Anterior Petrosectomy: Consecutive Series of 46 Patients with Attention to Approach-Related Complications

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Abstract

Objective Anterior petrosectomy (AP) was popularized in the 1980s and 1990s as micro-neurosurgery proliferated. Original reports concentrated on the anatomy of the approach and small case series. Recently, with the advent of additional endonasal approaches to the petrous apex, the morbidity of AP remains unclear. This report details approach-related morbidity around and under the temporal lobe.

Methods A total of 46 consecutive patients identified from our surgical database were reviewed retrospectively.

Results Of the 46 patients, 61% were women. Median age of the patients was 50 years (mean: 48 ± 2 years). Median follow-up of this cohort was 66 months. Most procedures dealt with intradural pathology ($n = 40$ [87%]). Approach-related morbidity consisted of only two patients (4%) with new postoperative seizures. There were only two significant postoperative hemorrhages (4%). Cerebrospinal fluid leakage occurred in two patients (4%) requiring reoperation.

Conclusion Approach-related complications such as seizures and hematoma were infrequent in this series, $< 4\%$. This report describes a contemporary group of patients treated with open AP and should serve as a comparison for approach-related morbidity of endoscopic approaches. Given the pathologies treated with this approach, the morbidity appears acceptable.

Keywords

- anterior petrosectomy
- morbidity
- operative technique

Introduction

Anterior petrosectomy (AP) was originally portrayed by House in the 1950s as an adjunct to middle fossa exposures for large acoustic neuromas. It was not formalized as a separate surgical approach for tumors other than acoustic neuromas until 1986.^{1–3} The procedure was further popularized and detailed in the early 1990s by Kawase et al in his

report of 10 patients undergoing AP,⁴ often alternatively called the extended middle fossa approach. It is currently a modular component of multiple approaches such as subtemporal, transzygomatic, and frontotemporal orbitozygomatic skull base procedures. AP is utilized to approach lesions in the central skull base that are upper paracalcineal, in the petrosal apex, in Meckel cave, and retropetrosal but superior to the internal auditory meatus or inferior petrosal sinus. To date,

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reports exist about its use for specific pathologies such as petroclival meningiomas, posterior circulation aneurysms, and petrous apex lesions; however, none of these is > 20 patients.^{3–8} Further, there are no contemporary reports in relation to AP.

Endoscopic endonasal approaches to the petrous apex have recently been detailed and are proliferating in the literature.^{9–13} As we begin to evaluate this new approach to the petrous apex, we need reliable morbidity data regarding the current gold standard approach to the petrous apex and resection. This series assesses AP for its associated morbidity when it is part of the approach. Further, this article serves as a contemporary series to demonstrate the application of this procedure.

Materials and Methods/Case Material

Inclusion Criteria

This study is a retrospective single institution study. Approval was obtained from the institutional review board. Inclusion criteria for further analyses were operative report with confirmed AP and at least 1 month of follow-up, unless death occurred sooner. A total of 46 patients between December 2003 and July 2012 were identified utilizing these criteria from the neurosurgical, pathologic, and clinical database based on the keyword search *anterior petrosectomy* or *extended middle fossa approach*. Phone interviews were conducted in January 2014 to establish complete follow-up; seven patients were not reachable and lost to follow-up.

Operative Procedure

Before the procedure, a lumbar drain is placed in the usual fashion. Details of frontotemporal orbitozygomatic (FTOZ), temporal craniotomy, and posterior petrosectomy as access craniotomies can be reviewed elsewhere. The floor of the middle fossa is flattened. Dura is elevated posterior to anterior; the greater superficial petrosal nerve (GSPN) is identified anatomically as well as with electrical stimulation. The middle meningeal artery is coagulated and separated, it is ensured that the superior petrosal sinus is dissected out of its groove in the petrous ridge, and the trigeminal nerve and ganglion are elevated extradurally out of the trigeminal impression. Retractors are then placed extradurally under the temporal lobe and aided by seating on the petrous ridge at the level of the trigeminal impression. Using a high-speed drill, the medial aspect of the floor of the middle cranial fossa is drilled polishing the bone and removing the bone down into the anterior petrous apex. The internal auditory canal (IAC) is first identified and skeletonized in the anterior face and dissected out laterally. Once the IAC is fully skeletonized, bone is drilled posterior to the GSPN, and the carotid is exposed to a thin eggshell of bone remaining over it, taking care to preserve the cochlea in the crux between the IAC and GSPN. Finally, the posterior fossa dura is exposed while drilling all bone down to the inferior petrosal sinus completing the bony removal.

