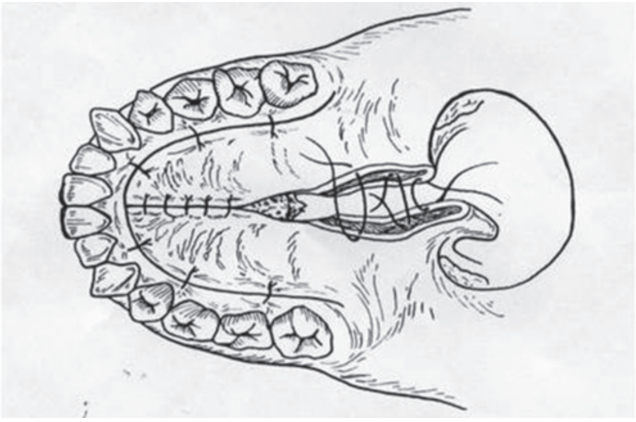

Fig. 4 A drawing of reconstruction of the palate. The hard palate is replaced and fixed by suturing of the palatal flaps in two layers.

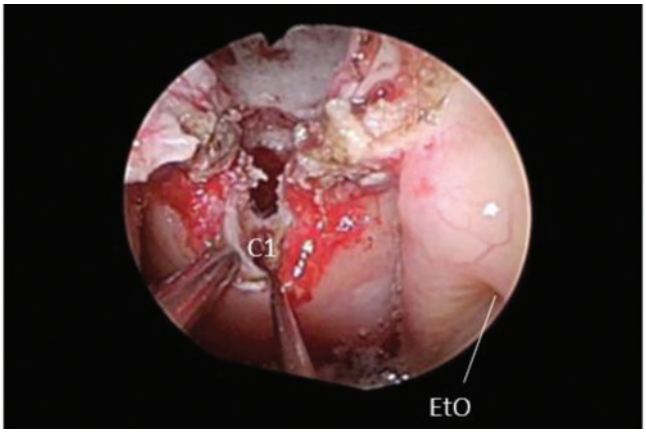

Fig. 5 Exposure of lower clivus and C1 in EEA for a tumor located around the CVJ. CVJ: cranio-vertebral junction, EEA: endoscopic endonasal approach, EtO: Eustachian tube orifice.

a straight or S-shaped pharyngeal incision. The surgical field covered the total length of the clivus, cranio-cervical junction, and C2 body. Bone resection along the tumor margin is required to achieve total resection of the chordoma. In a tumor with subdural invasion, the dural defect was covered with abdominal fat and coated with fibrin glue, and the mucosa was tightly sutured. Cases in which a mucosal defect was present, especially on the pharyngeal tonsil, a septal mucosal flap was used for closure. After tumor removal, the palatal bone was replaced and fixed by suturing the muco-periosteal flap in two layers (Fig. 4). The tracheal tube was removed the next day, but tube feeding was necessary for 1 week after surgery.

II. Endoscopic endonasal approach

The surgical approach and tumor resection were performed using a straight 4-mm endoscope; observations were made using angled scopes. An image guidance technology navigation system was also used. Resection of the right middle turbinate was performed and a nasoseptal flap was created. When the tumor extended into the subdural space, the binostril four-hand technique was applied to obtain a wider surgical space, and the posterior segment of the nasal septum was resected. Drilling of the floor of the sphenoid sinus and clivus were performed towards the CVJ, if necessary (Fig. 5). The vidian canal was a good landmark for the carotid arteries. The subdural component was removed carefully because the tumor was noted to involve the basilar arteries and brainstem. Reconstruction was performed using a multilayer approach: the fascia as a subdural inlay, a pedicled nasoseptal flap to cover the fascia, and oxidized cellulose with fibrin glue at the dural and osseous edges. Pressure was applied using a 14-F Foley catheter to maintain the multilayer reconstruction. Three or four days after the operation, the catheter was removed.

