Less Invasive Modified Extradural Temporopolar Approach for Paraclinoid Lesions: Operative Technique and Surgical Results in 80 Consecutive Patients

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Abstract

Keywords

- ▶ extradural temporopolar approach
- ▶ paraclinoid aneurysm
- ▶ paraclinoid tumors
- ▶ skull base technique
- ▶ anterior clinoid process

Background Extradural temporopolar approach for paraclinoid lesions can provide extensive and early exposure of the anterior clinoid process, and complete mobilization and decompression of the optic nerve and internal carotid artery, which can prevent intraoperative neurovascular injury. The present study investigated the usefulness of our less invasive modified technique and discussed its operative nuances.

Methods We retrospectively reviewed medical charts of 80 consecutive patients with neoplastic (21 patients) and vascular lesions (59 patients) who underwent the modified extradural temporopolar approach between September 2009 and March 2014.

Results Preoperative visual acuity worsened in 4 patients (5.0%) and worsening of visual field function occurred in 10 patients (12.5%). Postoperative outcome was good recovery in 71 patients, moderate disability in 6, severe disability in 2, and death in 1 (due to reruptured aneurysm). No operation-related mortality occurred in the series.

Conclusion Less invasive modified extradural temporopolar approach is safe and can be recommended for the surgical treatment of deeply located aneurysms and skull base tumors to reduce the risk of intraoperative optic neurovascular injury.

Introduction

Surgical management of paraclinoid lesions^{1–4} may require removal of the anterior clinoid process (ACP), which is one of the essential skull base techniques performed for better exposure of the carotid artery, and enlargement of the opticocarotid triangle.⁵ Therefore, removal of the ACP can provide improved access and exposure of the anatomical structures, reducing the risk of intraoperative neurovascular injury, because the optic nerve can be decompressed, visualized early, and mobilized safely.

Extradural complete removal of the ACP was introduced by Dolenc in 1983.⁶ Selective extradural anterior clinoidectomy introduced some modifications,⁷ which achieved significant improvement in visual outcome in patients with clinoidal meningiomas.^{4,8} Extradural temporopolar approach (ETA) is a variant of Dolenc's technique and provides a surgical corridor to the central skull base via the opened cavernous sinus (CS).³ The disadvantage of the ETA is the risk of injuring the neurovascular structures passing through the superior orbital fissure (SOF) during dissection.⁹ However, we have modified this approach,

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based on the histological findings of the lateral CS, to provide less invasive but adequate exposure of the ACP.^{10–13}

The present study investigated the usefulness of this modified approach and operative techniques and evaluated the surgical outcomes with special emphasis on the clinical and visual outcomes for paraclinoid lesions in a series of 80 consecutive patients.

Patients and Methods

Patient Characteristics

This retrospective analysis included 80 consecutive patients, 65 women and 15 men aged from 24 to 78 years (mean 53.5 years), with neoplastic and vascular lesions who underwent extradural anterior clinoidectomy with the trans-SOF approach at the National Defense Medical College Hospital and Juntendo University Shizuoka Hospital between September 2009 and March 2014. Medical charts, radiological findings, surgical techniques, complications, and final results of anterior clinoidectomy were retrospectively reviewed.

The topography of all tumors was analyzed accurately using preoperative magnetic resonance imaging (MRI) and intraoperative surgical assessment. Tumor size, obtained by measuring the greatest diameter in any single plane on the preoperative MRIs, ranged from 15 to 50 mm (mean 23.3 mm). The extent of tumor removal was based on intraoperative assessment and contrast-enhanced computed tomography (CT) and/or MRI performed on the day after surgery. Three-dimensional CT angiography (3DCTA) and/or digital subtraction angiography (DSA) are essential to investigate paraclinoid and basilar artery (BA) aneurysms. The ACP size, shape, pneumatization, and relationship with the sphenoid or ethmoid sinus were assessed on bone CT scans for safe clinoidectomy.

All patients underwent detailed pre- and postoperative evaluation of visual function, which consisted of testing visual acuity with optimum correction lenses for both eyes, visual field examinations, and fundoscopy.

