Fully Endoscopic Minimally Invasive Transrectus Capitis Posterior Muscle Triangle Approach to the Posterolateral Condyle and Jugular Tubercle

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Abstract

Background We evaluated a transrectus capitis posterior muscle triangle approach to the posterolateral foramen magnum, occipital condyles, jugular tubercle, and the fourth ventricle. We also assessed factors that affect the amount of bone removal required.

Objective To evaluate if the proposed approach is as effective as standard open approaches to expose the lateral portion of the foramen magnum.

Methods The proposed minimally invasive fully endoscopic approach was performed in 15 cadaveric specimens using 4-mm (0- and 45-degree) endoscopes.

Results Using a 5-cm straight paramedian incision, the rectus capitis posterior minor and major muscles were partially removed unilaterally, providing a corridor through the muscles to reach the foramen magnum region. After meticulous soft tissue dissection, key anatomical landmarks can be identified such as the greater occipital nerve, the vertebral artery that wraps around the atlanto-occipital joint, and the bony protuberance that heralds the occipital condyle. A suboccipital craniotomy associated with the transcondylar, supracondylar or paracondylar approach is performed depending on the amount of bone removal desired to maximize the surgical view. By doing so, the jugular foramen can be exposed laterally as well as the fourth ventricle medially.

Conclusion The proposed endoscopic approach can provide access through the transrectus capitis posterior muscle triangle leading directly to the occipital condyle. A stepwise approach is critical to gain a surgical corridor to the inferolateral petroclival region and the fourth ventricle.

Keywords

- posterolateral condyle
- jugular tubercle
- minimally invasive
- transrectus capitis posterior muscle triangle
- fully endoscopic

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Introduction

Endoscopic surgical approaches to the condyle are divided into three general groups: anterior, posterolateral, and posteroparameal. Anterior approaches include the “far medial” (transcondylar and transjugular tubercles) expanded endoscopic endonasal approach.¹ The posterolateral approach, usually through a far lateral approach, provides a surgical window for intradural and extradural lesions at the lower skull base and the craniovertebral junction. Most recent reports have used similar methods with microsurgical or keyhole exposure or endoscopy-assisted or purely endoscopic techniques.^{2–7} A posterior paramedian minimally invasive approach is the transrectus capitis posterior muscle triangle approach (TRCPMTA).

There are still major controversial issues for skull base (and/or endoscopic endonasal) surgical management of the occipital condyle (OC) and jugular tubercle (JT) because approaching this region can lead to craniocervical instability and occipitocervical fusion may be required.

We thought to determine whether an endoscopically controlled technique that includes a small paramedian incision, muscle-splitting exposure, and use of a naturally avascular area could provide short-distance access to the foramen magnum (FM) and inferior petroclival region.

Materials and Methods

All anatomical dissections were performed in the University of Pittsburgh Surgical Neuroanatomy Laboratory. The endoscopic endonasal approach (TRCPMTA) was performed on 15 formalin-fixed cadaveric specimens. Red and blue silicone was injected into the arterial and venous systems, respectively, of all 15 specimens. The heads were positioned to simulate the lateral “park-bench” position used in the operating room.

Four-mm-diameter, 18-cm-long endoscopes were used with 0 and 45-degree rod lenses (Karl Storz, Tuttlingen, Germany). A high-definition video camera was connected to a monitor for optimal display. Single-shaft instruments for endoscopic endonasal-surgery were used for dissection procedures. An endoscope holder was used to fix the endoscope for bimanual procedures, such as handling of a venous plexus dissection and bleeding, drilling the OC, and intradural microdissection.

Results

This anatomical-surgical study was based on anatomical division of the OC into anterior, middle, posterior, and endoscopic posterior paramedian approaches and the posterior paramedian expanded transcondylar approach.

Incision; Soft Tissue Dissection; Muscle Identification

A posterior paramedian linear skin incision was made in a 4- to 5-cm straight line, and distance from the midline was 2 cm (►Fig. 1A). The greater occipital nerve and the semispinalis capitis muscle (SCM) are shown (►Fig. 1B).

