Sequential Extradural and Intradural Devascularization of Anterior and Middle Fossa Meningiomas - An Anatomical and Surgical Successive Approach Based on Morphometric Measurements of Fixed and Predictable Anatomy

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BACKGROUND

Anterior and middle cranial fossa meningiomas account for approximately one third of all intracranial meningiomas and can be further classified based on their site of dural attachment and regional anatomy. Despite highly variable locations and surgical approaches, a critical step is effective devascularization to decrease intraoperative blood loss, improve visualization, reduce surgical time, and consequently improve post-operative outcomes.

Skull base surgery requires precise maneuvering around critical neurovascular structures. These operative challenges are compounded by limited visualization and distortion of soft tissues due to mass effect. Traditional approaches utilize soft-tissue landmarks which are inherently deformable whereas bony landmarks and neurovascular structures at bony foramina remain relatively constant and provide fixed and reproducible reference points. Although numerous skull base surgical approaches exist, there is limited quantitative anatomical guidance as simple “lines and rules” correlating expectant neurovascular structures with bony landmarks to guide sequential microdissection, particularly for early career skull base surgeons. A deformity-resistant objective framework, anchored in predictable bony anatomy limits variability, improves surgical safety, and mitigates inadvertent injury to neurovascular structures.

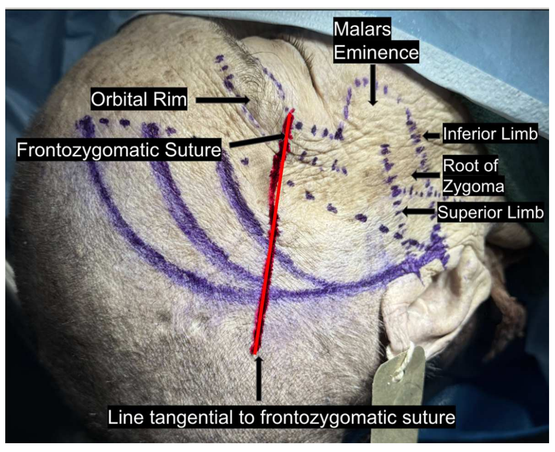
Through our work, we present a sequential framework based on anatomically grounded “lines and rules” that utilize bony landmarks and cranial nerve relationships to localize extradural and intradural arterial supply to anterior and middle cranial fossa meningiomas. Through cadaveric dissections and surgical videos, we illustrate safe surgical corridors and a stepwise sequence utilizing quantifiable measurements designed to achieve effective devascularization while minimizing neurovascular injury.

METHODS

Cadaveric dissections were performed using 20 preserved specimens (40 sides). We offer objective and predictable “lines and rules” for surgical localization of relevant cranial nerves and the most common arterial supply to anterior and middle cranial fossa meningiomas including: ophthalmic, meningo-orbital, cavernous sinus branches of the internal carotid (ICA) [inferolateral trunk (ILT) and meningohypophyseal trunk (MHT)], artery of the foramen rotundum, accessory middle meningeal, and middle meningeal artery (MMA). This microsurgical progression is presented as a sequential surgical extension of the traditional pterional and modified orbitozygomatic craniotomy towards a trans-cavernous and middle fossa expansion.

RESULTS

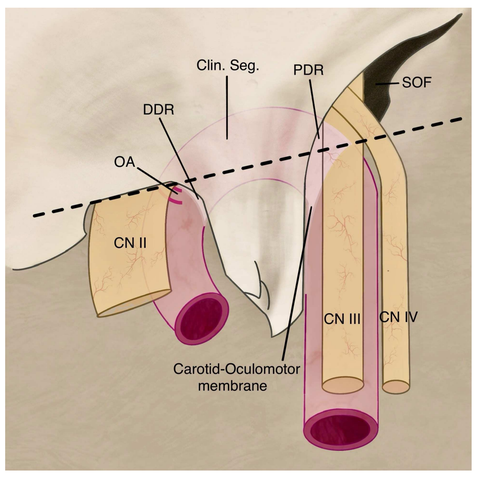
① Frontozygomatic suture line



If we draw a tangential line to the frontozygomatic suture, one can predict the following structures in sequence:

