

BACKGROUND

Surgery involving the sellar, parasellar, and clival regions presents significant technical challenges and over the decades, the endoscopic endonasal approaches (EEAs) have become the gold standard for accessing certain pathologies in the ventral skull base. During the EEAs, to safely remove sellar, cavernous sinus and clival lesions and prevent severe complications as internal carotid artery (ICA) branches injuries, and cranial nerves (CNs) palsies, a detailed knowledge of their anatomical location is crucial. The aim of this study was to provide a surgical roadmap of the anatomical relationship of the arteries and cranial nerves to the sellar floor and carotid segments during encountered in EEAs.

MATERIALS AND METHODS

Nine formalin-fixed and latex-injected specimens (18 sides) were dissected endoscopically with the midpoint of the sellar floor (MSF) representing a key landmark for measurements. For each structure, the superior-inferior and lateral distances from the MSF were recorded. The relationship between arteries and nerves and the internal carotid artery (ICA) segments was documented (Figures 1).

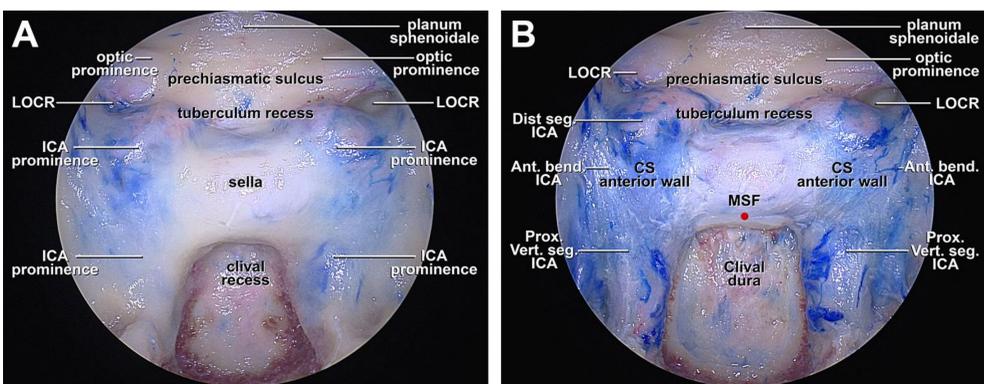


FIGURE 1. Cadaveric dissection of the endoscopic endonasal transsphenoidal approach. A. Endoscopic view of the posterior wall of the sphenoid sinus and related bony anatomical landmarks. B. Progressive bone drilling of the sellar, cavernous and clival areas. The midpoint of the sellar floor (MSF) and the internal carotid artery (ICA) segments represented the fixed landmark (red circle) to localize the main neurovascular structures. Abbreviations: Ant., anterior; CS, cavernous sinus; Dist., distal; ICA, internal carotid artery; LOCR, lateral optico-carotid recess; MSF, midpoint of sellar floor (red dot); Prox., proximal; Seg., segment; Vert., vertical.

RESULTS

The main arteries originated from the cavernous internal carotid artery (cICA) superior to the sellar floor. The meningo-hypophyseal trunk (MHT) arose posteromedial to the posterior ICA bend, with a mean position 2.6 mm superior and 9.95 mm lateral to the MSF. Its three principal branches (inferior hypophyseal, tentorial and dorsal meningeal arteries) were identified lateral to the MSF, along the medial aspect between the distal ICA and the superior portion of the proximal vertical ICA. In two sides (11.1%), the dorsal meningeal artery (DMA) arose directly from the ICA. The inferolateral trunk (ILT) originated lateral to the horizontal ICA in 15 sides (83.3%). Its posterior branch crossed inferolaterally the cavernous segment of the abducens nerve (CN VI) and the ophthalmic division of the trigeminal nerve (V1) (Figure 2).