Surgical Procedure

Extradural Procedure

After induction of general anesthesia, spinal drainage is performed just before positioning in the surgical posture to avoid postoperative cerebrospinal fluid (CSF) leakage and ensure adequate brain relaxation to obtain full exposure of the epidural space. Intraoperative monitoring procedures of the motor evoked potentials and visual evoked potentials are prepared to ensure safe clipping. The patient is placed in the supine position, and the head is rotated away from the operative side at ~30 degrees. A semicoronal skin incision is performed followed by interfascial dissection. In the case of paraclinoid aneurysm, the cervical carotid artery is routinely exposed for proximal control, suction decompression, intraoperative angiography, and high-flow bypass if necessary. A standard frontotemporal craniotomy is performed up to the supraorbital notch, and the temporal squama is

rongeured out until the floor of the middle cranial fossa is exposed, followed by orbitozygomatic osteotomy if needed to treat large or giant aneurysm and high-positioned BA complex aneurysms, and the orbitozygomatic bar is removed as in the two-piece method. The frontal dura and the temporal dura are subperiosteally dissected. The lesser wing of the sphenoid is flattened until the meningo-orbital band (MOB) is exposed. The middle fossa dura is dissected until the SOF and the foramen rotundum (FR) are exposed. The roof of the SOF is skeletonized and opened to expose the junction between the dura propria of the temporal lobe and the periosteal dura (→Fig. 1A). The bone around the MOB is drilled. The orbital apex is partially opened around the base of the ACP at the lateral extent of the SOF. The periorbita is partially exposed. The tip of the microscissors should be pointed at the dura propria junction at the SOF and the MOB is incised. The dura between the SOF and FR is partially incised. Peeling of the dura propria is started from the lateral wall of the SOF (→Fig. 1A) and continued until the ACP is exposed epidurally (→Fig. 1B). Care should be taken to maintain the sphenoparietal sinus on the dura propria side and to stop the peeling at the point where the sphenoparietal sinus drains into the CS to prevent postoperative problems with venous congestion. Before drilling of the ACP, dissection of the inferolateral part of the ACP, where the extradural part of the oculomotor nerve passes, is needed to avoid nerve injury. Drilling of the ACP with a high-speed drill using cold saline irrigation is started from the lateral part of the ACP, and the optic canal is then opened partially in the medial part of the ACP using a micro-punch to avoid heat injury, with thinning of the bone along the medial and anterior surfaces of the clinoid process. After removal of the ACP, the clinoid segment (C3) of the internal carotid artery (ICA) can be seen (→Fig. 1C). Final removal of the ACP may induce bleeding from the CS, which is easily controlled with surgical cottonoid and fibrin glue. The partially opened optic canal can be enlarged using a micro-punch, and the remainder of the optic strut between the opened clinoid space and optic canal can be removed with either a small diamond drill or micro-punch to provide space for the clip blade in cases of paraclinoid aneurysm.

Intradural Procedure

The dura mater is opened along the sylvian fissure and continued inferomedially to the level of the optic nerve. Additional wide opening of the sylvian fissure is helpful for minimal retraction of the frontal lobe to expose the ICA and the optic nerve. The posterior communicating artery, anterior choroidal artery, and their branches are identified. In addition, the horizontal portion of the anterior cerebral artery (ACA) is dissected. An incision from the falciform ligament to the optic sheath helps to mobilize the optic nerve. An additional incision is made across the distal dural ring to expose and identify the origin of the ophthalmic artery and to mobilize the ICA. Such incisions of the falciform ligament and distal dural ring will facilitate movement of the optic nerve and ICA.

Fig. 1 Schematic illustration of the operative techniques of modified extradural anterior clinoidectomy. Skeletonization of the superior orbital fissure (SOF) and only minimal dural incision between the SOF and foramen rotundum (FR) where no cranial nerves are present (A, broken line) are performed, because the junction between the dura propria and the periosteal dura is invaginated at the SOF and carries the risk of injury to the cranial nerves. The dura propria should be carefully peeled from the SOF to preserve the sphenoparietal sinus (SPS) on the peeled dura propria until the anterior clinoid process (ACP) is entirely exposed epidurally (B). After removal of the ACP, the optic canal (OC) should be opened using a micro-punch. The clinoid segment (C3) of the internal carotid artery can be seen (C). Abbreviations: C3, clinoid segment of the internal carotid artery; MOB, meningo-orbital band; II, optic nerve; III, oculomotor nerve; IV, trochlear nerve; V1, first division of the trigeminal nerve; V2, second division of the trigeminal nerve.

