Operative Technique

Endoscopic extradural anterior clinoidectomy and optic nerve decompression through a pterional port

André Beer-Furlan a,b, Alexander I. Evins a, Luigi Rigante a, Justin C. Burrell a, Giulio Anichini a, Philip E. Stieg a, Antonio Bernardo a,b,*

a Department of Neurological Surgery, Weill Cornell Medical College, Cornell University, New York, NY, USA
b Department of Neurosurgery, University of São Paulo Medical School (FMUSP), São Paulo, Brazil

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Abstract
Since the first description of the intradural removal of the anterior clinoid process, numerous refinements and modifications have been proposed to simplify and enhance the safety of the technique. The growing use of endoscopes in endonasal and transcranial approaches has changed the traditional management of many skull base lesions. We describe an endoscopic extradural anterior clinoidectomy and optic nerve decompression through a minimally invasive pterional port. Minimally invasive optic nerve decompression, with endoscopic extradural anterior clinoidectomy, through a pterional keyhole craniotomy was performed on five preserved cadaveric heads. The endoscopic pterional port provided a shorter and more direct route to the anterior clinoid region, and helped avoid unnecessary and extensive bone removal. An extradural approach helped minimize complications associated with infraction of the subdural space and allowed for the maintenance of visibility while drilling with continuous irrigation. Adequate 270° bone decompression of the optic canal was achieved in all specimens. Endoscopic extradural anterior clinoidectomy and optic nerve decompression is feasible through a single minimally invasive pterional port.

1. Introduction
Since the first description of the intradural removal of the anterior clinoid process (ACP), numerous refinements and modifications have been proposed to simplify and enhance the safety of the technique [1–11]. Dolenc pioneered the extradural technique for anterior clinoidectomies which provided a safe approach to the cavernous sinus and helped avoid infraction of the subdural space and its associated complications. The extradural anterior clinoidectomy was initially proposed for use in the management of carotid-cavernous fistulas and intracavernous aneurysms [12].

Over the following decades, the application of this technique was extended for use in the treatment of basilar tip aneurysms, lesions of the cavernous sinus, craniohypophyegiomas, peri- and supra-sellar meningiomas, and select giant pituitary adenomas [4,13–19]. Extralateral anterior clinoidectomies have also been shown to be effective for optic nerve decompression [20]. This is consistent with the fact that the optic strut forms the floor of the optic canal and the base of the anterior clinoid forms its lateral margin [21].

The growing use of endoscopes in endonasal and transcranial approaches has changed the traditional management of many skull base lesions. Use of the endoscope has been shown to improve anatomical visualization, reduce exposure and brain retraction, and minimize surgical morbidity [22]. Endoscopic neurosurgery is well established and widely accepted as a means of treatment for lesions of the cranial base [22–28].

In this study, we investigated the use of a minimally invasive pterional port with an endoscopic extradural anterior clinoidectomy for optic nerve decompression.

2. Methods
Minimally invasive optic nerve decompression, with endoscopic extradural anterior clinoidectomy, through a pterional keyhole craniotomy was performed on five preserved cadaveric heads injected with colored latex (red for arteries and blue for veins). Three-point fixation was achieved using a Mayfield head holder. The head was positioned with 5° extension and 10–15° of lateralization contralateral to the side of the approach.

Dissections were performed using 0° and 30° endoscopes with two dimensional optics (4 mm diameter, 18 cm length; Karl Storz, Tuttingen, Germany) and a 0° endoscopes with three dimensional optics (4.9 mm diameter, 30 cm length; Visionense, New York, NY, USA). Images were recorded and stored using the Karl Storz AIDA system and the Visionense software, respectively. An endoscope holder and a Greenberg retractor system were used to perform bimanual dissection and drilling. An Anschap eMax 2 Plus (DePuy...
Synthes, West Chester, PA, USA) electric neurosurgical drill was used.

3. Results

3.1. Pterional port

An approximately 5 cm vertical, anteriorly curved skin incision was made originating 1 cm above the zygomatic arch at the anterior border of the hairline and extended approximately 5 cm superiorly, gradually curving anteriorly toward the ipsilateral midpupillary line. The scalp was reflected anteriorly and an interfascial dissection was completed in order to avoid injury to the frontalis branch of the facial nerve. The fibers of the temporalis muscle were divided longitudinally, dissected subperiosteally, and retracted anteriorly and posteriorly until the pterion was exposed.

Drilling of the pterional keyhole craniectomy began with a small burr hole at the intersection of the sphenoparietal and coronal sutures. This point served as the posterior limit of the craniectomy. Small parts of the greater wing of the sphenoid, frontal, and parietal bones were removed until the lesser wing of the sphenoid was identified between the frontal and temporal dura. The dura was bluntly dissected from the bone and drilling continued anteriorly until a 2.5 × 2.5 cm oval or trapezoid shaped craniectomy with an anterior base was achieved. The larger bone opening at the anterior part of the craniectomy facilitated surgical maneuverability of instruments and dissection of deep-sited structures (Fig. 1).

Removal of the lesser wing of the sphenoid in an inferoposterior direction along the sphenoid ridge progressively increased the extradural working space (Fig. 2). After sufficient space was obtained, a rigid endoscope was introduced to improve illumination and visibility.