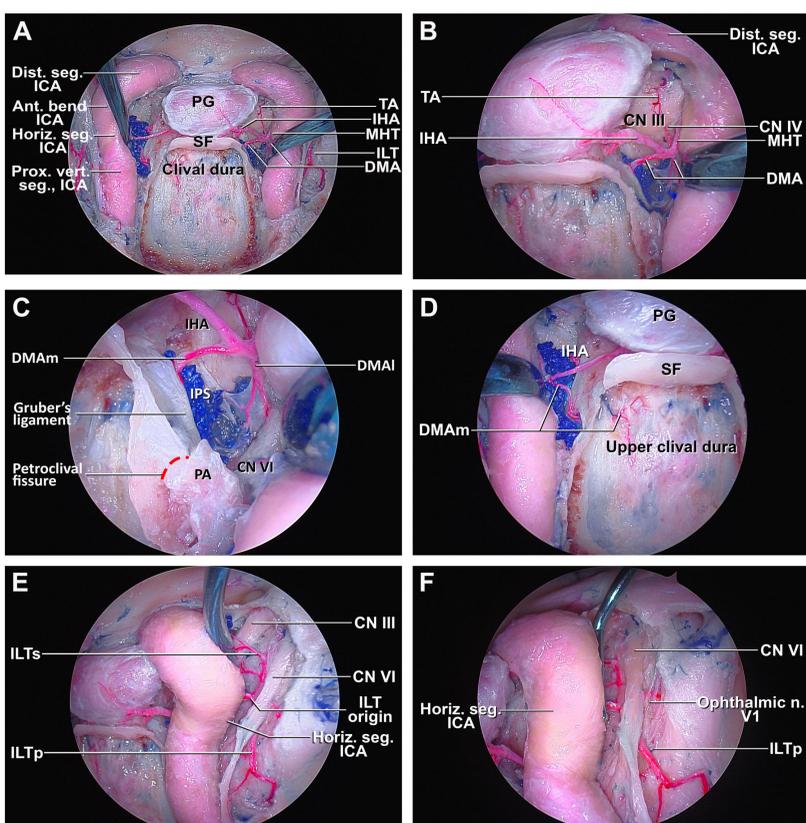


FIGURE 2. A. and B. In most of the cases the meningo-hypophyseal trunk (MHT) arose posteromedial to the posterior bend. The inferior hypophyseal artery (IHA) run medially with an inferior direction toward the sellar floor. C. The medial and lateral branches of dorsal meningeal artery (DMA) run inferomedially and posteriorly between the posterior bend and the proximal vertical ICA, and inferolaterally and posteriorly to the proximal vertical ICA, respectively. The lateral branch provided multiple arteries to the sphenopetroclival venous confluence. D. The medial DMA pattern consisted of a single trunk originating from MHT and directed medially toward the upper clival dura. E. In 83.3% the inferolateral trunk (ILT) origin was found laterally to the horizontal ICA with minor superior-inferior variations reflecting specimen-specific anatomical variability. In 16.7% originated laterally to the anterior bend. F. The posterior branch of ILT was found between the cavernous part of CN VI and the ophthalmic nerve (V1) at the lateral wall of the CS. Abbreviations: Ant., anterior; CN, cranial nerve; Dist., distal; DMA, dorsal meningeal artery; DMAM, medial dorsal meningeal artery; DMAI, lateral dorsal meningeal artery; GL, Gruber's ligament; ICA, internal carotid artery; IHA, inferior hypophyseal artery; ILT, inferolateral trunk; ILTs, inferolateral trunk superior branch; ILTp, inferolateral trunk posterior branch; IPS, inferior petrosal sinus; MHT, meningo-hypophyseal trunk; PA, petrous apex; PCF, petroclival fissure; PG, pituitary gland; Prox., proximal; Seg., Segment; TA, tentorial artery; Vert., vertical.