For BA complex aneurysms, just before the tentorial incision, the sylvian fissure should be opened widely and the arachnoid membrane around the oculomotor nerve should be incised to free the nerve from the medial temporal

lobe. After locating the cisternal and extradural parts of the oculomotor nerve, the medial tentorial edge is shaved from the anterior petroclinoid ligament. Following these procedures, the temporal lobe can be retracted posteriorly with the temporal dura mater to complete the ETA through the surgical corridor of the opened anterior part of the middle fossa and the CS. If the target lesion is located beneath the posterior clinoid process, the latter can be drilled away to expose the pontine cistern to secure the proximal BA. After temporary clips are applied to the BA and bilateral posterior cerebral arteries, aneurysm dissection and clipping are performed.

Microsurgical procedures using the ETA technique for removal of anterior skull base meningioma are performed as follows. The proximal part of the sylvian fissure is opened to drain CSF and to allow relaxation of the brain. After identification of the ipsilateral optic nerve and ICA, the tumor capsule is opened and the tumor is internally decompressed with ultrasonic surgical aspiration. After reduction of tumor volume, the ipsilateral optic nerve and chiasm are decompressed by sharp dissection along the tumor capsule–arachnoid interface. After identification of the contralateral optic nerve, the site of dural attachment is progressively coagulated with bipolar coagulating forceps to interrupt the blood supply. After additional piecemeal tumor debulking, the tumor is removed from underneath the optic chiasm in the contralateral to ipsilateral direction and then from underneath the ipsilateral optic nerve and ICA. The superior pole of the tumor is reduced from beneath the arachnoid covering the ipsilateral ACA. Finally, the tumor is dissected from the pituitary stalk and the interpeduncular cistern. The site of tumor attachment to the dura is widely coagulated with bipolar cautery. CSF leakage is a potential risk if the ethmoid air cells are opened during drilling of the ACP. Therefore, the opened ethmoid air cells should be carefully packed with autologous muscle with fibrin glue sealant.

Results

Patient Characteristics

The clinical characteristics of the patients are summarized in ▶ **Table 1**. Fifty-nine patients were treated for aneurysms, BA aneurysms in 15 and ICA aneurysms in 44. The aneurysm was small (<6 mm) in 24 cases, medium (6–11 mm) in 27, large (>12 mm) in 6, and giant (>25 mm) in 2. The presenting symptoms were subarachnoid hemorrhage (SAH) in 7 patients, asymptomatic in 43, and symptomatic in 6 including visual disturbance in 4, and hypopituitarism in 2. Twenty-one patients were treated for paraclinoid tumors, including medial sphenoidal ridge meningioma in 4, clinoidal meningioma in 3, tuberculum sellae meningioma in 3, CS tumor in 1, craniopharyngioma in 4, pituitary adenoma in 4, sphenoid-orbital cavernoma in 1, and paraclinoid malignant epidermoid in 1. Visual disturbance was the most common initial symptom in the tumor group. Eighteen patients presented with disturbance of visual acuity. Visual field deficits were present in 14 patients: 9 had unilateral nasal anopsia

Table 1 Clinical characteristics of paraclinoid lesions in 80 patients who underwent modified extradural temporopolar approach

