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Technical Note

Endoscopic endonasal posterior clinoidectomy

Danilo Silva[1], Moshe Attia[1], Jothy Kandasamy[1], Marjan Alimi[1], Vijay K. Anand[2], Theodore H. Schwartz[1,2,3]

Departments of [1]Neurosurgery, [2]Otolaryngology–Head and Neck Surgery, [3]Neurology and Neuroscience, New York Presbyterian Hospital, Weill Medical College of Cornell University, New York

E-mail: Danilo Silva - daniloncr@gmail.com; Moshe Attia - moshe.attia24@gmail.com; Jothy Kandasamy - jegajothy@hotmail.com; Marjan Alimi - marjan.alimi@gmail.com; Vijay K. Anand - vijayanandmd@gmail.com; *Theodore H. Schwartz - schwarh@med.cornell.edu *Corresponding author

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Abstract

Background: Posterior clinoidectomy is a useful procedure for maximizing exposure to the interpeduncular cistern via transcranial approaches for basilar tip aneurysms and select intracranial tumors. The value of posterior clinoidectomy during endonasal endoscopic transclival surgery is not well described.

Methods: We performed endoscopic endonasal transsphenoidal extradural bilateral posterior clinoidectomy and dorsum sella removal on five silicon-injected cadaveric heads. The dorsum sella was split in the midline and removed from medial to lateral until the posterior clinoids were encountered. The posterior clinoid was dissected from the medial wall of the cavernous sinus and mobilized medially in order to detach it from the ligaments and carefully fractured it from the bony attachment to the petrous apex and carotid canal. Following this, the clival and dorsum sella dura was opened to expose the interpeduncular cistern and its contents.

Results: The technical feasibility of endoscopic endonasal extradural posterior clinoidectomy was reproduced in all five cadaveric specimens. This technique was performed without damaging the vital structures, including preservation of the pituitary gland. After performing bilateral posterior clinoidectomy, the retrosellar dura was opened, allowing good visualization of the contents of the prepontine and interpeduncular cistern.

Conclusion: We describe the technique of endoscopic endonasal extradural posterior clinoidectomy. We believe this approach is best suited for retrosellar pathology located in the interpeduncular cistern and is a useful adjunct to the transclival approach to increase the field of view and maximize the extent of resection.

Key Words: Dorsum sella, endoscopic endonasal, extradural posterior clinoidectomy, interpeduncular cistern, posterior clinoid process, skull base

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INTRODUCTION

The posterior clinoid process (PCP) is an osseous structure located at the superolateral aspect of the dorsum sella.[14] Removal of the PCP through a transcranial approach has been described and emphasized

as an important step to achieve proximal control of the basilar artery for basilar tip aneurysm clipping.[1-3,7,10-14] The endoscopic endonasal transsphenoidal transclival approach is an alternative ventral route to the basilar tip and interpeduncular cistern.[4,5]

In this manuscript, we provide a detailed description of extradural PCP removal as an adjunct to the endonasal transclival approach. Although extradural endoscopic endonasal PCP removal has been reported during pituitary transposition to reach the interpeduncular cistern,[6] we describe a slightly different technique of extradural PCP removal to enhance the transclival approach in the absence of pituitary transposition.

MATERIALS AND METHODS

Cadaveric specimen preparation

We used five alcohol-preserved, colored silicon-injected cadaveric heads for five surgical dissections. The internal carotid arteries and the jugular veins were cannulated and injected with silicone pigment compound (Dow Corning, Midland, MI, USA). The cadaveric heads were then soaked in 70% ethyl alcohol for at least 24 h.

Surgical approach

Cadaveric heads were placed in a three-pin Mayfield headholder in a neutral position with slight extension. Under endoscopic visualization with a 0°, 18-cm-long, 4-mm-diameter, rigid endoscope (Karl Storz, Tuttlingen, Germany), the middle and superior turbinates were retracted laterally and the sphenoid ostia were identified bilaterally. The posterior 1 cm of the nasal septum adjacent to the vomeric bone and maxillary crest was resected. The sphenoid ostia were opened with Kerrison rongeurs (Codman/Johnson and Johnson, Raynham, MA, USA) and a complete sphenoidotomy was achieved. The mucosa of the sphenoid sinus was removed, and the rostrum was drilled out with an XMax pneumatic drill (Anspach, Palm Beach Gardens, FL, USA) to become flush with the floor of the sphenoid sinus. The sphenoid septum was removed with a rongeur forceps. The floor of the sella, the two carotid protuberances, the medial aspect of the optic canals, and the upper clivus were identified. The superior third of the clivus was exposed by drilling the posterior wall of the sphenoid sinus, starting at the sella and extending caudally to the level of the sphenoid sinus floor utilizing the drill and Kerrison rongeurs. Removing the bone of the floor of the sella permits slight elevation of the pituitary gland to reach the dorsum sella and PCPs.