Fig. 1 Skin incision and soft tissue dissection. (A) A 4- to 5-cm straight paramedian skin incision is used (B) After skin incision, the semispinalis capitis muscle and great occipital nerve are identified. (C-F) Stepwise dissection; the second fat gap (TSFG) is deep to the semispinalis muscle (C), and the third fat gap (TTFG) is deep to the rectus posterior capitis major (D). Identification of the two fat gaps facilitates recognition of the subrectus triangle (SRT). (F) Lateralization of the rectus capitis posterior major shows the inferior nuchal line and the rectus posterior capitis minor muscle. Inf.Nuchal.Line, inferior nuchal line; Rec.Cap.Post.Maj and Min.M, rectus capitis posterior major and minor muscle.

An avascular median raphe (AMR), identified in the midline, is the first fat gap (TFFG) (►Fig. 1A). The second fat gap (TSFG) is between the SCM and the rectus capitis posterior major muscles (RCPMMs) (►Fig. 1D, E). The third fat gap (TTFG) is between the RCPMMs and the rectus capitis posterior minor muscles (RCPmMs) (►Fig. 1E, F). The SCM was incised until TSFG and TFFG's fibrofatty tissue was dissected, and the deep cervical veins were encountered. The inferior oblique muscle and RCPMM in the TSFG were identified (►Fig. 1D).

The bony protuberances blocked exposure of the antero-lateral medulla and was removed (►Fig. 2A, B, D). An oval OC portion of the atlanto-occipital joint perpendicular to the hypoglossal canal on the long axis was situated in the anteromedial third of the OC. The goal of OC and JT removal is to expose the region between the superior cervical area to cranial nerves VII, VIII, IX, X, XI, and XII; the cerebellopontine angle; and the medulla, thereby reducing possible cerebellar retraction. The OC and the JT were removed in three steps. The posterolateral aspect of the OC was resected more often because it can increase the angle of the anteromedial direction of the OC in the forward direction. The posterior one-third of the condyle was resected from the cortical bone to expose the cancellous bone to the lateral aspect of the internal jugular veins (►Fig. 3B). This maneuver opened the intrajugular processes on the opposing edges of the jugular foramen (JF) (►Fig. 3C, D). The internal jugular vein was the target of the osseous stage. The posterior one-third of the OC was exposed during the jugular process.

The middle portion of the condyle was directed forward and medial to the smaller anteromedial part of the JF and hypoglossal canal (►Fig. 3B, C). The surgeon must be careful not to disturb a prominent vein within the condyle when drilling the cancellous bone. Several cadaver heads did not have this prominent vein.

The anterior portion of the condyle (►Fig. 3C, D) is directed superiorly and medially toward the JT and the basion. Medial condyle resection must be performed carefully. The anterior condylar veins and surrounding venous plexus might meet. Drilling of the condyle exposes the lateral aspect of the hypoglossal canal where the landmark is approximately the medial and posterior third of the condylar (►Fig. 3C, D).

The JT is a medially projecting bump of occipital bone anterior and rostral to the OC.⁸ The JT was drilled off extradurally to reach the lateral lower clivus. The basilar venous plexus with a marginal sinus encircled the superior cervical spinal cord and the FM. The anterior condylar veins must be carefully avoided. The JT was removed to expose the

Fig. 3 Stepwise dissection of the condylar stage. (A) the bony protuberance in the posterolateral aspect of the foramen magnum is partially drilled and used as a landmark to achieve the occipital condyle. (B and C) Further dissections is carried on through the posterior aspect of the occipital condyle using the high-speed drill. The cortical bone is removed after what the cancellous bone within the condyle is reached. The hypoglossal canal will be encountered between the anterior and medium third of the condyle. (D) Posterior view of the hypoglossal canal in between the occipital condyle and the jugular tubercle. The canal was an oblique direction from posteromedial to anterolateral. Hypogl.C, hypoglossal canal; Int.Jug.V, internal jugular vein; Occip.Cond, occipital condylar; Post.Cond.V, posterior condylar vein; Rec. Cap.Post.Maj.M, rectus capitis posterior major muscle.

Fig. 4 Dural opening. (A, B) The suboccipital surface of the dura is opened using an superior cut and a medial cut. (C, D) The two cuts are carried lateral and inferior, respectively, and the dura fold is retracted inferiorly using stitches. The cerebellomedullary cisten is exposed and the jugular foramen area can be reached. Inf.Hem.V, inferior hemispheric vein; PICA, posterior inferior cerebellar artery.

region in front of cranial nerves VII, VIII, IX, and X. The interior OC was then divided laterally into three echelons from exterior to interior.

