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Original Article

Anterior clinoidectomy: Description of an alternative hybrid method and a review of the current techniques with an emphasis on complication avoidance

Charles Kulwin, R. Shane Tubbs[1], Aaron A. Cohen-Gadol

Goodman Campbell Brain and Spine, Department of Neurological Surgery, Indiana University, Indianapolis, Indiana, [1]Pediatric Neurosurgery, Children's Hospital, 1600 7th Avenue South ACC 400, Birmingham, Alabama, USA

E-mail: Charles Kulwin - ckulwin@iupui.edu; R. Shane Tubbs - shane.tubbs@chsys.org; *Aaron A. Cohen-Gadol - acohenmd@gmail.com
*Corresponding author

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Abstract

Background: Anterior clinoidectomy is a difficult but important part of surgery for a variety of parasellar, proximal carotid and central skull base pathologies. First developed intradurally nearly 60 years ago, the promotion of an extradural technique decades later offered an approach with a different set of difficulties, risks and benefits. Many recent studies have demonstrated that there is no consensus about the "correct" side of the dura from which to remove the anterior clinoid process in a number of pathologies. Here, we review and compare the current techniques for intra- and extradural clinoidectomy and describe a hybrid alternative technique.

Methods: We used a hybrid method to potentially engage the advantages of the intradural and extradural techniques. The hybrid method starts with an extradural sphenoid wing osteotomy to the level of the superior orbital fissure (SOF). The dura is then incised parallel to the sphenoid wing lateral to the SOF, and the need for further bony removal, including clinoidectomy, is assessed after gentle elevation of the frontal lobe and release of cerebrospinal fluid through opening the optico-carotid cisterns and inspection of the pathology in relation to the clinoid. Sylvian fissure may be dissected to relieve retraction on the frontal lobe.

Results: The hybrid method allows an early identification of the optic nerve and its protection during clinoidectomy. The operator leaves the dura medial to the SOF intact and the clionoidectomy proceeds in an extradural fashion while intradural inspection periodically is performed to assess the extent of necessary extradural bony removal.

Conclusion: The hybrid method theoretically can be used as a versatile method under some circumstances. Cutting the dura along the sphenoid wing will prevent the dural layers from obscuring the clinoid and offers intradural visualization to monitor the lesion and potentially tailor bony removal.

Key Words: Clinoidectomy, complications, optic nerve, technical nuance

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INTRODUCTION

Anterior clinoidectomy is a technically difficult yet invaluable component of surgery for a variety of parasellar, proximal carotid and central skull base pathologies. Initially developed intradurally nearly 60 years ago,[8,13] the promotion of an extradural technique decades later[6] offered an approach with a different set of difficulties, risks and benefits. Recent publications and accompanying editorial responses[1,10,11,19,21,24] have demonstrated that there remains no consensus "correct" side of the dura from which to remove the anterior clinoid process in a number of pathologies. Here, we review and compare the current techniques for intra- and extradural clinoidectomy and describe a hybrid alternative technique.

Anatomical benefit of clinoidectomy

The result of anterior clinoidectomy is creation of the clinoid space, the cavity previously filled by the bony process. This potential space has been well defined in microsurgical anatomical studies.[10,14] The frontotemporal dura provides superior and lateral borders. The anterior limit is periorbita and sphenoid bone, defined by the extent of clinoidectomy, which may incorporate air cells in communication with the paranasal sinuses and predisposes the patient to postoperative cerebrospinal fluid rhinorrhea.[16] Inferomedially, the clinoid segment of the internal carotid artery provides the posterior limit, with the optic strut anteriorly, which may also be pneumatized and in communication with the sphenoid sinus.[3] Inferolaterally, the neurovascular structures of the cavernous sinus (including cranial nerves III, IV, V_1 and VI) lie under a layer of periosteal dura, emerging anteriorly into the superior orbital fissure. Given the large number of neurovascular structures in this region, the importance of any extra created space or mobility of any nerves or key vessels is clinically immediately apparent. The surgical benefits of this space have been quantitatively evaluated in a number of cadaveric studies. One common metric, the carotid–oculomotor triangle, has been found to increase in area twofold, in width three- to fourfold, with a twofold increase in the amount of exposed optic nerve.[9,23]