	Tumor	Aneurysm
Number of patients	21	59
Age (years)		
Range	24–78	31–78
Mean	54.2	59.9
Sex		
Male	7	8
Female	14	51
Side		
Right	14	37
Left	7	22
Aneurysm size		
Small (< 6 mm)	–	24
Medium (6–11 mm)	–	27
Large (> 12 mm)	–	6
Giant (> 25 mm)	–	2
Aneurysm site		
BA bifurcation	–	6
BA-SCA	–	9
IC paraclinoid	–	23
IC-Pcom (retrocarotid)	–	16
IC-Achor (retrocarotid)	–	4
IC-anterior wall	–	1
Symptom		
SAH	–	7
Non-SAH, enlarged	–	5
Non-SAH, asymptomatic	–	43
Non-SAH, symptomatic		
Visual disturbance	14	4
Diplopia	4	–
Tumor enlargement	1	–
Hypopituitarism	2	2
Types of tumors		
Medial SR meningioma	4	–
Clinoidal meningioma	3	–
TS meningioma	3	–
Pituitary adenoma	4	–
Craniopharyngioma	4	–
CS tumor	1	–
Sphenoorbital cavernoma	1	–
Epidermoid	1	–

Abbreviations: Achor, anterior choroidal artery; BA, basilar artery; CS, cavernous sinus; ETA, extradural temporopolar approach; IC, internal carotid artery; Oph, ophthalmic artery; Pcom, posterior communicating artery; SAH, subarachnoid hemorrhage; SCA, superior cerebral artery; SR, sphenoid ridge; TS, tuberculum sellae.

and 5 had bitemporal hemianopsia. All patients had normal endocrine function except for 2 patients with hypopituitarism caused by mass effect of the tumor.

Surgical Procedures

The surgical procedures are summarized in ▶Table 2. Spinal drainage was induced in 72 patients. Orbitozygomatic craniotomy was additionally performed in 20 of the 80 patients. Total removal of the ACP was performed in 77 patients, and partial clinoidectomy in 3. The optic canal was opened widely in 31 patients and partially in 49. The falciform ligament was cut in 30 patients. The dural ring was incised in 26 patients. Suction decompression was used for clipping of the aneurysms in 10 patients. The cervical ICA was secured in 36 patients for proximal control of the ICA, and high-flow bypass was needed in one.

Total removal of the ACP was performed in 18 patients in the tumor group, and the optic canal was opened widely in 17 patients (▶Table 2). Complete resection of the tumor was achieved in 10 patients (▶Table 3). Subtotal resection was performed in 10 patients, mainly for craniopharyngioma and pituitary adenoma. The residual tumor was visualized during the operation and optic nerve decompression was performed in these 10 patients. However, adhesion between the optic nerve, pituitary gland, and tumor was tight, so tumor extending to the CS could not be completely resected. Partial removal was performed in one patient with medial sphenoidal ridge meningioma, which extended into the contralateral infrachiasmatic region.

Visual Outcome

Overall visual acuity after surgery was improved in 11 patients, unchanged in 62, and worsened in 4 (▶Table 3). Only three patients were impossible to evaluate due to unconsciousness caused by SAH and mass effect. Three patients had improved visual acuity among the four patients with preoperative visual dysfunction caused by aneurysmal compression in the aneurysm group. Visual acuity was improved in 8 patients, unchanged in 10, and worsened in 2 in the tumor group. Visual field deficit was improved in 12 patients, unchanged in 55, and worsened in 10 patients postoperatively. These postoperative visual disturbances were usually confirmed as transient unilateral lower-nasal quadrantanopia, which was definitely detected using a quantitative visual examination without subjective visual symptoms.

Surgical Outcomes

Postoperative outcome was good recovery in 71 patients, moderate disability in 6, and severe disability in 2, and death in 1 (▶Table 3). One patient with ruptured giant ophthalmic aneurysm died of rupture of the remnant unruptured aneurysm located at the distal ACA secondary to severe SAH during postoperative intensive therapy for cerebral spasm. One patient in the tumor group suffered consciousness disturbance due to thalamic dysfunction caused by mass effect and

Table 2 Surgical procedures for paraclinoid lesions in 80 patients who underwent modified extradural temporopolar approach