Results

The upper limit of the surgical approach was the frontal skull base in both TO-TPA and EEA. For EEA, the upper limit was the posterior wall of the frontal sinus, and for TO-TPA, the upper limit was the optic chiasma. The lower limit of the surgical approach was the C3 vertebral body in TO-TPA, and the C1 level in EEA.

Table 1 shows a clinical summary and the surgical results for the TO-TPA group, and Table 2 shows those for the EEA group. In the TO-TPA group, GTR was limited in a case of upper cervical chordoma (Case 9). However other large tumors extending from the clivus to the upper cervical spine were not completely removed (STR 4, PR 4) because of lateral tumor extension into the parapharyngeal space. However, in the EEA group, all tumors except one were localized only in the clivus. GTR was achieved in 3 cases and STR in 2 cases, and the incidence of subdural invasion was the

Table 1 Patient characteristics and surgical results in transoral-transpalatal approach

Case	1	2	3	4	5	6	7	8	9
Age/Gender	71F	12F	12F	30M	10F	11F	62M	43M	72F
Symptom	II III IV	V XII	VI IXX	VI VIII	XXIXII	None	VI	VI	None
Upper end	FB	MC	LC	MC	LC	LC	UC	UC	C1
Lower end	C1	C2 body	C2 odontoid	CVJ	C3	C2 body	LC	CVJ	C3
Subdural extension	Yes	Yes	Yes	No	Yes	No	Yes	No	No
Extent of resection	STR	PR	PR	PR	PR	STR	STR	STR	GTR
Intra/post-operative CSF leak	Yes/No	No/No	No/No	No/No	Yes/No	No/No	No/No	No/No	No/No
Other complication	No	No	No	No	No	No	No	No	Pharyngeal fistula
Operative time (hours)	9.41	6.41	9.91	6.30	7.36	9.80	7.55	7.40	3.50
Oral intake	11 POD	10 POD	10 POD	7 POD	12 POD	5 POD	4 POD	7 POD	80 POD
Hospitalization days	53	35	34	17	29	26	16	25	115
Pre-/post-operative KPS	90/90	70/70	80/80	90/90	50/60	100/100	90/90	90/90	90/90

CSF: cerebrospinal fluid, CVJ: cranio-vertebral junction, FB: frontal base, GTR: gross total removal, KPS: Karnofsky performance status, LC: lower clivus, MC: middle clivus, POD: post-operative day, post-operative KPS: KPS at the time of discharge, PR: partial removal, STR: subtotal removal, UC: upper clivus.

Table 2 Patient characteristics and surgical results in endoscopic endonasal approach

Case	1	2	3	4	5	6	7	8	9
Age/Gender	68M	42M	44M	74F	62F	62F	78F	33M	41F
Symptoms	VI	VI	VI	II III	III	III IV	III IV	VI	IV XII
Upper end	UC	UC	UC	UC	UC	UC	FB	UC	UC
Lower end	MC	MC	LC	MC	MC	MC	C1	UC	LC
Subdural extension	No	No	No	Yes	Yes	Yes	Yes	No	Yes
Extent of resection	GTR	GTR	STR	PR	GTR	PR	STR	PR	PR
Intra-/post-operative CSF Leak	No/No	No/No	No/No	No/No	Yes/No	Yes/No	No/Yes	No/No	No/No
Other complications	No	No	No	AHC BSI	Meningitis	DI	Meningitis	No	No
Operative time (hours)	4.71	3.91	4.06	6.00	3.18	8.31	10.18	3.03	3.83
Oral intake	1 POD	1 POD	1 POD	1 POD	1 POD	1 POD	1 POD	1 POD	1 POD
Hospitalization days	17	14	12	39	48	32	182	10	15
Pre-/post-operative KPS	100/100	100/100	90/90	80/60	90/70	90/90	50/50	90/90	100/100

AHC: acute hydrocephalus, BSI: brainstem infarction, DI: diabetes insipidus, FB: frontal base, GTR: gross total removal, KPS: Karnofsky performance status, LC: lower clivus, MC: middle clivus, POD: post-operative day, post-operative KPS: KPS at the time of discharge, PR: partial removal, STR: subtotal removal, UC: upper clivus.

same as that in the TO-TPA group (5 cases each).