3.2. Extradural exposure of the ACP

An endoscope holder was used to perform bimanual dissection and drilling, and the procedure continued with removal of the lateral wall of the orbit until identification of the meningo-orbital dural fold (MODF) – a duplication of the dura that stretches between the periorbita and temporal lobe dura at the superior orbital fissure (SOF).

The bone around the SOF and orbital roof was drilled, thinned, and removed. The MODF was divided laterally and medially along the edges of the SOF to reveal the orbitomeningeal artery and a cleavage plane between the temporal fossa dura and the inner layer of the lateral wall of the cavernous sinus (Fig. 3). Detaching the anterior cranial fossa dura using a dissector without continuous brain retraction expanded the extradural space, increased

![Fig. 1. Intra-operative photographs showing the right pterional port. (A) The craniectomy is initiated with a burr-hole at the intersection of the sphenoparietal and coronal sutures. (B) Increased extradural space is gained with drilling of the lesser wing of the sphenoid. (C) The periorbita is kept intact and serves as a landmark for removal of the lateral wall and roof of the orbit. (D) A larger bone window is made at the anterior portion of the craniectomy in order to avoid limited surgical maneuverability.](image)

FD = frontal dura mater, LSW = lesser sphenoid wing, PO = periorbita, TD = temporal dura mater.
exposure of the lateral and superior aspects of the ACP, and facilitated identification of the superior bony edge of the optic canal. The dura was elevated until exposure of the ACP was sufficient for drilling, and the base of the ACP and the optic canal roof were safely identified (Fig. 4A).

3.3. Endoscopic extradural anterior clinoidectomy and optic nerve decompression

The same principles for the microscopic extradural anterior clinoidectomy and optic nerve decompression were applied with the exception of submerged drilling. In order to improve exposure and safety while drilling the ACP, the frontotemporal dura was retracted using a 1 cm wide retractor blade connected to the Greenberg retractor system.

The optic canal and its bone edge were identified. The roof and lateral wall of the optic canal were removed using a diamond drill bit. While drilling, the extradural space was continuously irrigated using 0.9% saline solution to clear the bone dust and maximize visibility (Fig. 4B). Extreme care was taken to avoid tearing the periorbita and the escape of orbital fat into the surgical field. Troughs were drilled on each side of the nerve and a thin shell of bone was left on the superior aspect of the nerve. This shell was later fractured and elevated with a dissector. While unroofing the optic canal in a medial to lateral direction, care was taken to not injure the underlying optic sheath or continue beyond the medial border of the canal to avoid opening of the sphenoid or ethmoid sinuses.

The central cancellous bone of the ACP was drilled and its cortical bone was thinned (Fig. 4C). The optic strut, a bridge of bone between the optic canal and the SOF that attaches the base of the ACP to the body of the sphenoid bone, was drilled anteromedially under the optic nerve sheath in order to increase decompression of the optic canal. Once the ACP was freed from the optic strut, the clinoid tip became mobile, and was, in some specimens, dissected and removed from the petroclinoid and interclinoid ligaments. After removal of the ACP, the clinoidal space and the clinoidal segment of the internal carotid artery were exposed.

Removal of the ACP and the optic strut resulted in a 270° bone decompression of the optic canal. The falciform ligament and optic sheath were finally incised parallel to the long axis of the optic nerve to achieve more complete decompression while avoiding the ophthalmic artery that ran inferiorly to the optic nerve (Fig. 4D).

4. Discussion

The anatomy of the ACP and its relationship with its surrounding structures has been widely discussed in the literature [7,31–35]. We evaluated the feasibility of performing extradural removal of the ACP, a challenging procedure, through an exclusively endoscopic pterional port.

Endoscopic approaches targeting the ACP have yet to be studied in depth. In 2011, Komatsu et al. described the feasibility of an endoscopic extradural anterior clinoidectomy through a supraorbital keyhole craniotomy in cadavers [36]. More recently, Baidya et al. performed an intradural anterior clinoidectomy in cadavers, highlighting the safety of drilling with the assistance of an endoscope [37].

We believe that the pterional port provides a shorter and more direct route to the anterior clinoid region, and helps avoid unnecessary and extensive bone removal. An extradural approach
minimizes complications associated with infraction of the subdural space and allows the surgeon to maintain visibility while drilling with continuous irrigation. The endoscopic pterional port approach in itself may have limited clinical application in optic nerve decompression or small parasellar lesions with optic canal involvement. However, in the context of “dual-port” or “multi-port” management of large lesions, the pterional port has great potential as an auxiliary approach to transcranial or endonasal approaches by enhancing visualization of the relationship between tumors and the optic nerve after anterior clinoidectomy and optic canal unroofing [37–40]. In the future, such “dual-port” or “multi-port” endoscopic approaches will likely become increasingly popular with the refinement of robotic neurosurgery.

5. Conclusion

Endoscopic extradural anterior clinoidectomy and optic nerve decompression is feasible through a single minimally invasive pterional port. Adequate 270° bone decompression of the optic canal is achieved. Quantitative evaluation of this technique and its application in a clinical setting, alone or combined with other endoscopic approaches, need to be studied further.

Conflicts of interest/disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

References