1. Sphenofrontal suture
2. Meningo-orbital band and contents
3. Junction of lesser and greater wing of sphenoid
4. Mid-portion of clinoidal crest
5. Sylvian fissure

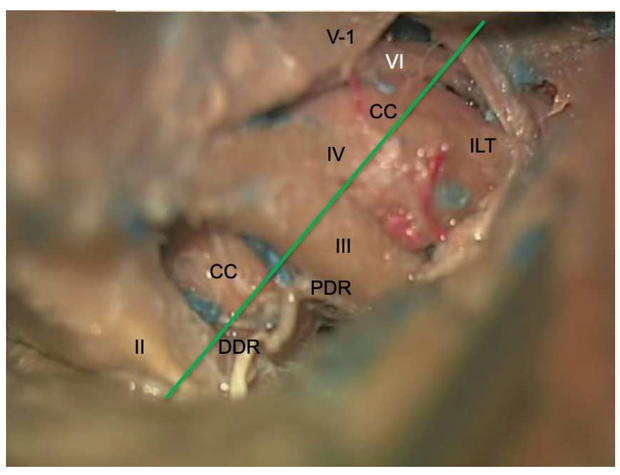
② Falciform Ligament Line (FLL)



If we draw a line tangential to falciform ligament at the transition of the intraorbital to intracranial optic nerve, this line will cross the following from medial to lateral:

1. Distal dural ring (DDR)
2. Ophthalmic artery (OA) (distal to DDR)
3. Posterior wall of clinoidal segment (Clin. Seg.) of ICA
4. Proximal dural ring (PDR)
5. The point where CN IV begins crossing over CN III at superior orbital fissure (SOF).
6. FLL is just anterior to ILT and CN VI which can be located lateral to ILT (refer to "NANA" rule ' Figure #3)

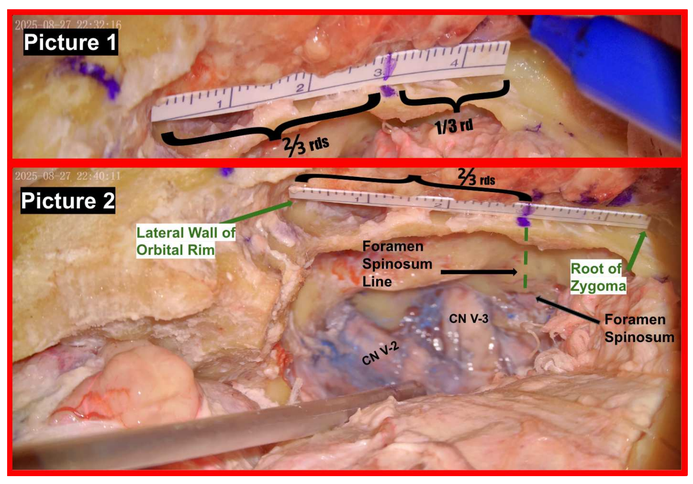
③ "Nerve, Artery, Nerve, Artery" Rule



When approaching the cavernous sinus just posterior to the aforementioned falciform ligament line the following structures can be identified from lateral to medial:

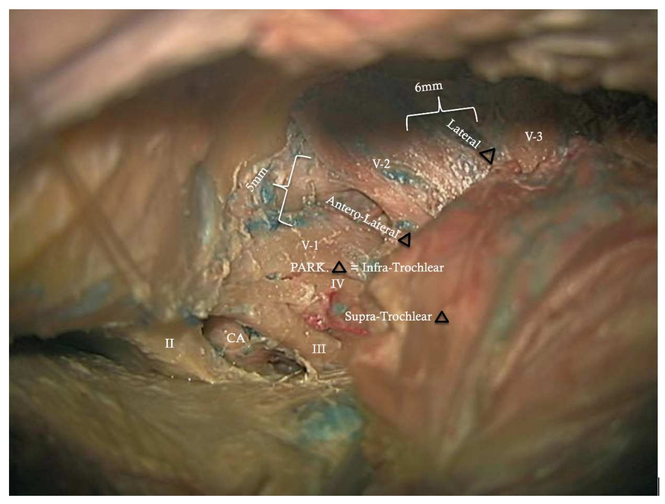
1. CN V1 "Nerve"
2. ILT "Artery"
3. CN VI "Nerve"
4. Horizontal segment of cavernous ICA in the subtrochlear (Parkinson's) triangle "Artery"