Surgical complications were lower in TO-TPA than EEA. One patient, who had been treated with heavy-ion radiation pre-operatively, complained of pharyngeal fistula after surgery. No post-operative CSF leakage was observed in the TO-TPA group; the subdural part was removed only in the case with a dural defect smaller than 10 mm, with the aim of preventing CSF leakage (Fig. 6). In the EEA group, surgical complications occurred in 4 cases: post-operative meningitis with or without CSF leakage, acute hydrocephalus with brain stem infarction, and diabetes insipidus. They occurred only in tumors with subdural extension, and these EEA complications were caused by active surgical removal in the subdural space (Fig. 7). In the TO-TPA group, mean operative time was 7.52 hours. On the other hand, mean operative time was 5.25 hours in the EEA group.

Oral intake was started an average of 15.5 days after surgery in the TO-TPA group, while all patients in the EEA group started oral intake the day after the operation. The mean hospitalization in the EEA group was almost same as that of TO-TPA group: 41 days in the EEA group and 38.9 days in the TO-TPA group. In patients without surgical complication, average hospitalization was shorter in EEA (13.6 days) than TO-TPA group (29.3 days). However 5 patients having surgical complications needed longer hospitalization more than 1 month. According to the pre- and post-operative KPS scores, no patient deteriorated following surgery, with two exceptions in the EEA group with complications (Cases 4, 5).

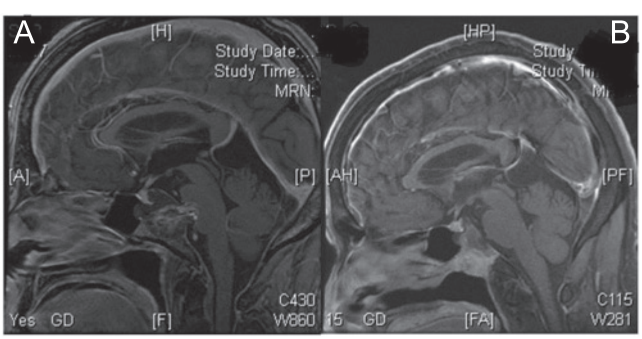

Fig. 6 Case 7, 62 years old male in the TO-TPA group. A: Pre-operative sagittal MRI-Gd shows a clival chordoma with small subdural mass invading into the pons. B: The subdural tumor was removed successfully by TO-TPA, from a dural hole of 7 mm in diameter without CSF leakage, preserving the arachnoid lining. The dural defect was closed with abdominal fat coated with fibrin glue. The patient had no CSF leakage post-operatively. CSF: cerebrospinal fluid, MRI-Gd: magnetic resonance imaging-gadolinium, TO-TPA: transoral-transpalatal approach.

Discussion

Both TOA and EEA have the advantage of providing a direct extradural route without brain retraction. EEA is less invasive with minimal displacement or distortion of surrounding structures.[7]

Upward access of TOA is limited by the degree of mouth opening, the patient's tongue size, and the position of the soft palate. TOA provides midline exposure of the inferior one-third of the clivus. Inferior exposure provided by TOA is limited by the degree of mouth opening and the size of the patient's oral cavity, and is reported to extend from the C2 vertebra down to the C3 vertebra.[6,17] TO-TPA increases the rostral exposure of the TOA by removing the hard palate bone and provides surgical fields superior to the sphenoid sinus. It is useful for removing tumors around the CVJ that extend beyond the hard palate.[6] In a cadaveric study using endoscopy, Visocchi et al. reported that TOA provides better exposure of the CVJ, both in the sagittal and coronal plane.[18] TOA also has the advantage of easier access between the C1 and C3 regions. However, a disadvantage of TO-TPA is the lateral limitation by microscopic axis toward parapharyngeal tumors due to the presence of the