Intradural anterior clinoidectomy

Generally, the intradural clinoidectomy begins with a standard pterional craniotomy. The dura over the lesser wing of the sphenoid may be retracted, the orbit skeletonized and the lesser wing of the sphenoid drilled extradurally, depending on the specific approach.[18,24] The dura over the convexity is opened, the Sylvian fissure is dissected widely[18,20,24] and the local cisterns drained as needed to allow frontal and temporal lobe retraction for the desired surgical corridor. The dura is then excised or reversed off the optic canal, the anterior clinoid process (ACP) and medial lesser sphenoid wing, including falciform ligament release for increased optic nerve mobility. Alternatively, the dura over the ACP may be left in place and drilled through directly. At this point, a number of drill and nondrill techniques have been described for bony removal[12,18,20,24] depending on the desired surgical corridor, location of pathology and the surgeon's preference. Classically, drilling with a small diamond burr starts at the junction of the optic canal roof and the medial ACP, and is continued laterally across the ACP, then down the optic strut. The final bony attachment is broken with a small curette and the remaining clinoid tip is dissected free from the surrounding tissue. Recently, alternatives have been described, including using an ultrasonic cavitator in place of a drill,[2] or en block clinoid removal.[24] At this point, additional drilling of the remaining optic strut, lesser sphenoid wing, optic canal roof or further portions of the sella turcica is an option.

Extradural anterior clinoidectomy

The originally described extradural Dolenc[6] procedure from 1985 has seen several recent modifications.[4,10,17,26] Originally described through a standard pterional craniotomy, it has also been described in conjunction with an orbitozygomatic or modified orbitozygomatic craniotomy.[4,17] Described intracranial techniques involve a number of variations in order and nature of the steps of the procedure and, therefore, the general process with notable options only will be described. The sphenoid ridge is drilled/rongeured flat to the lateral base of the ACP. Dura is elevated over the next area of drilling, generally the floor of the anterior cranial fossa, ACP and/or the superior orbital fissure (SOF). Previously, the orbit would be unroofed and the optic canal opened at this point,[6,25] but more recent technical descriptions open the lateral SOF,[10,17] including the superior lesser sphenoid wing portion, thereby removing, first, the superalateral ACP base and then the inferior greater sphenoid wing portion. This reveals the apex of the SOF contents, allowing for their mobility as well as identification and division of the frontotemporal dural fold (alternatively, the orbitotemporal periosteal fold).[10] Recent anatomic and technical descriptions of this anatomy have illuminated the surgical relationship of the frontotemporal dural fold neurovascular anatomy, allowing precise division and, thereby, superior visualization of the ACP but avoiding damage to the neighboring cerebrovascular structures. After sufficient division and retraction of the dura, the optical canal is unroofed, dividing the second of the three base points of the ACP, its superaomedial connection. At this point, removal of the ACP en bloc k[26] has been noted, but more commonly the ACP is cored out, with the optic strut drilled inferior to the optic canal, severing the third and final connection of the ACP, allowing the remaining ACP shell and tip to be microdissected free. Again, key steps may be varied or added (such as opening the foramen rotundum) depending on surgeon preference and the targeted pathology.

Considerations and complications

Described major complications related to anterior clinoidectomy in modern series include postoperative cerebrospinal fluid (CSF) leak, damage to optic nerve in the form of visual field deficits (either direct neural damage or ischemia due to ophthalmic artery manipulation), oculomotor palsy and intraoperative aneurysm rupture. Each of these will be discussed in the context of the two approaches to clinoidectomy.

CSF rhinorrhea postoperatively occurs when the facial sinuses are, intentionally or inadvertently, made contiguous with the subarachnoid space. In the context of clinoidectomy, this can involve incursion into the frontal, ethmoid or sphenoid sinuses. While ethmoid and frontal sinus involvement can generally be avoided with careful surgical corridor planning, the sphenoid sinus (or, rarely, the ethmoid) can extend into the optic strut and/or the ACP itself (referred to as a pneumatized optic strut or pneumatized clinoid process), necessitating sinus violation for adequate bony removal. Various incidences of this anatomical variant are reported,[3,16] most suggesting a roughly 10% incidence of ACP pneumatization, which is sphenoidal in origin via optic strut extension in about 80%, but roughly 10% involve anterior root extension of the ethmoid sinus as well.[16] While not avoidable, this is usually detectable preoperatively on planning computed tomography imaging, allowing intraoperative steps to be taken to prepare to plug any sinus opening with muscle or fat.