RESULTS (CONTINUED)

The location of oculomotor (CN III), trochlear (CN IV), ophthalmic (V1), and abducens (CN VI) nerves within the cavernous sinus (CS) and clival region, and their relationship with the sellar floor and the ICA segments, were reported. The interdural entry point of CN VI was located at the mid-clivus, 10.17 mm inferior and 11.53 mm lateral to the MSF, 4.11 mm superior to the foramen lacerum, and medial to the petrous apex (PA) and proximal vertical segment of the ICA.

Within the lateral wall of CS, the cavernous segment of CN VI was observed at two consistent positions:

- **Proximal:** lateral to the superior portion of the proximal vertical ICA and inferior to the horizontal ICA.
- **Distal:** lateral to the midpoint of the C-shape of the anterior ICA bend.

The ophthalmic nerve (V1) was found inferior and lateral to the cavernous CN VI. The entry points of CN III and CN IV into the CS were located between the distal segment of ICA and posterior bend, with CN IV coursing inferior and lateral to CN III. At their exit point from the lateral wall of CS toward the superior orbital fissure (SOF), CN III was found lateral to the distal ICA, whereas CN IV ran lateral to the superior edge of the anterior bend, inferior to CN III before crossing superiorly at the SOF (Figures 3 and 4).

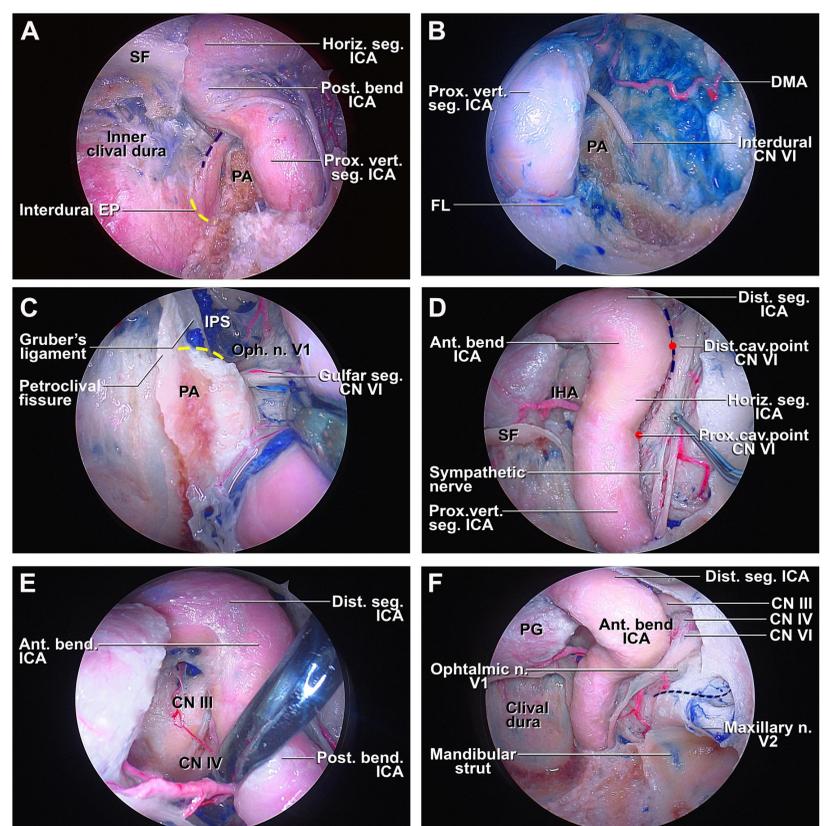


FIGURE 3. A. The interdural point of the abducens nerve (yellow dotted line) was described as the point where the nerve exits the distal compartment and pierces the dura. Following an ascending trajectory, the nerve passes over the tip of the petrous apex (PA) (blue dotted line) towards the CS. B. The position of the interdural entry point of the CN VI superior to the foramen lacerum and medial to the proximal vertical segment of the ICA. C. The gulfar segment of the CN VI passes posterior to the proximal vertical ICA before giving rise the cavernous segment. D. The proximal cavernous point was the point where the nerve exits the sphenopetroclival confluence and enters the CS and is located lateral to the superior proximal ICA and inferior to the lateral horizontal ICA. The distal cavernous point was the point lateral to the midpoint of the C-shape of the anterior bend (blue dotted line). E. The trochlear nerve (CN IV) at the entry point of the CS was located inferior and lateral to the oculomotor nerve (CN III), medial to the posterior