Endoscopic Intradural Exposure; Extradural Lower Cranial Nerves; Fourth Ventricle

The dura is opened in a curvilinear fashion, with its base hinged laterally and pulled tight against the lateral aspect of the craniotomy (►Fig. 4A, B). Under endoscopic guidance, dural openings were placed over the upper cervical cord, lateral lower aspect to the upper aspect of the cervical spinal cord, medulla oblongata, and cerebellar hemisphere, exposing the cerebellar tonsil (►Fig. 4C, D).

The lateroinferior intradural space had limited exposure to the C2 root. Open arachnoid dissection allowed identification of neurovascular structures: The posteroinferior cerebellar arteries (PICAs) arose from the VA (►Fig. 5A, B). When the arachnoid membrane of the VA was resected, the VA, anterior spinal artery, XI and XII cranial nerves, dentate ligaments, and the C1 root were exposed (►Fig. 5 A–D). The intradural procedure, which

began with opening the arachnoid membrane of the great cistern, microdissection, and minimal elevation of the cerebellar tonsil, improved visualization as far rostrally as the pontomedullary junction.

The VA pierced the dura and ascended in front of the dentate ligaments and accessory nerve (►Fig. 5A, C). It then followed the posterior spinal cord and coursed backward around the lateral surface of the medulla oblongata and between the rootlets of the glossopharyngeal, vagus, and accessory nerves (►Fig. 6A–F).

The safest and most direct approach to the fourth ventricle is the midline suboccipital approach. Using endoscopy, the bilateral cerebellar tonsils, biventral lobules, cerebellomedullary fissure, and foramen of Magendie became recognizable (►Fig. 7A, B). Gentle separation of the cerebellar tonsils exposed the cerebellomedullary fissure through the opened vallecule, giving an unimpeded view of the inferior roof of the fourth ventricle (►Fig. 7C, D). PICAs should be carefully noted. The foramen of Magendie and the small tuft of choroid plexus were clearly seen (►Fig. 7A–D).

Fig. 5 The arachnoid bands of the cerebellomedullary cistern are divided using sharp dissection and the endoscope is advanced further in. (A, B) After retracting superomedially the tonsil, the accessory and hypoglossal nerves, vertebral artery, posterior inferior cerebellar artery, and dentate ligament can be seen. (C, D) Relationship of the neurovascular structures within the cerebellomedullary fissure are shown. The hypoglossal nerve running to the hypoglossal canal and C1 and accessory nerves directing to the jugular foramen can be well appreciated. Acce.N, accessory nerve; Cer.Med.Fiss, cerebellomedullary fissure; Dent.Lig, dentate ligament; Hypogl.N, hypoglossal nerve; Medulla, medulla; PICA, posterior inferior cerebellar artery; Vagus.N, vagus nerve; Vert.A, vertebral artery.

Discussion

Selecting a specific approach to reach the OC (the central support of the posterior cranial base) in the deepest part of the skull base may be based on many factors, including anatomical and clinical considerations. The far lateral suboccipital approach combined with dorso-medial condyle resection allows a more medial surgical trajectory.^{9–12}

When tumor is located anterior to the brainstem, it can be reached via access to the clivus and FM using an expanded endonasal transclival approach (EETA), which follows a medial to partly lateral trajectory because the transendonasal angle and depth make it difficult to travel across the lateral OC. However, drilling the OC is more risky because it may cause vascular and/or nerve injury. Also, it is necessary to remove part of the capsule of the atlanto-occipital joint, which could cause craniocervical instability and/or hypermobility.

The Fat Gap; Distinguishing New and Subrectus Triangle Landmarks

We demonstrated that approaching the three fat gaps (►Fig. 1) is useful in identifying posterior cervical muscle groups, increasing operative space, and avoiding excessive bleeding and nerve damage. This approach is associated with a short surgical approach line and is minimally invasive. Also, the role of the endoscopic technique regarding the SRT (►Fig. 1) and most of the posterior neck is emphasized in the TRCPMTA. Minimally invasive surgery in this region is difficult because the thick muscle layers restrain safe exposure of the deep-seated atlanto-occipital joint and neurovascular structures.¹³ Two sets of muscles are especially significant for identifying the vascular structures involved in these exposures: the RCPMMs and the RCPmMs. The RCPMMs originate from the spinous process of the axis and insert into the inferior nuchal line, comprising an MRT (►Fig. 8 E). An SRT is formed in deep tissue by RCPMMs, RCPmMs, the