For extradural procedures, the dura was not opened. However, for intradural pathology, a dural opening was

made horizontally over the inferior temporal gyrus. This horizontal incision is then bisected with a linear incision extending from it toward the superior petrosal sinus. A separate dural incision is made over the posterior fossa dura that is taken again toward the superior petrosal sinus. The superior petrosal sinus is then coagulated and cut. In the case of a larger sinus, LIGACLIPS (Ethicon US LLC, Cincinnati, Ohio, United States) are used. At the confluence of the tentorial, posterior fossa dura, and temporal dura, the trigeminal nerve is identified just underneath the superior petrosal sinus. Care is taken to identify this carefully and protect its fibers. Looking above and below the tentorium, the fourth nerve is identified and protected, and the tentorial incision is made through the edge of the tentorium.

Statistical Analysis

JMP Pro 10 (JMP, v.10.0.0, SAS Institute Inc., Cary, North Carolina, United States, 1998–2011) was used to process the data, applying nonparametric statistical tests (Fisher exact test) or Pearson chi-square analysis where appropriate to assess significance.

Results

Demographics

Of the 46 patients in this study, 61% were women (men $n = 18$, women $n = 28$). These patients were enrolled between December 2003 and July 2012. Over this 103-month period, an anterior petrosectomy was performed once every 2.2 months. Median age of patients was 50 years (mean: 48 ± 2 years); range was 6 to 76 years at the time of surgery. Median follow-up of this cohort was 66 months; mean was 58 months with a range of 1 to 121 months.

Surgery

Procedures were roughly equally divided by surgical side (right = 21 [46%]; left = 25 [54%]). Of the 46 patients, 37 (80%) had solely an anterior petrosectomy; 9 had an anterior petrosectomy as part of a combined petrosal approach. Of the 37 patients with a sole anterior petrosectomy, 17 were achieved through a temporal craniotomy, and 20 through an FTOZ craniotomy.

Pathology

Most procedures dealt with intradural pathology ($n = 40$ [87%]). Extradural pathology consisted of cholesterol granuloma (7%), chondrosarcoma (4%), and chordoma (2%). Intradural pathologies included meningioma (46%) of which most were approached through a combined petrosal. Further intradural pathologies were aneurysms (13%), schwannoma (13%), as well as other miscellaneous pathologies as detailed in **Table 1**.

Complications

Approach-Related Morbidity

Only two patients (4%) had new postoperative seizures. These two patients had left-sided procedures (of 25 total); however, there was no statistical significance to this difference.

Table 1 Pathologies treated through an anterior petrosectomy

	Pathology	Number	%
Extradural			13
	Cholesterol granuloma	3	7
	Chondrosarcoma	2	4
	Chordoma	1	2
Intradural			87
	Meningioma	21	46
	WHO 1	20	44
	WHO 2	1	2
	Posterior circulation aneurysm	6	13
	Basilar	5	11
	Superior cerebellar artery	1	2
	Schwannoma	6	13
	Trigeminal	4	9
	Other	2	4
	Brainstem cavernoma	3	7
	Epidermoid	2	4
	Hemangioblastoma	1	2
	Melanocytoma	1	2

Abbreviation: WHO, World Health Organization.

Cerebrospinal fluid (CSF) leakage occurred in two patients (4%) requiring reoperation. One patient with intact hearing had a repeat operation with obliteration of the middle ear for cerebrospinal fluid rhinorrhea. A separate patient had a CSF leak through the wound, responding to wound revision and shunting. There were only two (4%) significant postoperative hemorrhages in this group; ►Fig. 1 gives an example). One patient had a clinically silent temporal lobe ischemic event identified on postoperative magnetic resonance imaging.