An argument can be made that intradural clinoidectomy may have a lower incidence of CSF rhinorrhea for two reasons. First, through intradural evaluation of the anatomy of the lesion and target corridor, the necessity of clinoidectomy can be further evaluated, and some number of anterior clinoid processes could theoretically be spared. Second, the necessary exposure can be decided intraoperatively and a smaller amount of bony removal may be indicated, possibly avoiding sinus invasion.[18] While an extradural clinoidectomy would theoretically leave the dura intact, the dura is frequently opened later in the operation, increasing the risk of a CSF fistula. However, recent series[3,7] using modern extradural clinoidectomy and sinus plugging techniques have shown a great reduction in the incidence of CSF fistulas (from 10 to 40% to 0 to 2%), suggesting that postoperative CSF rhinorrhea is a function of operative experience and technique, regardless of the chosen dural approach.

Oculomotor deficit

Of the neural structures related to the cavernous sinus and SOF, cranial nerve III is the most commonly affected cranial nerve by clinoidectomy given its size and location directly inferior to the ACP in the first layer of connective tissue overlying the SOF. Depending on the location of the injury, dysfunction frequently may be limited to only the superior branch, producing ptosis and upgaze palsy, or more extensive oculomotor dysfunction.

Intradural series have noted a 10–75% rate of any third nerve dysfunction (transient or permanent) with 4–13% permanent deficit,[5,18,19] compared with an 8–14% incidence of transient and 0–5% incidence of permanent oculomotor palsy in extradural series.[4,7,26] Microsurgical advances and improved anatomical understanding in the last decade have significantly reduced the incidence of this complication. The heterogeneity of the reported patient populations (the patients in the intradural series tend to harbor more vascular lesions while the patients in the extradural series tend to harbor more tumors) precludes definitive comparisons of complication rates. However, the extradural approach appears to carry a somewhat lower incidence of complications. The direction and nature of bone removal would seem to explain this discrepancy. Extradural approaches identify and usually laterally decompress the SOF with careful exploration of the lateral SOF dura, early in the dissection process.[17] Intradural approaches, however, describe a more medial start to bone removal, either with the ACP or with the optic canal and moving laterally[18,24] toward the less well-defined SOF.

Optic nerve deficit

Cranial nerve II deficits are harder to quantify as a large number of patient series requiring clinoidectomy consist of the patients presenting with preoperative visual field changes harboring craniopharyngiomas, large or giant ICA aneurysms and medial sphenoid wing meningiomas. Modern intradural series describe a small (0–3%) incidence of visual deterioration with either standard or en bloc clinoidectomy,[19,24] while extradural series only describe a slightly higher incidence (0–10%).[4,7,26] The intradural technique offers a theoretically safer method, given early visualization of the nerve, and the ability to drill more medially to laterally away from CN II,[24] rather than drilling toward the optic nerve along the sphenoid wing. Both intra- and extradural techniques generally unroof the optic canal prior to removing the ACP, which likely contributes to the rarity of this complication. Ample irrigation during drilling is important to decrease the incidence of heat injury to the nerve. Unroofing and untethering the optic nerve before manipulation of the clinoid will further protect the nerve from inadvertent injury.

Aneurysm rupture

Aneurysms of the internal carotid artery around the ACP often necessitate clinoidectomy and are simultaneously at a risk of premature rupture during bone removal. While aneurysm rupture during clinoidectomy is only rarely reported,[15,22] it has been described during both intradural and extradural clinoidectomy. The advantages of an intradural approach include an early visualization of the relevant anatomy, including ACP erosion by the aneurysm dome, as well as the localization of the aneurysm neck and determination of the necessity and extent of clinoidectomy, possibly avoiding a step that exposes the aneurysm to further mechanical stress. An extradural approach does retain a dural layer of protection over the aneurysm, although this benefit is controversial.