Fig. 6 Jugular foramen and Internal acoustic meatus structures. (A, B) The glossopharyngeal, vagus, and accessory nerves entering the jugular foramen. (C) The superior vestibular nerve and the inferior vestibular nerve, facial nerve with a labyrinthine branch of the anterior inferior cerebellar artery (AICA) courses toward the internal acoustic meatus. (D) The glossopharyngeal, vagus, and accessory nerves course between the jugular foramen and brainstem are visualized. (E) The vagus nerves (Vagus.N) arise from the brainstem near the lateral end of the pontomedullary sulcus and the foramen of Luschka (F). The posterior inferior cerebellar artery (PICA) passes between the vagus rootlets and medial to the accessory nerves in the cerebellomedullary cistern. Acoust.B, acoustico-facial bundle; Dent.Lig, dentate ligament; Hypogl.N hypoglossal nerve; Inf.Vest.A, inferior vestibular nerve; Sup.Vest.A, superior vestibular nerve; Trig.N, trigeminal nerve; Vert.A, vertebral artery.

posterior atlanto-occipital membrane (forming the base of the sub-triangle), and the posterior atlas (►Fig. 8A–H). The SRT has only part of the VA in its structure (some cadavers have only CVP and lateral and posterior condylar

veins). Thus, the RCPMMs and RCPmMs should be removed carefully without violating the VA after being well orientated. MRTs and SRTs create ample working space for endoscopic surgery. The posterior atlanto-occipital membrane, forming the base of the SRT, blends with the periosteum of the posterior arch of the atlas. The structure of the RCPMMs and SRT and the atlanto-occipital membrane offer a useful roadmap for safe identification and exposure of the VA.

Vertebral Artery Management; Lateral Suboccipital Craniotomy; Condylar Resection

VA exposure and protection are important. It may be encased by a venous plexus, may be superficially displaced, and its location and course might vary because it could leave the transverse foramen, later making a sharp turn medially and run in a groove in the sulcus arteriosus.⁸ When stripping the atlanto-occipital membrane from the FM, the surgeon should be aware of the variability of the vein and the VA. The VA was released from across the dural entry point, and its mobilization could make it possible to create a working space to facilitate a superoinferior cervical cord trajectory.

With TRCPMTA, the bone is removed with the goal of creating a corridor between the lower medulla and cerebellum, thereby reducing cerebellar retraction. It includes both a lateral suboccipital approach and a lateroinferior approach. It allows transcondylar, supracondylar, and paracondylar exposure. The minimally invasive craniectomy, which is performed low in the suboccipital region, extends from the inferior nuchal line approximately to the posterior and lateral edge of the FM. It then extends to the posterior edge of the OC. The arch of C1 is removed posterolaterally to the sulcus arteriosus—any variants of which can make the exposure dangerous.⁸ The bony protuberances of the occipital bone could hinder access to the condylar and occipital articular surface areas and the JT. The OC represents a second obstruction, which is associated with cranial nerves IX, X, XI, and XII. The bony rim of the FM is resected to the OC (►Fig. 9A, B), and the posterior one-third of the OC is removed, which may be helpful when the FM is deep. The role of condylar resection is more straightforward for extradural tumors. It creates a surgical corridor along the condylar long axis that causes minimal posterior nerve, medulla oblongata, or cerebellar retraction.

Management of the OC with a craniectomy at the craniocervical junction and petroclival region has been undertaken based on different viewpoints. Some articles discussing intradural anterior FM tumors advocated against condylar resection,^{14–16} whereas others suggest that partial condylar resection may be needed in some patients,^{10,17–19} including those in whom the surgical corridor has not been enlarged by the lesion.²⁰ We believe that in the presence of large tumors, the limited working space can be enlarged using partial condylar resection. It adds to the panoramic view of lateroanterior lesions, obviating the need for brain retraction.

