Surgical Anatomy of the Medial Wall of the Orbit in 14 Human Cadavers

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J Neurol Surg B

Abstract

Objective The aim of our study is to present the anatomical landmarks to perform an endoscopic endonasal approach to the medial wall of the orbit (EEAMO).

Material and Methods We performed 14 complete nasal and orbital endoscopic dissections in 7 adult cadaveric heads.

Results The EEAMO provides a surgical corridor between the medial rectus muscle superiorly and the inferior rectus muscle inferiorly .The mean distance between the ethmoidal crest and medial rectus muscle was 1.5 cm (range, 1.3–1.9 cm). The width of the medial rectus muscle was 1.2 cm (range, 1–1.5 cm). The main vascular structure in this retrobulbar space was the ophthalmic artery that crosses over the optic nerve in 86% of the cases. In its intraorbital route, the anterior ethmoidal artery and the ethmoidal nerves were situated inferior to the superior oblique muscle in all cases. The posterior ethmoidal artery was found superior to it. We could identify the inferior division of the oculomotor nerve in this surgical approach.

Conclusions The EEAMO allows adequate exposure of the space between the medial rectus muscle and the inferior rectus muscle. The location of the ethmoidal crest of the palatine bone, and its relationship with the medial rectus muscle, is a useful anatomical landmark for this surgical approach.

Keywords
- ► orbital
- ► endoscopic sinus surgery
- ► sinus anatomy
- ► optic nerve

Introduction

Orbital tumors are rare lesions that represent less than 1% of the head and neck tumors.[1] Approximately 70% of the cases are benign lesions, being the cavernous hemangioma and the dermoid cyst the most common pathologies.[2,3]

The treatment of most of these tumors usually requires surgical excision. External approaches, either transcutaneous, transconjunctival, or transcranial are most commonly used because they allow easy access to all the orbital walls.[4,5] However, for lesions located in the inferior and medial orbital compartment, these approaches provide a more restricted visual field and usually require orbitotomies, displacement of the eyeball and/or detaching of the orbital muscles.

The endoscopic endonasal approach can be considered as an effective and safe alternative for the treatment of tumors located in this region. There is not much experience regarding the management of intraorbital lesions, and there are few

received
December 3, 2015
accepted after revision
January 20, 2016

DOI http://dx.doi.org/10.1055/s-0036-1579544.
ISSN 2193-6331.

references to cases exclusively operated by endoscopic approach. The complexity of this anatomical region and the variability of the neurovascular structures require a thorough study of this anatomical area. The aim of our study is to present the anatomical landmarks to perform an endoscopic endonasal approach to the medial wall of the orbit (EEAMO). We describe the neurovascular structures and the muscles in this location and their relationships.

Material and Methods

From April 2014 to April 2015, we performed 14 complete nasal and orbital dissections in 7 adult cadaveric heads provided by the Department of Anatomy of the Faculty of Medicine of the Autonomous University of Barcelona. The Institutional Review Board of the Santa Creu i Sant Pau hospital reviewed and approved this study. The specimens were formalin fixed according to the standard protocols of the Department of Anatomy.

For the endoscopic dissection, we used 0 and 45-degree rigid endoscopes and standard surgical instruments. In both nasal cavities, we removed the middle turbinate and performed a wide septectomy to allow bimanual dissection (four-hand technique).

We performed the dissection with the same technique that would be used in a surgical scenario. In each nasal cavity, we performed a complete ethmoidectomy, identifying the anterior and posterior ethmoidal canals. We made a wide, middle antrostomy reaching the infraorbital canal in its route across the roof of the maxillary sinus.

We identified the ethmoidal crest (EC) of the perpendicular plate of the palatine bone, and the sphenopalatine foramen with its neurovascular structures in every specimen. Next, we opened a wide, bilateral sphenoidotomy to explore the main anatomical landmarks in the lateral sinus wall: the optic nerve (ON), the internal carotid artery, and the opticocarotid recess. After exposing the lamina papyracea, we removed it in anterior to posterior direction until the ON canal was exposed. Finally, we incised the periorbita from posterior to anterior and carefully removed the orbital fat to demonstrate the neurovascular and muscle structures of this anatomical region.