Description of an alternative hybrid technique

We have employed the following hybrid method to potentially engage the advantages of the intradural and extradural techniques. The hybrid method starts with an extradural sphenoid wing osteotomy to the level of the SOF. The dura is then incised parallel to the sphenoid wing lateral to the SOF [Figure 1], and the need for further bony removal including clinoidectomy is assessed following gentle elevation of the frontal lobe and release of CSF through opening the optico-carotid cisterns and inspection of the pathology in relation to the clinoid. Sylvian fissure may be dissected to relieve retraction on the frontal lobe.

This exposure allows an early identification of the optic nerve and its protection during clinoidectomy [Figures 2 and 3]. At this stage, the operator leaves the dura medial to the SOF intact and the clionoidectomy proceeds in an extradural fashion, while intradural inspection periodically is performed to assess the extent of necessary extradural bony removal [Figures 3 and 4a and b].

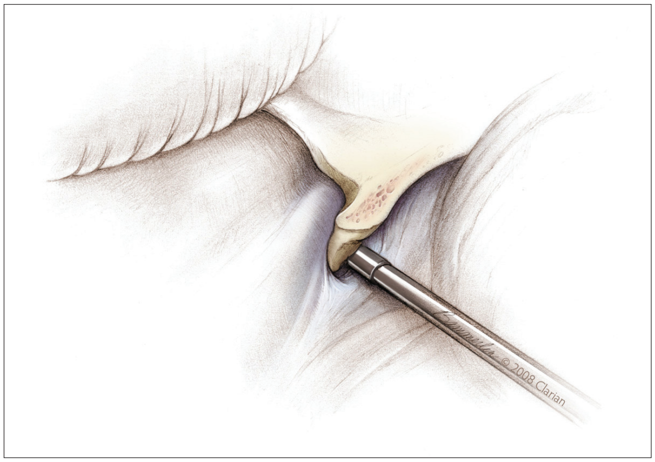

Figure 1: The hybrid method starts with an extradural sphenoid wing osteotomy (sketched for the left-sided approach) to the level of the superior orbital fissure. The dura is then incised parallel to the sphenoid wing lateral to the superior orbital fissure and along the frontal and temporal lobes. The need for further bony removal including clinoidectomy is assessed following gentle elevation of the frontal lobe and release of cerebrospinal fluid through opening the optico-carotid cisterns and inspection of the pathology in relation to the clinoid. Sylvian fissure may be dissected to relieve retraction on the frontal lobe

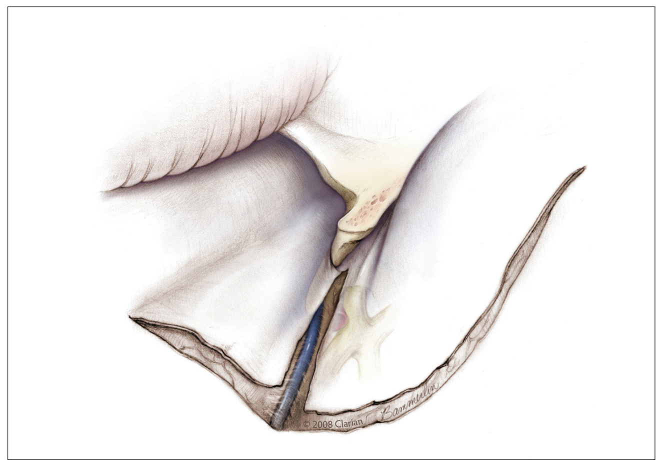

Figure 2: This dural opening relieves the tension by the frontal and temporal dural folds and allows an easy identification of the medial clinoid