bend. F. The CN III is lateral to the distal ICA. The trochlear nerve is lateral to the superior edge of the anterior bend. The blue dotted line marked the inferior limit of the CS. Abbreviations: Cav., cavernous; CN, cranial nerve; Dist., distal; DMA, dorsal meningeal artery; EP, entry point; FL, foramen lacerum; GL, Gruber's ligament; ICA, internal carotid artery; IHA, inferior hypophyseal artery; IPS, inferior petrosal sinus; n., nerve; Oph., ophthalmic; PA, petrous apex; PG, pituitary gland; Prox., proximal; Seg., segment; SF, sellar floor; Vert., vertical.

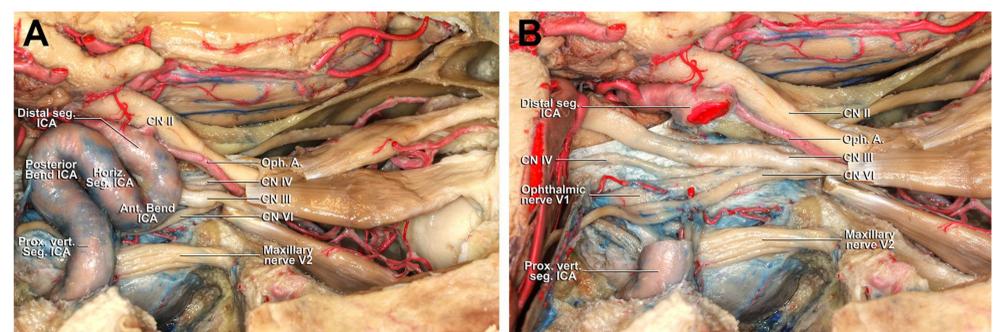


FIGURE 4. A sagittal section exposing the cranial nerves (CNs) from the cavernous sinus to the superior orbital fissure (SOF). A. The interdural CN VI run medially to the proximal vertical segment of the ICA before crossing the sphenopetroclival venous confluence and enters the cavernous sinus (CS). At the CS the proximal and distal cavernous segments were visible between the superior proximal vertical ICA and the midpoint of the C-shape of the anterior bend. The CN III at its exit point from the CS runs lateral to the distal ICA. B. The ICA is sectioned from the proximal vertical segment to the origin of the ophthalmic artery. From below to above the position of the CNs is shown in the lateral CS before entering the SOF. The CN VI after piercing the clival dura ascends with a medial to lateral trajectory to reach the lateral CS passing superiorly to the ophthalmic nerve V1 before reaching the SOF. The trochlear nerve runs inferior to the CN III at the lateral CS before crossing superiorly at the entrance of SOF. Abbreviations: Ant., anterior; CN, cranial nerve; Dist., distal; Horiz., horizontal; ICA, internal carotid artery; Oph. A., ophthalmic artery; Post., posterior; Prox., proximal; Seg., segment; Vert., vertical.

CONCLUSIONS

In endoscopic endonasal approaches, the sellar floor and internal carotid artery (ICA) segments serve as reliable landmarks for anticipating the position of critical neurovascular structures. This study provided a surgical "roadmap" where the midpoint of the C-shape of the anterior bend of ICA was a reliable landmark to observe the distal cavernous segment of CN VI. The oculomotor nerve, along the lateral wall of the cavernous sinus, was positioned lateral to the distal ICA, whereas the trochlear nerve ran lateral to the superior edge of the anterior bend.