Results

We achieved complete exposure of the three muscles of the medial orbital wall, the medial rectus muscle (MRM), the inferior rectus muscle (IRM), and the superior oblique muscle (SOM) in all 14 nasal cavities (►**Fig. 1**). We analyzed two main measurements, the distance between the upper and lower margins of the MRM and the distance from the EC to the lower margin of the MRM.

The mean distance between the margins of the MRM was 1.2 cm with a standard deviation (SD) of 0.01 cm. The lowest value was 1 cm and the highest value was 1.5 cm. The median was 1.2 mm.

The mean distance between the EC and the MRM was 1.5 cm with an SD of 0.15 cm. The lowest value was 1.3 cm and the highest value was 1.9 cm. The median was 1.5 mm (►**Table 1** and ►**Fig. 2**).

The ophthalmic artery (OA) and the ON were identified through the anatomical window between the IRM and the MRM. The OA enters the orbit through the optic canal inferior and lateral to the ON and bends cranially to appear above the ON following the lower edge of the SOM in 86% of the cases (12/14). In the remaining 14% cases, the artery was inferior to the ON (►**Fig. 3**).

In its intraorbital route, the anterior ethmoidal artery (AEA) was situated inferior to the SOM describing a curvature before being placed on the ethmoidal roof. The posterior ethmoidal artery (PEA) was found superior to the SOM in all nasal cavities (►**Fig. 4**).

The origin of the supraorbital artery (SOA) was found between the two ethmoidal arteries in the proximity of the origin of the PEA (►**Fig. 4**). In two nasal cavities, we identified (14%) a common trunk for both arteries. We identified several posterior ciliary arteries in the retrobulbar space (►**Figs. 3B** and **5**).

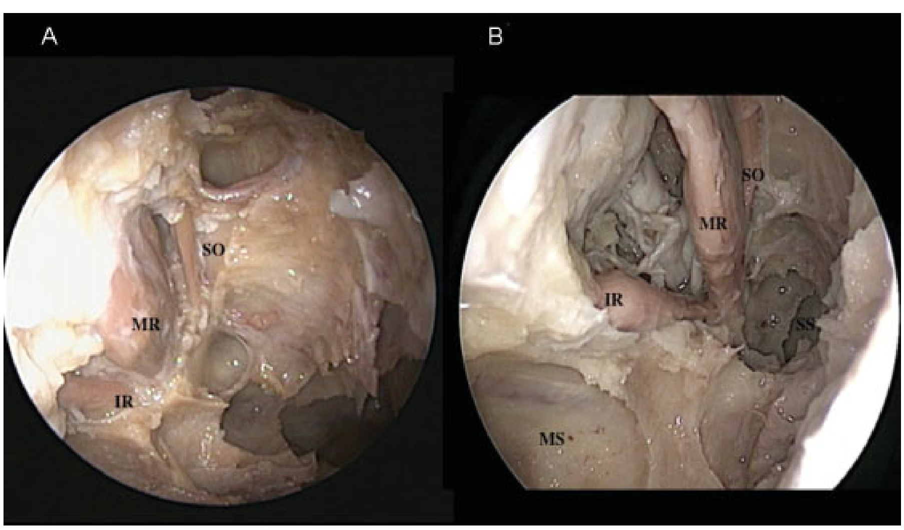

Fig. 1 (**A** and **B**) Muscles of the medial orbital wall in the right nasal cavity. In the figure (**B**), the orbital fat has been partially removed and the MR medially displaced. IR, inferior rectus; MR, medial rectus; MS, maxillary sinus; SO, superior oblique; SS, sphenoid sinus.