	Tumor	Aneurysm	Total
Number of patients	21 (100%)	59 (100%)	80 (100%)
Surgical procedure			
Removal of the ACP			
Entirely	18 (85.7%)	59 (100%)	77 (96.3%)
Partially	3 (14.3%)	0 (0%)	3 (3.7%)
Optic canal opening			
Wide	17 (81%)	14 (23.7%)	31 (38.8%)
Partial	4 (19%)	45 (76.3%)	49 (61.2%)
Falciform ligament			
Cut	8 (38.1%)	22 (37.3%)	30 (37.5%)
No-cut	13 (61.9%)	37 (62.7%)	50 (62.5%)
Dural ring			
Incised	0 (0%)	26 (44.1%)	26 (32.5%)
Not incised	21 (100%)	33 (55.9%)	54 (67.5%)
O-Z craniotomy	10 (47.6%)	10 (16.9%)	20 (25%)
High-flow bypass	0 (0%)	1 (1.7%)	1 (1.3%)
Posterior clinoidectomy	0 (0%)	3 (5.1%)	3 (3.8%)
Cervical IC secured	0 (0%)	36 (61%)	36 (45%)
Suction decompression	0 (0%)	10 (16.9%)	10 (12.5%)
Spinal drainage	20 (95.2%)	52 (88.1%)	72 (90%)

Abbreviations: ACP, anterior clinoid process; ETA, extradural anterior clinoidectomy; IC, internal carotid artery; O-Z, orbitozygomatic.

did not show improvement in cognitive dysfunction postoperatively, resulting in severe disability. One patient in the aneurysm group had severe hemiparesis caused by anterior choroidal artery infarction, resulting in severe disability. Direct clipping of the aneurysm neck was achieved in 57 cases, and the only unclippable giant aneurysm located at the paraclinoid segment was trapped with extracranial-intracranial high-flow revascularization. Therefore, all aneurysms were successfully treated with clipping and/or trapping, and postoperative 3DCTA or DSA revealed no major branch occlusion or residual aneurysm. There was no surgical mortality related to ETA in either group.

Complications

No patient suffered postoperative meningitis. Complications are summarized in ▶Table 3. One patient suffered postoperative CSF leakage related to pneumatized ACP. Seven patients developed oculomotor nerve palsy but all recovered within 3 months. One patient suffered transient brain swelling caused by sphenoparietal sinus injury during peeling of the dural layers. Two patients with craniopharyngioma had postoperative transient diabetes insipidus. No permanent neurological deficits were encountered, except in one patient who experienced postoperative hemiparesis due to cerebral infarction of the anterior choroidal artery.

Representative Cases

Case 1

A 67-year-old female presented with mild headache and MRI incidentally discovered paraclinoid aneurysms projecting medial-inferiorly on the right (▶Fig. 2A). The aneurysm was located at the distal side of the distal dural ring (▶Fig. 2B; arrow). The modified ETA was performed and complete clipping was achieved (▶Fig. 2C–G), and the postoperative course was uneventful.

Case 2

A 43-year-old male presented with right progressive visual disturbance. 3DCTA showed a tumor located at the tuberculum sellae (▶Fig. 3A). The ETA with standard frontotemporal craniotomy was performed (▶Fig. 3B–D). Gross total removal was achieved and the postoperative course was uneventful. Postoperative visual examination showed his visual disturbance had improved.

Discussion

Removal of the ACP¹⁴ is one of the essential skull base techniques to treat cerebral aneurysms of the ICA and BA, and skull base tumors. Anterior clinoidectomy can be performed through the intradural approach or extradural

Table 3 Surgical outcome of paraclinoid lesions in 80 patients who underwent modified extradural temporopolar approach