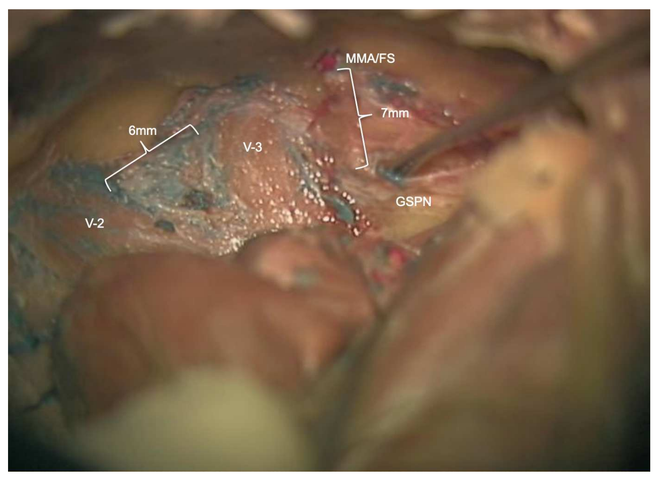
④ Foramen Spinosum Line



Two-thirds the distance from the lateral orbital rim to the root of the zygoma a point is demarcated in purple along the ruler, and a perpendicular line (Foramen Spinosum Line) from this point will identify the foramen spinosum and its' contained MMA.

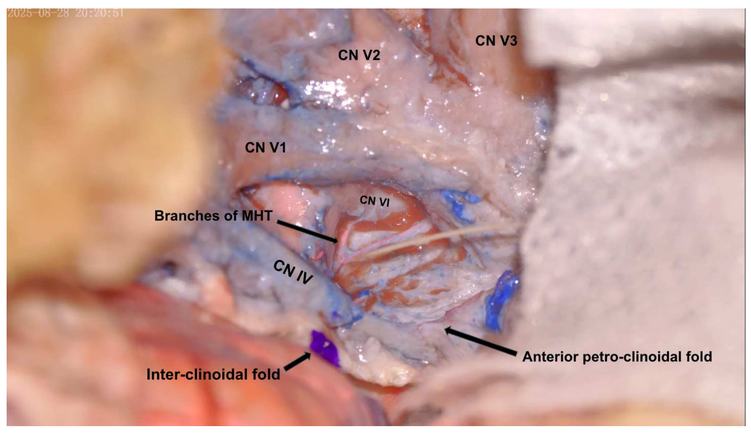
⑤ 5,6,7 Rule





5mm: Distance between the lateral border of CN V1 at the level of SOF and the medial border of CN V2 at the foramen rotundum where the artery of foramen rotundum can also be located.
6mm: Distance between lateral border of CN V2 at foramen rotundum and the medial border of CN V3 at the foramen ovale where the accessory meningeal artery can also be located.
7mm: MMA (localized by the foramen spinosum line) to the greater superficial petrosal nerve (GSPN).

⑥ Trochlear Line - "10mm Rule"



If we draw a line from where CN III enters the carotid triangle under the inter-clinoidal fold to a distance of 10mm along the anterior petro-clinoidal fold, we will reach the point of entrance of CN IV into the tentorium (anterior petro-clinoidal fold). The MHT can be found under the trochlear line, between ILT (anteriorly) and CN VI (laterally) running over the cavernous ICA.

CONCLUSION

Devascularization of anterior and middle cranial fossa meningiomas is a crucial step in their resection. We offer the aforementioned “lines and rules” as a method to predict and guide anatomical localization of arterial supply and relevant cranial nerves. This provides safe surgical corridors for identification of neurovascular structures and early extra and intradural devascularization based on predictable bony landmarks. This microsurgical progression is presented in a stepwise surgical extension from the traditional pterional and modified orbitozygomatic craniotomy towards a trans-cavernous and middle fossa approach.