Table 1 Measurements to identify the belly of the MRM

Nasal cavity	EC–MRM (cm)	Width of the MRM (cm)
1R	1.5	1.1
1L	1.3	1.1
2R	1.5	1.2
2L	1.6	1.2
3R	1.6	1.1
3L	1.6	1.0
4R	1.8	1.4
4L	1.9	1.5
5R	1.4	1.1
5L	1.5	1.2
6R	1.4	1.2
6L	1.4	1.3
7R	1.7	1.3
7L	1.5	1.2
Median	1.5	1.2

Abbreviations: EC, ethmoidal crest; MRM, medial rectus muscle.

The nasociliary nerve (NCN) was identified parallel to the inferior edge of the SOM, giving rise to the anterior and posterior ethmoidal nerves, located inferior to the muscle. Finally, after running superior to the curvature of the AEA, the nerve ends as the infratrochlear nerve (►**Fig. 6**).

We found the inferior division of the oculomotor nerve (cranial nerve [CN] III) between MRM and IRM. It divided into three branches for the MRM, for the IRM, and for the inferior oblique muscle (IOM). Each branch divided into several fascicles when entering the muscles (►**Fig. 5**).

In six nasal cavities, we extended the dissection to the superior orbital wall. We identified the superior rectus muscle (SRM) and exposed the trochlear nerve (CN IV) crossing cranially the SRM to reach the SOM. In four nasal cavities, the trochlear nerve showed two trunks entering the muscle, while in the other two cases it appeared as a single trunk (►**Fig. 7**).

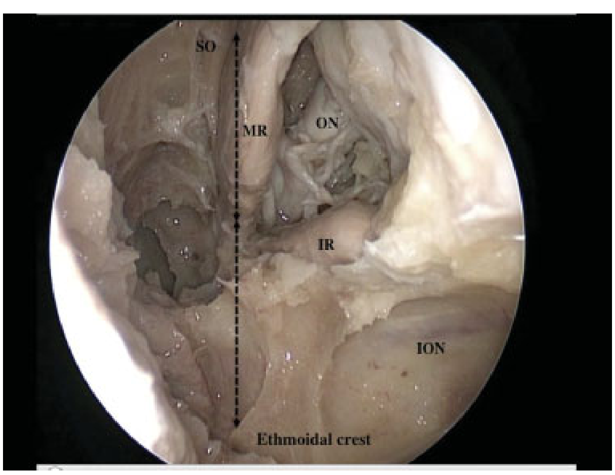

Fig. 2 Relationship between the ethmoidal crest of the palatine bone and the medial rectus muscle in the left nasal cavity. ION, infraorbital nerve; IR, inferior rectus; MR, medial rectus; ON, optic nerve; SO, superior oblique; SR, superior rectus.

Discussion

Approach selection in the management of intraorbital tumors depends on the location and tumor size, being the external approaches the more widely used. Lateral orbitotomy provides an excellent exposure for lesions located posterior, inferior, and lateral to the ON. For lesions located superior to the nerve, the supraorbital approach and the pterional approach are, for most authors, the route of choice. The transconjunctival approach is limited to small lesions in the orbital floor, while medial orbitotomy is used for lesions inferior and medial to the ON.[3,6] In this inferomedial quadrant, the EEAMO can be an effective and safe alternative to external approaches.

Resection of intraorbital lesions using exclusively an endonasal approach is relatively recent and published series include few patients. The first cases were reported in the 80s, mainly related to the removal of intraorbital foreign bodies and to biopsies.[7,8] In 1999, Herman et al[9] successfully performed an excision of an orbital hemangioma employing a purely endonasal approach for the first time. In the following years, several series have been published being the multiinstitutional study of Castelnuovo et al[10] and the review published by Dubal et al,[11] the largest case series to date. In these publications, the hemangioma, the osteoma, and the schwannoma represent the most frequent tumors treated with this surgical approach. Most authors recommend this approach only in lesions located in the medial–inferior quadrant of the orbit that do not extend laterally to the ON.[6,10,12–14]

Muscle Structures

Once the periorbita is opened and the intraorbital fat is removed, the muscle plane constituted by the IRM, MRM, and the SOM can be observed. The EEAMO provides a surgical corridor between the MRM superiorly and the IRM inferiorly.