	Tumor	Aneurysm	Total
Extent of tumor removal			
GTR	10 (47.6%)		
STR	10 (47.6%)		
PR	1 (4.8%)		
Visual acuity			
Improved	8 (38.1%)	3 (5.1%)	11 (13.8%)
Unchanged	10 (47.6%)	52 (88.1%)	62 (77.5%)
Worsened	2 (9.5%)	2 (3.4%)	4 (5%)
N.A.	1 (4.8%)	2 (3.4%)	3 (3.8%)
Visual field deficit			
Improved	9 (42.9%)	3 (5.1%)	12 (15%)
Unchanged	8 (38.1%)	47 (79.7%)	55 (68.8%)
Worsened	3 (14.3%)	7 (11.7%)	10 (12.5%)
N.A.	1 (4.8%)	2 (3.4%)	3 (3.8%)
Oculomotor nerve injury	1 (4.8%)	6 (10.2%)	7 (8.8%)
CSF leakage	0 (0%)	1 (1.7%)	1 (1.3%)
Brain swelling	1 (4.8%)	0 (0%)	1 (1.3%)
Diabetes insipidus	2 (9.5%)	0 (0%)	2 (2.5%)
Temporal lobe contusion	0 (0%)	0 (0%)	0 (0%)
Surgical outcome			
GR	20 (95.2%)	51 (86.4%)	71 (88.8%)
MD	0 (0%)	6 (10.2%)	6 (7.5%)
SD	1 (4.8%)	1 (1.7%)	2 (2.5%)
VS	0 (0%)	0 (0%)	0 (0%)
D	0 (0%)	1 (1.7%)	1 (1.3%)

Abbreviations: CSF, cerebrospinal fluid; D, death; ETA, extradural anterior clinoidectomy; GR, good recovery; GTR, gross total removal; MD, moderate disability; N.A., not available; PR, partial removal; SD, severe disability; STR, subtotal removal; VS, vegetative state.

approach.^{3,7} Extradural anterior clinoidectomy is more extensive than the intradural procedure and requires a clear understanding of the anatomical background of the ACP and its surrounding neurovascular structures. In particular, the surgeon must have good knowledge of the osseous structure of the SOF, the neurovascular structures passing through the SOF, and the membranous structures including the MOB and walls of the CS. Extradural anterior clinoidectomy through the trans-CS approach requires peeling of the lateral wall of the CS to expose the entire ACP for drilling.³ Recently, the latter method has been refined by minimizing the area of peeling in the lateral wall of the SOF, including the anterior part of the CS that requires extradural exposure of the ACP.^{15,16} In addition, we have further developed this extradural procedure,^{10–13} based on the histological findings that the junction between the dura propria and the periosteal dura was invaginated at the SOF. This modified approach requires skeletonization of the SOF to expose this junction and needs only minimal dural incision between the SOF and FR where no cranial nerves are present. Compared with

previous surgical procedures, our modified approach can cause fewer surgical complications (►Table 4).

Cadaveric studies have shown that the anterior clinoidectomy technique can double the exposure and mobilization of the optic nerve and ICA, as well as triple or quadruple the opticocarotid triangle width and oculomotor triangle size.^{5,17} ETA facilitates access to such difficult locations, especially in the presence of tumor extension into the CS, optic canal, or infraoptic and subchiasmatic regions. Subsequently, the medial tentorium should be carefully shaved off from the anterior petroclinoid ligament to avoid injury to the extradural part of the oculomotor nerve. After tentorial cutting, the temporal lobe with dura mater can be retracted posteriorly. We have not experienced any temporal lobe contusion due to such retraction. The extension of the dura propria peeling into the CS depends on the individual pathology. In our all patients, the pituitary stalks were preserved, so no one required hormonal replacement or suffered hypothalamic dysfunction postoperatively, and patients with tumors extending into the optic canal achieved improvement in visual deterioration. In addition,

Fig. 2 A 67-year-old female presented with mild headache and magnetic resonance imaging incidentally discovered paraclinoid carotid artery aneurysms on the right (A, B). The extradural temporopolar approach combined with orbitozygomatic osteotomy was performed (C–G). The roof of the superior orbital fissure is skeletonized and opened to expose the junction between the dura propria of the temporal lobe and the periosteal dura, and the anterior clinoid process (ACP) is exposed epidurally (D). After removal of the ACP, the clinoid segment (C3) of the internal carotid artery can be seen (E). The falciform ligament is incised to mobilize the optic nerve (II). An additional incision is made across the distal dural ring to expose and identify the origin of the ophthalmic artery and to mobilize the internal carotid artery. The paraclinoid carotid artery aneurysm is dissected and clipped (F, G). The postoperative course was uneventful. Abbreviations: OC, optic canal; C2, ophthalmic segment of the internal carotid artery; C3, clinoid segment of the internal carotid artery; II, optic nerve; V1, first division of the trigeminal nerve; V2, second division of the trigeminal nerve.

future visual deterioration may be delayed after eventual tumor recurrence or regrowth, because the optic nerve is already decompressed from the surrounding falciform ligament and optic canal. Consequently, the ETA technique was useful for maximal resection of tumors involving the retrochiasmatic space.