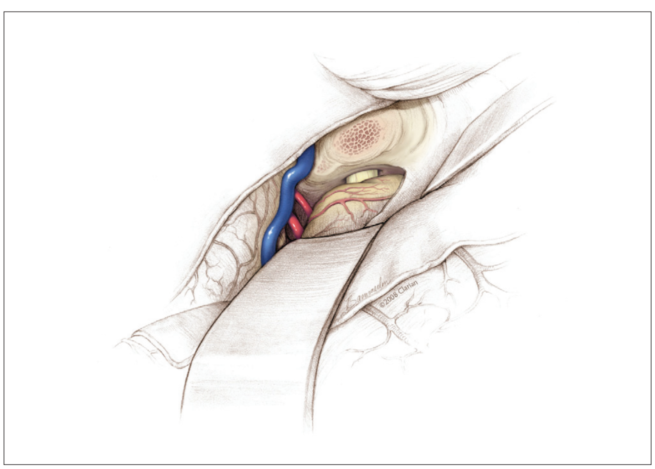

Figure 3: This exposure allows an early identification of the optic nerve and its protection during clinoidectomy. Clinoidectomy may proceed in an extradural fashion while intradural inspection periodically is performed to assess the extent of necessary extradural bony removal

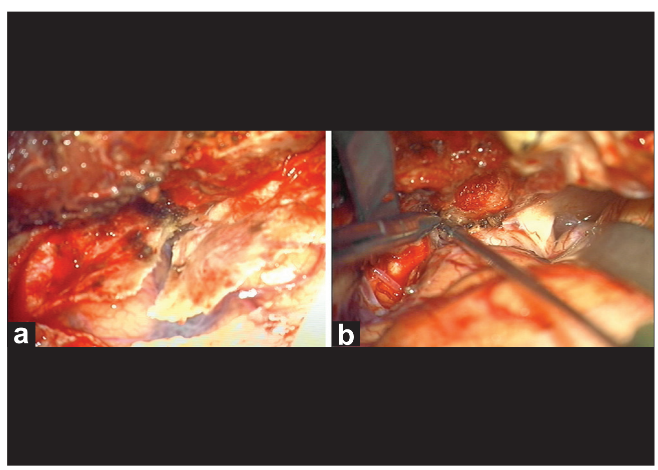

Figure 4: Intraoperative images (left-sided craniotomy) demonstrate the extent of dural opening (a) and clinoidal removal under direct monitoring of the optic nerve (b)

DISCUSSION

The above statements emphasize the advantages and disadvantages of intradural and extradural techniques for clinoidectomy. It is important to note that the surgeon should prefer the method he or she feels most comfortable with. This preference is often affected by the surgeon's training. Extradural clinoidectomy is advantageous during removal of the medial sphenoid wing meningiomas as aggressive bony removal facilitates extradural devascularization of the tumor and may enhance gross tumor removal, especially if the clinoid is infiltrated with tumor. The intradural technique may be preferred for clipping of ophthalmic aneurysms as bony removal can be tailored based on the pathology at hand and clinoidectomy can be done under careful monitoring of the aneurysm to prevent manipulations that would place the aneurysm at risk of intraoperative rupture.

The hybrid method theoretically can be used as a versatile method under both circumstances mentioned above. Cutting the dura along the sphenoid wing will prevent the dural layers from obscuring the clinoid and offers intradural visualization to monitor the lesion and potentially tailor bony removal.