There are several landmarks that can be useful to open this surgical corridor safely. Hwang et al[15] analyzed the orbit and paranasal sinuses of 100 patients by computed tomographic scan. They found that the mean distance between the medial orbital floor and the inferior margin of the MRM was 7.3 mm measured at the anterior ethmoid and 2.9 mm at the posterior ethmoid. According to several publications,[15,16] the mean distance between the inferior and superior margins of the MRM lies between 7.2 and 9 mm. Karaki et al[17] suggest that the location of the basal lamella of the middle turbinate (third lamella) is the most important landmark for an endoscopic endonasal approach to the orbital retrobulbar space. They show that the third lamella is located approximately 4 mm posterior to the eyeball. In this regard and in accordance with other authors,[18] they refer to the AEA as the boundary between the bulbar and retrobulbar spaces. According to our data, we suggest to initially identify the belly of the MRM considering the distance from the EC. The inferior

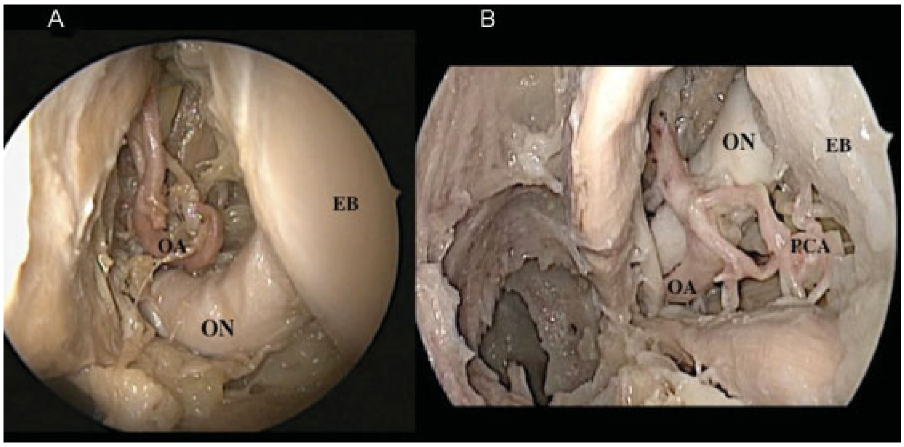

Fig. 3 (**A** and **B**) Location of the ophthalmic artery between the medial rectus muscle and the inferior rectus muscle in the left nasal cavity. (**A**) The OA runs superior to the optic nerve. (**B**) The OA runs inferior to the optic nerve. EB, eyeball; OA, ophthalmic artery; ON, optic nerve; PCA, posterior ciliary arteries.

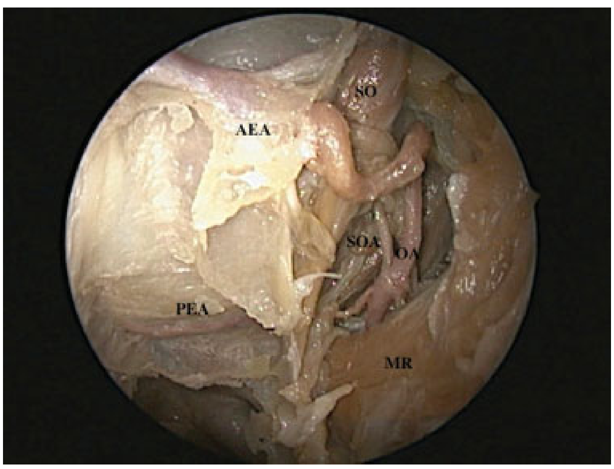

Fig. 4 The left ophthalmic artery and its medial branches. AEA, anterior ethmoidal artery; MR, medial rectus; OA, ophthalmic artery; PEA, posterior ethmoidal artery; SO, superior oblique; SOA, supraorbital artery.