Fig. 7 Endoscopic view of the fourth ventricle. (A) The endoscope is directed toward the vallecula, cerebellomedullary fissure, and foramen magnum; the medulla oblongata and tonsils can be recognized. (B, C) Visualization of foramen of Magendie and the choroid plexus passing through it. The inferior cerebellar peduncle can be seen in the lateral portion of the obex. (C, D) Internal view of the floor of the fourth ventricle using a 45-degree endoscope. The median sulcus divides the floor longitudinally in the midline. Each half of the floor is divided longitudinally by an irregular sulcus, the sulcus limitans, which deepens lateral to the facial colliculus and hypoglossal triangles to form the superior and inferior foveae. The stria medullaris crosses the floor at the level of the lateral recess. The hypoglossal and vagal nuclei and the area postrema are stacked one above the other in the lower part of the floor. Cer.Med, cerebellomedullary fissure; Coll, colliculus; Chor.Plex, choroid plexus; For, foramen; Hypogl, hypoglossal; Inf, inferior; Ped, peduncle; PICA, posteroinferior cerebellar artery; Striae.Med, Stria medullaris; Suboccip, suboccipital; Tri, triangle; V, vein.

Occipital Condyle and Jugular-Condylar Zones

Based on the extent of surgical exposure achieved by the surgical approach, the OC region can be divided into anterior, middle, and posterior portions according to the mechanics of the OC. Because of the complexity of the OC and its surrounding structures, one must be well aware of its anatomy to be able to choose the most advantageous surgical approach. Drilling transcondylar, supracondylar, or paracondylar extensions could facilitate exposure of targeted regions.

The posterior portion (posterior one-third) stretches from the posterior joint capsule cartilage to the posterior margin of the jugular fossa (→Figs. 9A, B, 10A, B, 11A–D). This area is bound anteriorly by the internal jugular veins, cranial nerve XII, and the posterior rim of the jugular fissure; posteriorly by the VA and posterolateral condylar vein, and the posterior joint capsule cartilage; and laterally

by the cerebellar tonsil, medulla oblongata, and cranial nerve XI. The posterior one-third can be exposed utilizing TRCPMTA. The posterior lateral third of the condyle is not threatened by removal.²¹

The middle OC (middle one-third) is the portion between the intrajugular process and anterior rim of the hypoglossal canal (→Figs. 9A, B, 10A, B, 11A–D). It is bound anteriorly by cranial nerve XII, posteriorly by cranial nerve IX, and laterally by the CPA.

The anterior OC (anterior one-third) is the portion that extends from the anterior rim of the hypoglossal canal to the anterior of the joint capsule cartilage (→Figs. 9A, B, 10A, B, 11A–D). This part is bound anteriorly by the atlanto-occipital joint tissues, posteriorly by cranial nerve XII, laterally by the medulla oblongata, and superiorly by the JT.

The topographic anatomy of the OC makes its surgical approach feasible. There are similar reports in the

Fig. 8 Occipital-cervical muscles in a layer by layer dissection. (A, B) After exposing the avascular median raphe (AMR), the first fat pad between the edges of the semispinalis capitis muscle can be seen. After removing it, the inferior nuchal line muscles can be visualized. (C, D) The major rectus triangle is situated in the depth of this area between the medial edges of both rectus capitis posterior major muscles and the inferior nuchal line. The subrectus triangle is situated between the rectus capitis posterior major and minor muscles (Rec.Cap. Post.Maj and Min.M) medial edges and the C1 posterior arch. (E, F) Shows a diagram of the major rectus triangle and the subrectus triangle. (G) The vertebral artery and vertebral venous plexus crossing in the depth of the suboccipital triangle (between the superior and inferior oblique and the rectus capitis posterior major muscles), behind the atlanto-occipital joint and across the C1 posterior arch. (H) diagram of the suboccipital triangle. Inf.Obl.M, inferior oblique muscle; Semispin.Cap.M, semispinalis capitis muscle; Sup.Obl.M, superior oblique muscle; Vert.A, vertebral artery.

literature.²² The extent of the surgical dissection of the OC achieved by the surgical approach, which is the approach of choice for removing a tumor from this region, must take into account the nature and location of the lesion.