Dorsectomy and posterior clinoidectomy

Dorsectomy and posterior clinoidectomies were performed with 30° angled endoscopic visualization looking up, using a high-speed 1-mm diamond drill and a 1-mm Kerrison rongeur. The pituitary gland was elevated extradurally to expose the dorsum sella, which was drilled in the midline until eggshell thin. The dorsum sella was then split in and removed with a Kerrison from medial to lateral until the PCPs were encountered on either side [Figure 1]. The PCP was then dissected from the petroclinoid ligament laterally and interclinoid ligaments anteriorly. Rather than drill directly over the PCP, which risks damaging the surrounding structures, the PCP was mobilized *en bloc* off the clival dura and its ligamentous attachments from lateral to medial and carefully fractured it from the bony attachment to the petrous apex and carotid canal [Figures 2 and 3]. This maneuver brings the PCP toward the midline where the dorsum sella was split. Following dorsectomy and resection of both PCPs, the retrosellar and clival dura was opened with a sickle knife and resected. Using 0° and angled endoscopes, the prepontine and interpeduncular cisterns were brought into view. The membrane of Liliequist was dissected, and the basilar artery, basilar perforators, superior cerebellar arteries, posterior cerebral arteries, mammillary bodies, and third nerves were identified [Figure 4].

RESULTS

The technical feasibility of endoscopic endonasal extradural posterior clinoidectomy was reproduced in all five cadaveric specimens. This technique was performed without damaging vital structures, including preservation of the pituitary gland. After performing bilateral posterior clinoidectomy, the retrosellar dura was opened, allowing good visualization of the contents of the prepontine and interpeduncular cistern [Figures 5–8].

DISCUSSION

The posterior clinoid processes along with the dorsum sella form the posterior part of the sella turcica and the superior part of the clivus at the center of the cranial base as a component of the body of the sphenoid bone.[8,14] The anteromedial and anterolateral aspects of the PCP are related to the sella turcica and the posterior margin of the cavernous sinus, respectively.[14] During the development of traditional transcranial skull base approaches to the basilar tip, posterior clinoidectomy became a central maneuver in achieving exposure of the basilar bifurcation.[1-3,7,10-14] These traditional approaches and their variations focused on providing the best route for complex aneurysm surgery of the upper portion of basilar artery. With the development and improvement of the endoscopic endonasal transsphenoidal approach for midline tumors, the PCP and dorsum sella had to be accessed to obtain complete removal of clival-based tumors that extend into this region or removed to reach the interpeduncular cistern and retrosellar area.

The transcranial intradural techniques can be performed

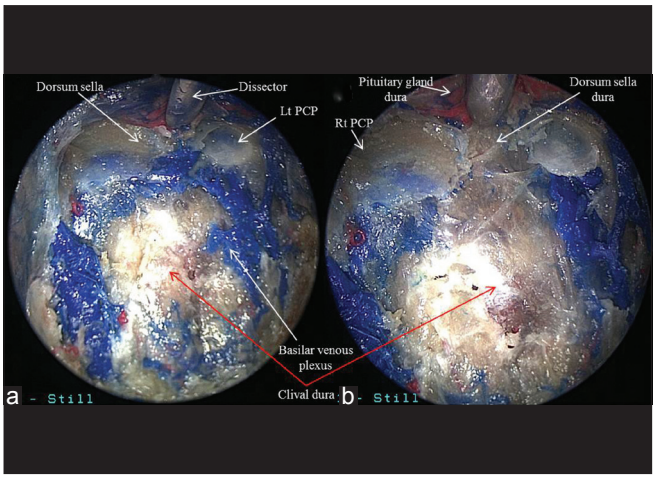

Figure 1: (a) The posterior wall of the sphenoid sinus has been completely removed between the internal carotid arteries and the basilar venous plexus resected to expose the dura behind the clivus. The bone of the floor of the sella has been completely removed. The pituitary gland is elevated extradurally and the dorsum sella is drilled and split in the midline, leaving the two posterior clinoid process (PCPs) laterally. (b) Closer view of the two PCPs after the midline dorsum sella has been removed