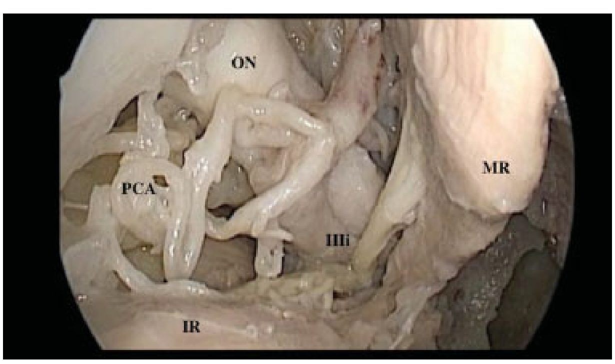

Fig. 5 Inferior branch of the oculomotor nerve (CN III) in the right nasal cavity. IR, inferior rectus; IIIi, inferior branch of the CN III; IR, inferior rectus; CN, cranial nerve; MR, medial rectus; ON, optic nerve; PCA, posterior ciliary arteries.

margin of MRM is approximately 1.5 cm from the crest and the width of the MRM at the level of the posterior wall of the maxillary sinus has been always between 1 and 1.5 cm. This relationship between the EC and the MRM represents the posterior limit. We use the AEA canal as the anterior and superior boundary, because the ethmoidal arteries run cranially to the MRM. The articulation of the lamina papyracea and the maxillary sinus, the ethmoid-maxillary angle, is the inferior limit.

Vascular Structures

The main vascular structures in the retrobulbar space are the OA and its branches. They provide the main arterial supply to the orbit, together with the infraorbital artery and the orbital branch of the middle meningeal artery, both branches of the maxillary artery.

The OA arises from the internal carotid artery and enters through the optic canal inferior and lateral to the ON.[19–21] In 8% of the cases, it may emerge from the superior orbital fissure (SOF).[22] In the intraorbital course, the artery crosses over the external and superior surface of the ON in 66 to 88% of the cases and then runs along the inferior margin of the SOM. In the remaining cases, the OA runs below the ON.[21,23] We report similar findings, with the OA above the ON in more than 85% of the cases. The OA gives three groups of branches: lateral, superior, or medial to the ON. The ethmoidal arteries arise from this latter group and they are located along the medial orbital wall. Interestingly, the AEA runs inferior to the SOM while the PEA runs above the muscle. In our dissections, we did not find the PEA below the SOM in any specimen. We do not recommend systematic intraorbital dissection of the ethmoidal arteries during EEAMO, but it is essential to identify them in the ethmoidal roof. These arteries allow division of the medial orbital wall in three regions: the bulbar space, the retrobulbar space, and the orbital apex (►**Fig. 8**).

We can locate the SOA during dissection in proximity to the PEA. Then the artery runs over the elevating muscle of the upper eyelid reaching the supraorbital notch. In 84% of the cases, the SOA is an independent trunk and it forms a

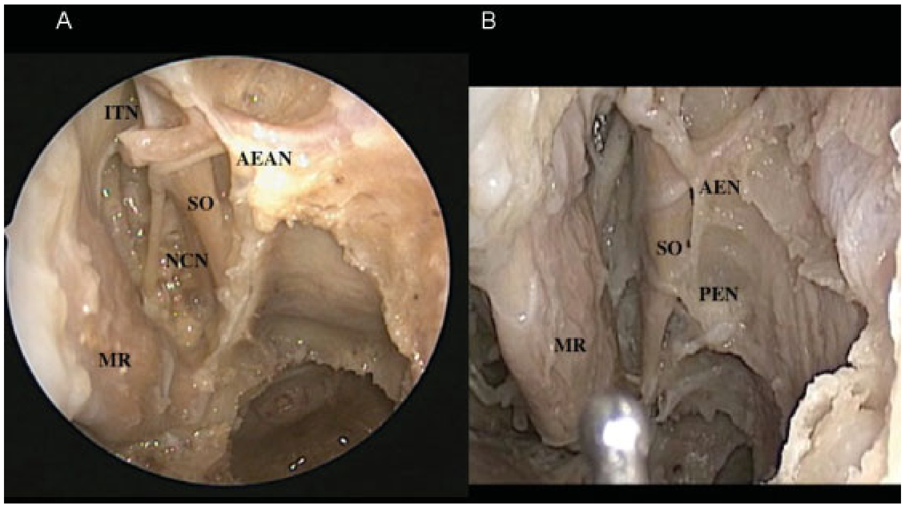

Fig. 6 (**A** and **B**) Nasociliary nerve and its branches in the right nasal cavity. AEAN, anterior ethmoidal artery and nerve; AEN, anterior ethmoidal nerve; ITN, infratrochlear nerve; MR, medial rectus; NCN, nasociliary nerve; PEN, posterior ethmoidal nerve; SO, superior oblique.