In the present study, one patient suffered transient brain swelling caused by sphenoparietal sinus injury during peel-

ing of the dural layers. The sphenoparietal sinus should be carefully dissected and spared at the dura propria. Care should be taken to maintain the sphenoparietal sinus at the dura propria and to stop the peeling at the point where the sphenoparietal sinus drains into the CS to prevent problems with venous congestion. One patient suffered postoperative CSF leakage related to pneumatized ACP. Oculomotor nerve palsies occurred in seven patients but all

Fig. 3 A 43-year-old male presented with right progressive visual disturbance. Three-dimensional computed tomography angiography showed an abnormal lesion located at the tuberculum sellae (A). The extradural temporopolar approach with standard frontotemporal craniotomy was performed. The foramen rotundum (FR) and superior orbital fissure (SOF) are exposed (B). The roof of the SOF is skeletonized and opened to expose the junction between the dura propria of the temporal lobe and the periosteal dura. The anterior clinoid process (ACP) is exposed epidurally (C). After removal of the ACP, the falciform ligament (FL) is incised (D) to mobilize the optic nerve (II). Gross total removal was performed. Postoperative course was uneventful and visual examination showed normalized visual disturbance. Abbreviations: IC, internal carotid artery; V1, first division of the trigeminal nerve; V2, second division of the trigeminal nerve.

Table 4 Comparison of surgical procedure and outcome for various extradural anterior clinoidectomy procedures

	Dolenc ⁶	Yonekawa et al ⁷ SEAC	Day et al ³ ETA	Present series
Surgical procedure				
Orbital unroofing	+	–	–	–
Optic canal opening	+	+	+	+
SOF skeletonization	+	–	+	+
Unroofing FR	–	–	+	–
MOB cutting	+	–	+	+
DR incision at the SOF	+	–	+	+
Peeling of the dura	+	–	+	+
Clinoidal space	Wide	Narrow	Wide	Wide
Surgical results				
Extent of tumor removal				
GTR	N.A.	87.50%	N.A.	47.60%
STR	N.A.	N.A.	N.A.	47.60%
PR	N.A.	N.A.	N.A.	4.80%
Surgical outcome				
Favorable (GR, MD)	N.A.	N.A.	N.A.	96.20%
Poor (SD, VS, D)	N.A.	N.A.	N.A.	3.80%

Table 4 (Continued)

	Dolenc ⁶	Yonekawa et al ⁷ SEAC	Day et al ³ ETA	Present series
Complications				
Visual disturbance worsened	N.A.	12.50%	N.A.	5.0% (permanent)
Oculomotor disturbance	N.A.	10%	18%	8.8% (transient)
CSF leakage	N.A.	0	N.A.	1.30%

Abbreviations: CSF, cerebrospinal fluid; D, death; DR, dural ring; ETA, extradural temporopolar approach; FR, foramen rotundum; GR, good recovery; GTR, gross total removal; MD, moderate disability; MOB, meningo-orbital band; N.A., not available; OC, optic canal; PR, partial removal; SD, severe disability; SEAC, selective extradural anterior clinoidectomy; SOF, superior orbital fissure; STR, subtotal removal; VS, vegetative state.

recovered within 3 months. All cases of oculomotor paresis were due to detachment and movement of the intradural part and were not related to the surgical approach.

Conclusion

Analysis of our series of 80 patients with paraclinoid lesions who underwent our modified ETA found that total or subtotal resection of the tumors and clipping of the aneurysms were achieved with minimal surgical complications in the majority of the patients. This technique leads to excellent improvement in the visual function and overall clinical outcomes in patients with large tumors encasing the optic nerve and ICA, or extending into the optic canal and infrachiasmatic space. This modified approach is a useful and safe surgical technique.

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