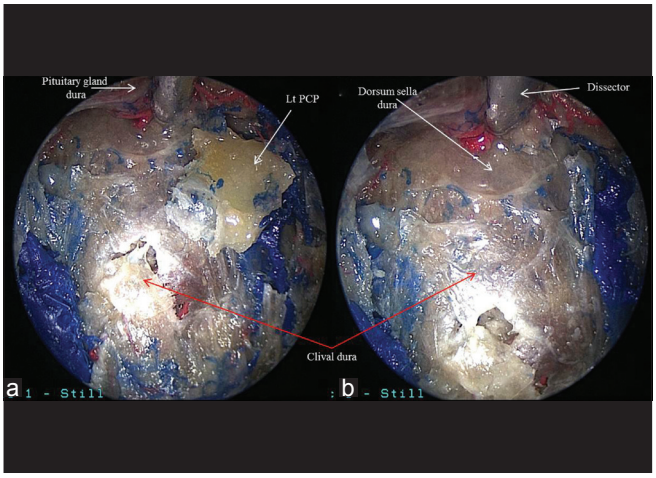

Figure 3: (a) The left posterior clinoid process (PCP) is removed exposing the dura behind the dorsum sella. (b) After the left PCP is removed, the dura of the dorsum sella is completely exposed once the pituitary is elevated extradurally

using a pterional craniotomy with either Yasargil[11] or Dolenc[3] approaches. Both techniques carry the risk of damaging the third nerve and posterior communicating artery once the drilling of the PCP is performed under some degree of mobilization of these structures. In an attempt to protect the neurovascular contents of the interpeduncular cistern[10] and the structures of the cavernous sinus[13,14] during the drilling of the PCP, two techniques were described via an orbitozygomatic craniotomy. Seoane *et al.*[10] emphasize the need to preserve the dura covering the posterior aspect of the PCP and upper clivus while drilling the PCP through a transcavernous approach.

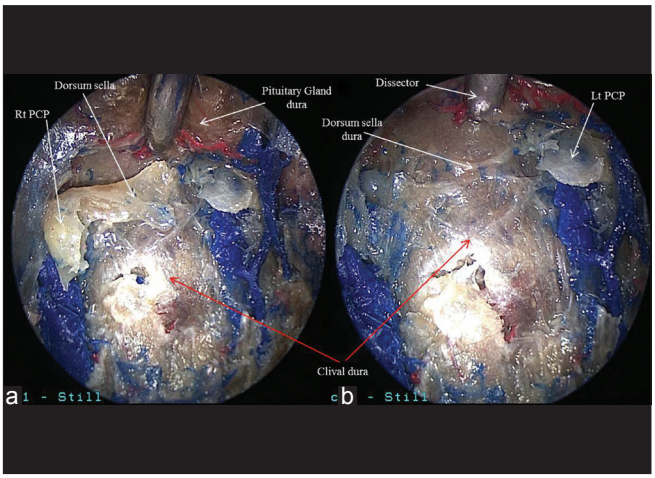

Figure 2: Elevating the pituitary gland extradurally, (a) the right posterior clinoid process (PCP) is dissected free from the clival dura and removed leaving the left PCP. (b) The left PCP remains after the right PCP is removed

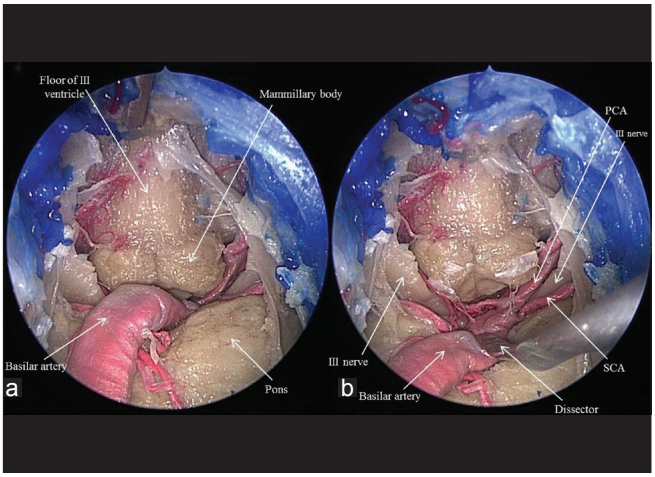

Figure 4: Opening the dorsum sella dura reveals the contents of the interpeduncular cistern including (a) the mammillary bodies, floor of the third ventricle, basilar artery, (b) posterior cerebral and superior cerebellar arteries, and oculomotor nerves