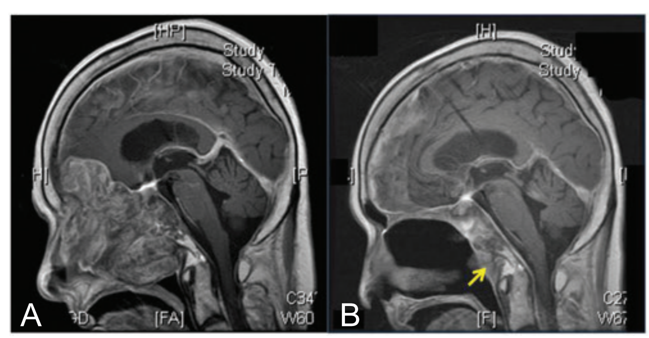

Fig. 7 Case 7, 78 years old female in the EEA group. A: Pre-operative sagittal MRI-Gd shows a huge tumor in the nasopharyngeal space extending from the frontal base to the C1 level. The frontal base had a large bone defect, and the tumor was covered with a thin dural layer, which had to be removed with the tumor, sparing CSF leakage during surgery. The dural defect was covered with abdominal fat and a septal mucosal flap. B: Post-operative MRI. Most of the tumor was removed by EEA, except for a small residue in CVJ (*arrow*). The patient had post-operative CSF leakage followed by meningitis, which resulted in a long period of hospitalization. CSF: cerebrospinal fluid, CVJ: cranio-vertebral junction, EEA: endoscopic endonasal approach, MRI-Gd: magnetic resonance imaging-gadolinium.

pterygoid process superiorly and atlanto-occipital joint inferiorly. Therefore, tumor invasion into the parapharynx or lateral to the CVJ limits complete removal, and that is the main reason for the lower radicality compared to EEA, as shown in this article.

TPA is currently partially being replaced by EEA. EEA was developed as a new strategy for treating skull base tumors, the surgical field extending upward to the frontal sinus and downward to the CVJ, decreasing the lateral dead angle. Although the lateral limit of the EEA is basically the internal carotid artery (ICA),[19] by using transpterygoid approach cavernous sinus lateral to the ICA and furthermore middle cranilal fossa can be reached.[20] The lesion in the dorsum sellae or posterior clinoid could be resected by superior transposition of the pituitary gland and infundibulum.[21] It was reported that EEA has 100% GTR rates in mid-clival chordomas, but this percentage decreases to 50% for lower clival lesions, even when treated in the most technologically advanced institutions.[19] EEA should be preferred for clival lesions,[10] but it remains difficult to use this approach for lesions around the CVJ, because the operative tool is hampered by the hard palate. The nasopalatine line (NPL) and the nasoaxial line (NAxL), as defined in sagittal computed tomography (CT) images, predict the inferior limit of usefulness of the EEA.[23,24] The NPL connects the inferior point of the nasal bone to the posterior edge of the hard palate in the mid-sagittal plane. The NAxL connects the midpoint of the line from the rhinion to the anterior nasal spine of the maxillary bone, to the tip of the posterior nasal spine of the palatine bone. The NPL predicts the inferior limit to be the C2 body.[23] NAxL predicts the inferior limit to range from the dens to the upper half of the C2 body. Aldana et al. reported that the NAxL is more accurate for predicting this lower limit, while the NPL overestimates the inferior surgical dissection limit, based on cadaver dissections.[24]

In this study, C1 was the most inferior level in the EEA series, while the C3 vertebral body was the most inferior level in the TO-TPA series for surgical resection. Figure 8 shows the range of TOA, TPA and EEA in the sagittal plane. EEA can be used if the tumor lies above the C1 and C2 odontoid processes, but one should consider selecting TOA when it extends below the C2 vertebral body. Therefore, a combination of endoscopic TOA and EEA will be a better option for large tumors extending from the upper clivus to the C2 body. Such a combination may increase the radicality by extending the superior and lateral overview through the endoscope, thus avoiding an invasive palatal incision.