Pathology-Specific Overall Morbidity

Three patients (7%) benefited from shunting due to symptomatic hydrocephalus after their anterior petrosectomy. Subjective worsening of facial sensation was reported in 24 patients (52%) immediately after the operation; two of these patients had corneal complications secondary to worsened sensation. However, at last follow-up, 92% reported improved or stable facial sensation prior to surgery. Therefore facial sensation was worse than preoperative function in 8% of patients. Both of these patients had keratitis. One received two corneal transplants secondary to this procedure. New-onset postoperative immediate diplopia occurred in 65% ($n = 30$); however, this statistic improved to 15% of patients with persistent diplopia at last follow-up. Immediate postoperative worsened seventh nerve function occurred in seven patients (15%), but at last follow-up only one patient had persistent facial weakness (3%).

Medical complications included two (4%) hospital-acquired pneumonias, two diagnosed deep vein thrombosis (DVT) (4%), and one non-ST elevation myocardial infarction.

Mortality

Two patients died within 30 days postoperatively; therefore the 30-day mortality rate was 4%. The first was a 47-year-old man who previously underwent a posterior petrosectomy for a large epidermoid at an outside institution 10 years before this most recent surgery. He presented to the emergency department with acute mental status change and hemiplegia for an unknown duration. There was a large recurrence of his previously known epidermoid. He underwent an AP and was reopened in a combined petrosal approach. Postoperatively he continued to have altered mental status, requiring prolonged intubation, and ultimately he was diagnosed with ventilator-associated pneumonia. He became difficult to ventilate, and in discussion with the family 21 days postoperatively, he was allowed to die. A second patient who died within 30 days was a 69-year-old woman with a World Federation of Neurosurgery grade 3 ruptured basilar tip aneurysm of 9 mm. She was taken to surgery, and the aneurysm was successfully treated via a FTOZ and AP. However, postoperatively she developed severe vasospasm recalcitrant to medical and invasive therapy. Given her poor preoperative and postoperative examination, care was withdrawn.

Fig. 1 Patient treated with a 5-cm petroclival meningioma with a significant postoperative hemorrhage. (A) Immediate postoperative computed tomography axial images demonstrating intraparenchymal hematoma in left temporal lobe. (B) Three months after surgery, coronal T1 with gadolinium contrast serial images demonstrates encephalomalacia.

Extradural Case Complications

Only one complication (17%) was seen with extradural cases, a chondrosarcoma involving Meckel cave, in which there was worsened postoperative facial numbness and resultant keratitis.

Meningiomas

There were 21 meningiomas in this series (—Table 1). Complete Simpson grade 2 resection occurred in 67%, near-total resection in 19%, and aggressive subtotal in 14% of patients. Two patients experienced postoperative seizures (10%); one patient developed hydrocephalus (5%). Worsened facial sensation immediately after the operation occurred in 15 patients (71%); 2 had eye complications. At last follow-up, 88% of patients reported improved or stable facial sensation compared with preoperative function. Worsening diplopia was reported in 85% (18 patients); however, at last follow-up, 75%

reported no diplopia. Of the 25% with persistent diplopia, 100% without exception were satisfied with the correction of their deficits with an ophthalmologic procedure or prism glasses. There was one significant hemorrhage (5%). DVT occurred in two patients (10%). There were no pulmonary complications or postoperative CSF leaks.

Aneurysms

Six patients with aneurysms were treated in this series. There was only one patient with postoperative diplopia (8%) that remained at latest follow-up. There were no postoperative fifth or seventh nerve deficits. Significant postoperative hemorrhage occurred in one patient (8%), as well as one brainstem stroke resulting in mild hemiparesis. One patient developed hydrocephalus requiring treatment likely related to the subarachnoid hemorrhage. One patient developed pulmonary complications. There were no postoperative CSF leaks, seizures, or DVTs.