Youssef *et al.*[14] described a longitudinal incision over the dura covering the PCP and the creation of a lateral dural flap with the meningeal and endosteal dura along the medial wall of the cavernous sinus. These recent techniques improve protection of the third nerve, entering the cavernous sinus, and vascular structures within the interpeduncular cistern using the dura overlying the PCP. Salma *et al.*[9] described an extradural endoscope-assisted technique for removing the PCP working through the sphenoid sinus from a lateral subtemporal approach. They accessed the sphenoid sinus by drilling the middle fossa floor between V2 and V3 under microscope visualization. Then, under endoscope assistance, they went beyond the line between V2 and V3 to perform an extradural transcranial transsphenoidal posterior clinoidectomy. They stressed that entering

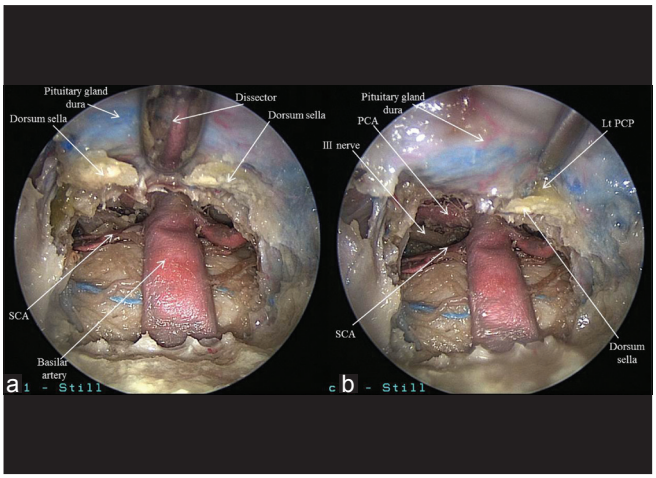

Figure 5: (a) The dorsum sella in the midline has been removed and both posterior clinoids are still in place. Bilateral superior cerebellar arteries are visualized. (b) After removing the right posterior clinoid process (PCP), the right PCA and third nerve come into view. In this specimen, the dura was first opened behind the clivus before the PCPs were removed to show the additional intradural exposure gained with this maneuver

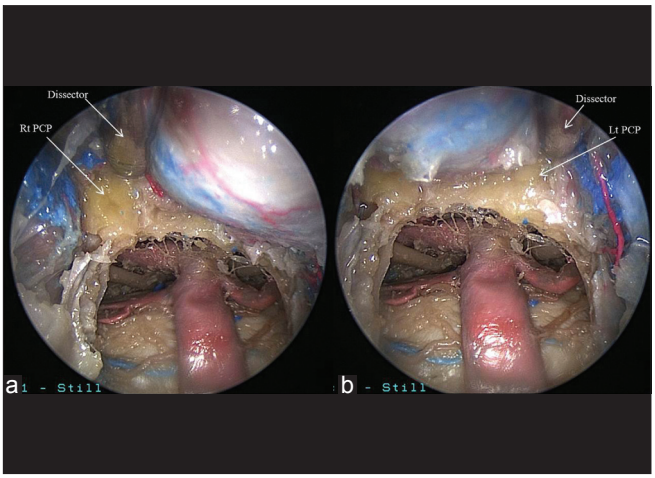

Figure 6: Close-up view of (a) right and (b) left posterior clinoid process (PCP) after elevating the pituitary gland extradurally. In this specimen, the dura was first opened behind the clivus before the PCPs were removed to show the additional intradural exposure gained with this maneuver

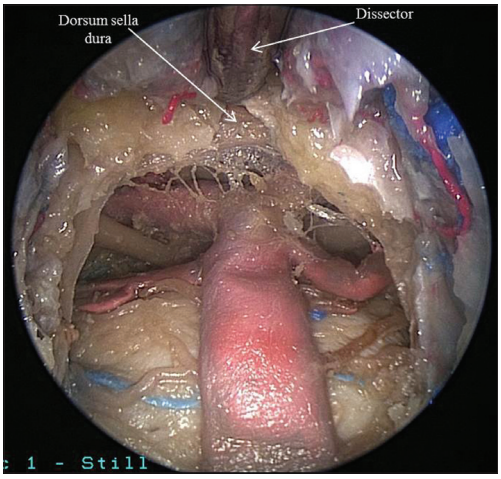

Figure 7: Close-up view of the midline dorsum sella removed with both posterior clinoid process (PCPs) in place. In this specimen, the dura was first opened behind the clivus before the PCPs were removed to show the additional intradural exposure gained with this maneuver