REFERENCES

1. Chang DJ, The "no-drill" technique of anterior clinoidectomy: A cranial base approach to the paraclinoid and parasellar region. Neurosurgery 2009;64:96-105.
2. Chang HS, Joko M, Song JS, Ito K, Inoue T, Nakagawa H. Ultrasonic bone curettage for optic canal unroofing and anterior clinoidectomy. Technical note. J Neurosurg 2006;104:621-4.
3. Chi JH, Sughrue M, Kunwar S, Lawton MT. The "yo-yo" technique to prevent cerebrospinal fluid rhinorrhea after anterior clinoidectomy for proximal internal carotid artery aneurysms. Neurosurgery 2006;59(Supp 1):ONS101-7.
4. Day JD, Giannotta SL, Fukushima T Extradural temporopolar approach to lesions of the upper basilar artery and infrachiasmatic region. J Neurosurg 1994;81:230-5.
5. De Jesus O, Sekhar LN, Riedel CJ. Clinoid and paraclinoid aneurysms: surgical anatomy, operative techniques, and outcome. Surg Neurol 1999;51:477-87; discussion 87-8.
6. Dolenc VV. A combined epi- and subdural direct approach to carotid-ophthalmic artery aneurysms. J Neurosurg1985;62:667-72.
7. Dolenc VV. Transcranial epidural approach to pituitary tumors extending beyond the sella. Neurosurgery 1997;41:542-50; discussion 51-2.
8. Drake CG, Vanderlinden RG, Amacher AL. Carotid-ophthalmic aneurysms. J Neurosurg. 1968;29:24-31.
9. Evans JJ, Hwang YS, Lee JH. Pre- versus post-anterior clinoidectomy measurements of the optic nerve, internal carotid artery, and opticocarotid triangle: A cadaveric morphometric study. Neurosurgery 2000;46:1018-21; discussion 21-3.
10. Froelich SC, Aziz KM, Levine NB, Theodosopoulos PV, van Loveren HR, Keller JT. Refinement of the extradural anterior clinoidectomy: Surgical anatomy of the orbitotemporal periosteal fold. Neurosurgery 2007;61:179-85; discussion 85-6.
11. Gonzalez-Darder JM. [Intradural anterior clinoidectomy. Anatmoclinical study and its usefulness in the treatment of trans-segmentary C5-C6 trans-segmentary paraclinoid aneurysms]. Neurocirugia 2007;18:201-8.
12. Hadeishi H, Suzuki A, Yasui N, Satou Y. Anterior clinoidectomy and opening of the internal auditory canal using an ultrasonic bone curette. Neurosurgery 2003;52:867-70; discussion 70-1.
13. Hauser MJ, Gass H, Optic nerve pressure by aneurysm relieved by decompression of optic nerve; report of a case. AMA Arch Ophthalmol 1952;48:627-31.
14. Kim JM, Romano A, Sanan A, van Loveren HR, Keller JT. Microsurgical anatomic features and nomenclature of the paraclinoid region. Neurosurgery 2000;46:670-80; discussion 80-2.
15. Korosue K, Heros RC. "Subclinoid" carotid aneurysm with erosion of the anterior clinoid process and fatal intraoperative rupture. Neurosurgery 1992;31:356-9; discussion 9-60.
16. Mikami T, Minamida Y, Koyanagi I, Baba T, Houkin K. Anatomical variations in pneumatization of the anterior clinoid process. J Neurosurg 2007;106:170-4.
17. Noguchi A, Balasingam V, Shiokawa Y, McMenomey SO, Delashaw JB Jr. Extradural anterior clinoidectomy. Technical note. J Neurosurg 2005;102: 945-50.
18. Nutik SL. Pterional craniotomy via a transcavernous approach for the treatment of low-lying distal basilar artery aneurysms. J Neurosurg 1998;89:921-6.
19. Nutik SL, Removal of the anterior clinoid process for exposure of the proximal intracranial carotid artery. J Neurosurg 1988;69:529-34.
20. Ohmoto T, Nagao S, Mino S, Ito T, Honma Y, Fujiwara T. Exposure of the intracavernous carotid artery in aneurysm surgery. Neurosurgery 1991;28:317-23; discussion 24.
21. Parkinson D. A surgical approach to the cavernous portion of the carotid artery. Anatomical studies and case report. J Neurosurg 1965;23:474-83.
22. Romani R, Kivisaari R, Celik O, Niemela M, Perra G, Hernesniemi J. Repair of an alarming intraoperative intracavernous carotid artery tear with anastoclips: Technical case report. Neurosurgery 2009;65:E998-9; discussion E9.
23. Sade B, Kweon CY, Evans JJ, Lee JH. Enhanced exposure of carotico-oculomotor triangle following extradural anterior clinoidectomy: A comparative anatomical study. Skull Base 2005;15:157-61; discussion 61-2.
24. Takahashi JA, Kawarazaki A, Hashimoto N. Intradural en-bloc removal of the anterior clinoid process. Acta Neurochir (Wien) 2004;146:505-9.
25. Van Loveren HR, Keller JT, el-Kalliny M, Scodary DJ, Tew JM Jr. The Dolenc technique for cavernous sinus exploration (cadaveric prosection). Technical note. J Neurosurg 1991;74:837-44.
26. Yonekawa Y, Ogata N, Imhof HG, Olivecrona M, Strommer K, Kwak TE, *et al*. Selective extradural anterior clinoidectomy for supra- and parasellar processes. Technical note. J Neurosurg 1997;87:636-42.