Schwannoma

Six patients with schwannomas were treated in this series as shown in **Table 1**. All were resected completely (100%). Patient-reported immediate postoperative worsening in facial sensation occurred in five patients (83%); however, at last follow-up, 83% reported improved or stable facial sensation compared with preoperatively. No eye complications were reported. Two patients had worsened postoperative diplopia (33%); at last follow-up, only 17% ($n = 1$) reported persistent postoperative diplopia. There were no significant hemorrhages. No patient developed seizures, hydrocephalus, or medical (pulmonary, DVT, myocardial infarction) complications postoperatively.

Discussion

Open AP was developed as an alternative skull base approach providing an anterior vantage point of the brainstem. It ultimately serves as an approach to lesions in the petrous apex, clivus, or below the tentorium but above the seventh and eighth nerve complex. At the time of its popularization, more favored lateral approaches such as retrosigmoid or posterior petrosectomy (retrolabyrinthine, transcranial, translabyrinthine, and transcochlear) were frequently used. One original advantage was less risk to the facial function (transcochlear transposition) or hearing (antecedent risk of perilymphatic approaches, or working around the seventh and eighth nerves to pathology). The approach providing the most anterior working aperture to the anterior brainstem and clivus naturally is endonasal; however, until the expansion of endoscopic endonasal surgery, microscopic visualization was limited and obviously did not have adjunctive use of angled endoscopes allowing further visualization of the petrous apex. Both approaches offer unique advantages. It is beyond the scope of this article to compare the two. But it is clear that in the future they will both have a role in managing petrous apex lesions, likely determined by pathology. Shortly, endonasal endoscopic AP will report series of short-term results and have few if any series of open APs to compare approach-related complications. There is the perception, as stated in Zanation et al, that "The transcranial middle fossa approach is technically difficult. . . . Some degree of brain retraction is necessary, which could result in brain injury" and that approach-related complications require separate approaches other than open AP.¹³ Currently there are no data to support excessive hemorrhage, seizure, or CSF leak rates from open AP. Here we demonstrate the approach-related morbidity of open AP to be no greater than 4%, with a relatively low CSF leak rate of 4%. This should serve as a future baseline comparison for endonasal AP reports.

In this report, we demonstrate a relatively low incidence of complications for lesions occurring extradurally, an overall complication rate of 17%, or one in six cases. This case was a chondrosarcoma involving Meckel cave. Surgical manipulation of the fifth nerve commonly results in numbness, whether it is performed transcranially or endonasally. It should be considered that when future reports discussing

endonasal AP appear, most of these lesions will likely arise extradurally, such as chordomas and chondrosarcomas, and be maintained extradurally or secondarily extend to the subarachnoid space. Therefore, given that this series treats a high number of petroclival meningiomas and aneurysms, we would expect a higher complication rate because notoriously petroclival meningiomas perhaps have the highest rate of new-onset cranial palsies after surgery.

In comparison with other open AP series, it is difficult to make direct comparison to the available case series reported and this contemporary series because the details in these older reports do not exist in terms of complications. For instance, Megerian et al reported in 1996 on 10 patients having undergone open AP. But they report only major complications, of which there appears to be 70%, and no specific cranial nerve details besides that of the seventh cranial nerve are presented (there was a 20% postoperative facial weakness that did resolve).⁶ In Kawase's original report in 1991, 10 patients with meningiomas were treated, resulting in 60% new postoperative pathology-related morbidity. This present report suggests this number for petroclival meningiomas is higher, 85% for immediate postoperative diplopia and 71% for worsening facial sensation. However this improved to 25% diplopia and 12% worsened facial sensation at last follow-up.⁴ Therefore, although a high rate of immediate postoperative worsening was seen, these deficits typically resolve with time, and further, those with postoperative diplopia were satisfied with their treatments for its correction.

Conclusion

Approach-related complications such as seizures and hematoma were infrequent in this series, < 4%. Pathology-related morbidity was highest for diplopia, 15%, and worsening facial numbness, 8%. This report with a contemporary group of patients treated with open AP should serve as a comparison for approach-related morbidity of endoscopic approaches. Given the pathologies treated with this approach, the morbidity appears acceptable.

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