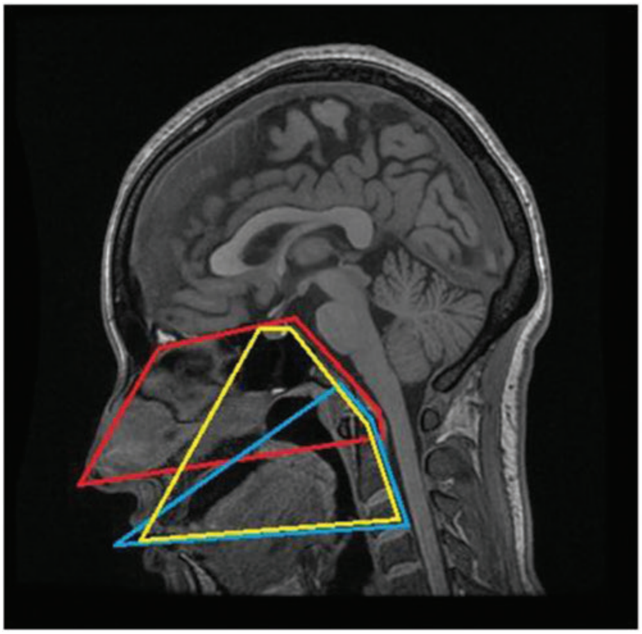

Fig. 8 **Limits of each approach in the mid-sagittal plane on MRI. *Red line* indicates EEA, *blue line* TOA, and *yellow line* TO-TPA. The surgical field of TO-TPA overlaps with that of EEA in the upper areas, and with that of TOA in the lower areas. EEA: endoscopic endonasal approach, MRI: magnetic resonance imaging, TOA: transoral approach, TO-TPA: transoral-transpalatal approach.**

Subdural tumor removal has been a risk factor for CSF leakage and infection via the transnasal/oral routes. A comparison of bacterial colonization rates in transoral and transnasal nasopharyngeal samples revealed higher rates in transoral nasopharyngeal swabs.[25] Therefore in the current series the subdural lesion was removed by TO-TPA only in a case in which the subdural mass was smaller than 10 mm. The dural defect was closed safely using abdominal fat and a mucosal covering in the pharynx in such cases. This might explain the low incidence of CSF leakage and meningitis in our series of TO-TPA. In the EEA group, however, removal of the subdural part was more aggressive than in the TO-TPA group, resulting in a high rate of meningitis or brain stem infarction with or without post-operative CSF leakage. The mucosal layer of the naso-pharynx around the pharyngeal tonsil is very fragile and it is difficult to achieve primary mucosal closure as in the pharynx; in addition, complete closure by EEA is not easy in the case of a large dural defect, even when using a naso-septal mucosal flap. In case of a large subdural mass, two-stage EEA followed by a transcranial approach, such as the suboccipital condylar approach[26] or condylar fossa approach[27] may be more effective than EEA alone at preventing CSF leakage and infection.

Finally, it should be noted that most chordomas are likely to regrow, even when surgery seems to suggest GTR. Therefore, selection of the surgical method should be based not only on the degree of removal, but also on how to maintain the patient's quality of life (QOL) in combination with additional radiosurgery or a second operation.

Conclusion

EEA is a less invasive and a more effective surgical method for chordomas localized in the clivus, for giving a better lateral overview than the microscope. However, in cases in which the tumor extends down to the C2 body, TOA, or a TOA/EEA combination should be considered. Reducing the surgical complications during or after removal of the subdural part is an important task for EEA.

Conflicts of Interest Disclosure

The authors have no conflict of interest directly relevant to the content of this article.

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