Extensive drilling of the OC increases the risk of postoperative atlanto-occipital instability.⁸ Although few biomechanical studies have reported resection of the OC in excess of 50%, more than 70% resections caused OC instability suggesting the need for OC fusion.^{23,24} This approach ensures that the basion (→ Fig. 9 B) and dens (basion/dens interval [BDI]) of the bone are integrated; radiologic displacement of greater than 10 mm between the basion and dens is considered abnormal.²⁵ A displacement of greater than 12 mm or less than 4 mm between the basion and the posterior C2 line or a displacement of greater than 12 mm from the basion to dens was considered abnormal.^{26,27} It could be improved by shifting the exposure corridor laterally via bone resection (i.e., changing the angle between the lower medulla and cerebellum).²⁸

This route is mostly blind from the inferior margin of the hypoglossal canal to the level of the JT, and access is partly limited. However, the EETA and the far lateral approach via internal jugular veins and the condylar compartment can reach it but only with removal of a critical mass of the condyle, which would necessitate fusion to provide stability.¹

We have found that piece-by-piece removal of the OC was helpful in the presence of pathology in the ventral midline lateral space to gain more exposure. Extradural drilling of transcondylar, supracondylar, or paracondylar extensions is applicable to facilitate exposure of targeted regions, such as the lateral space of the FM, a lateral-lower clivus, and the JF.

Condylar Vein Networks

The drainage pathways of the anterior condylar veins, lateral condylar veins, intracondylar veins, and posterior condylar veins are complex networks that may include the inferior petrosal sinus, inferior petrosal vein, and venous plexus of the hypoglossal canal. The posterior or lateral approach to the JF, hypoglossal canal, anterior FM, or petroclival region requires careful management of the drainage venous networks. Drilling the rim of the FM and surrounding area should be done carefully to avoid damaging the posterior condylar veins. The lateral condylar vein is used as a landmark because it courses along the full length of the lateral edge of the OC.²⁹

The most commonly encountered bleeding is brisk venous plexus bleeding that occurs during condylar removal. It can be controlled, however, with Surgifoam (Ethicon, Somerville, New Jersey, United States) and bipolar coagulation. In two reports, the VA was a landmark, with no transposition required in any of the cases^{30,31} Traditionally, superficial anatomical landmarks include the presence of variability.

Navigation is an indispensable auxiliary tool during suboccipital craniotomy. Stereotactic navigation can aid in mapping the location of sinuses.³² Navigation is particularly valuable when drilling condylar bone. We must be careful as hypoglossal veins course through the hypoglossal canal and can be divided by the fibrous or bone septa.³³

Fig. 9 Foramen magnum and occipital condyle anatomy and relationships - Inferior-posterior view. (A, B) bony structures involved in the endoscopic transcondylar approach. Cond.Canal, condylar canal; Hypogl.Canal, hypoglossal canal; Jug.Tubercle, jugular tubercle; Occip.Cond, condylar-occipital.

Fig. 10 Condylar and jugular tubercle region. The internal jugular vein arises from the jugular foramen just lateral to the occipital condyle. When drilling it, care should be taken not to injury the jugular vein laterally. (A, B) Posterior superior and inferior view of the jugular foramen and jugular tubercle. For.Lacerum, foramen lacerum; For.Magnum, foramen magnum; For.Ovale, foramen ovale; Hypogl.Canal, hypoglossal canal; Jug.For, jugular foramen; Jug.Tubercle, jugular tubercle; Occip.Cond, condylar-occipital; Pet.Part, petrosal part; Sig.Part, sigmoid part.

Fig. 11 (A, B) relationship between the anterior portion of the occipital condyle and the internal carotid artery and the jugular vein (C, D) petroclival region showing the sigmoid sulcus coursing toward the posterior part of the jugular foramen where it will join the jugular bulb. Anteriorly, the petroclival fissure meets the jugular foramen where the IX, X and XI nerves and the inferior petrosal sinus passes. AICA, anterior-inferior cerebellar artery; Car.A, carotid artery; CN VII, VIII, IX-XI, XII, cranial nerve, For.Ovale, foramen ovale, Jug.For jugular foramen, Jug. Tubercle, jugular tubercle; Hypogl.Canal, hypoglossal nerve; Int.Jug.V, internal jugular vein; Int.Ac.Meatus, internal acousticofacial meatus; Occip.Cond, occipital condyle; Sig.Sinus, sigmoid sinus.

Conclusion

The TRCPMTA provides direct access to the VA, allowing proximal vascular control. The approach is minimally invasive, provides a short surgical pathway, and offers a relatively large exposure range for the surgical method. Although this article does not have the intentions to prove that the proposed approach is superior to the conventional microscopic or endoscope-assisted previously described approaches, the TRCPMTA is feasible and should be taken into consideration when choosing the approach to the lateral FM region and inferior petroclival area.

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