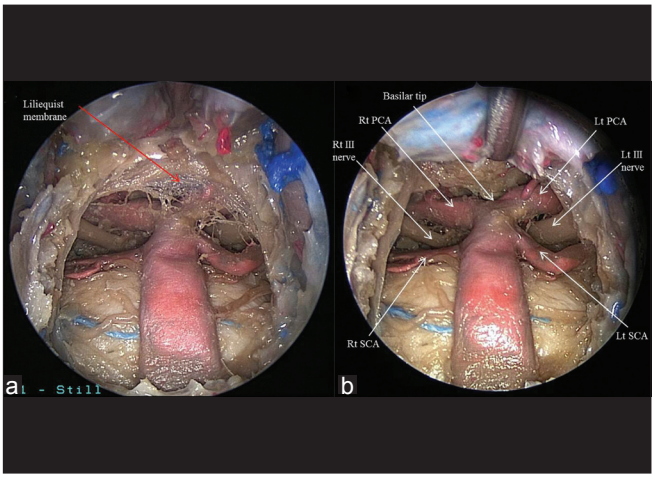

Figure 8: (a) Exposure of the Liliequist membrane following bilateral posterior clinoidectomy. (b) Exposure of the interpeduncular cistern and its contents following removal of the Liliequist membrane. In this specimen, the dura was first opened behind the clivus before the posterior clinoid process were removed to show the additional intradural exposure gained with this maneuver

the sphenoid sinus provided more room to perform safe dissection maneuvers and that working under endoscope assistance improved their exposure.[9] Kassam *et al*.[6] reported the first endoscopic endonasal extradural posterior clinoidectomy as a step in the pituitary transposition approach to the interpeduncular cistern. In this technique, the pituitary transposition, with bilateral ligation of the inferior hypophyseal arteries, is performed before the removal of the PCP. Then, after the dorsum sella is drilled away, the carotid artery is mobilized laterally within the cavernous sinus to expose the carotid canal. At this point, using a 1-mm diamond drill bit, an osteotomy is performed between the carotid canal and the PCP. Finally, the medial mobilization of the PCP detaches it from the carotid canal.[6] The main advantages of these recent extradural techniques are the reduced risk of damaging the neurovascular structures adjacent to this region. Our technique is different from that described by Kassam *et al*. in several ways. First, we find posterior clinoidectomy to be a useful maneuver even if pituitary transposition is not being performed. The PCP can be removed without opening the dura of the pituitary gland, providing increased exposure to the top of the clivus extradurally as well as the interpeduncular cistern [Figures 5–8]. This maneuver is useful for achieving a complete resection of clival-based tumors such as

chordomas and chondrosarcomas. Additionally, we do not drill the fracture line between the carotid canal and the PCP. Instead, we perform a midline split of the dorsum sella and carefully remove it from medial to lateral, using a 1-mm Kerrison rongeur, until we find the PCP. We do so working from below the pituitary gland with slight elevation of the gland. Extradural elevation off the pituitary gland helps reduce injury and maintain its vascular supply. Gentle pressure on the medial wall of the cavernous sinus is efficient in preventing damage to the carotid artery during medial mobilization and detachment of the PCP from the carotid canal. The main advantage of our technique consists of sparing the pituitary gland from excessive mobilization during transposition, which might lead to future endocrinological dysfunction.

The limitations of our study are intrinsic to cadaveric studies. All specimens in our dissections had well-pneumatized pre-sellar and sellar sphenoid sinus anatomy. We believe that the presence of a non-pneumatized conchal type sphenoid sinus would complicate our technique, making it more technically demanding, but not impossible.

CONCLUSION

We describe the technique of endoscopic endonasal extradural posterior clinoidectomy. As an extradural technique, the risk of damaging the neurovascular structures such as the third cranial nerve, hypophysis, carotid artery, and posterior communicating artery is low. We believe this approach is best suitable for tumoral pathologies located in the retrosellar space, such as extradural chordomas as well as lesions in the interpeduncular cistern. As this is a cadaveric study, future clinical application of our technique will be required to validate its application.

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