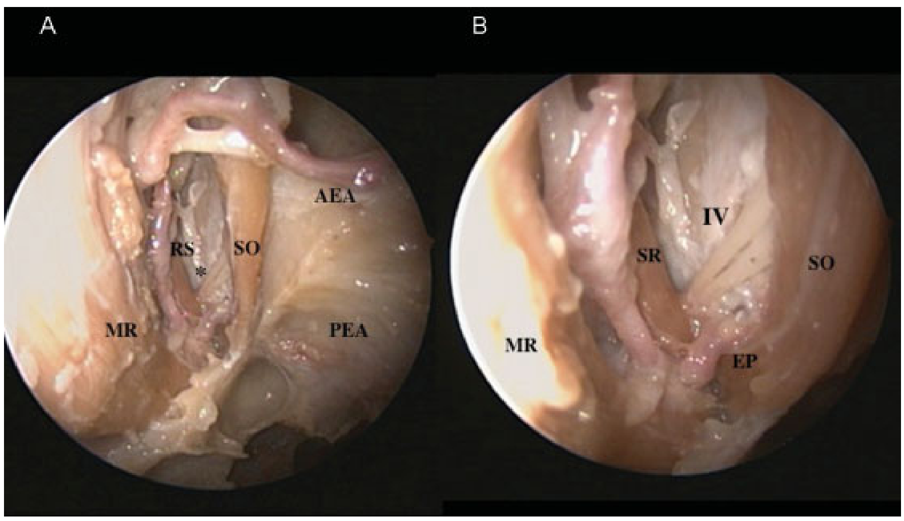

Fig. 7 (**A** and **B**) The trochlear nerve (CN IV) between the superior rectus muscle and the oblique superior muscles in the right nasal cavity. In (**B**), the endoscope is placed between SO and SR. *, IV nerve with two trunks entering the oblique superior muscle; AEA, anterior ethmoidal artery; CN, cranial nerve; MR, medial rectus; PEA, posterior ethmoidal artery; SO, superior oblique; SR, superior rectus.

common trunk with the PEA in the remaining cases.[24] We found a common trunk with the PEA in 14% of the cases. The muscular arteries arise from the inferior surface of the OA. They can be divided into superior and inferior branches. The vascularization for the MRM and the IRM originates in most cases from an inferomedial trunk.[23]

Neural Structures

The ON is divided into four segments: intracranial, intracanalicular, intraorbital, and intraocular[19].The intraorbital segment is located between the MRM and the IRM. It measures approximately 3 cm long from the intracranial end to the insertion into the eyeball.

The sensory innervation of the orbit depends on the first and the second branches of the trigeminal nerve, V1 or ophthalmic nerve, and V2 or maxillary nerve, respectively. The ophthalmic nerve divides into three branches at the lateral wall of the cavernous sinus: the lacrimal nerve, the frontal nerve, and the NCN. The lacrimal nerve and the frontal nerve enter the SOF outside the common annular tendon, while the NCN goes through the SOF inside the annular tendon. The NCN runs between the two branches of the oculomotor nerve, superior to the ON. At its emergence, the NCN is located below the SRM, but then runs between the SOM and the MRM gives the ethmoidal branches. Finally, the NCN ends as the infratrochlear nerve.[21,25] In our series, we identified the NCN and the ethmoidal branches inferior to the SOM in all specimens.

The intraorbital segment of the oculomotor nerve (CN III) has a length of 1.5 to 2 cm.[26]

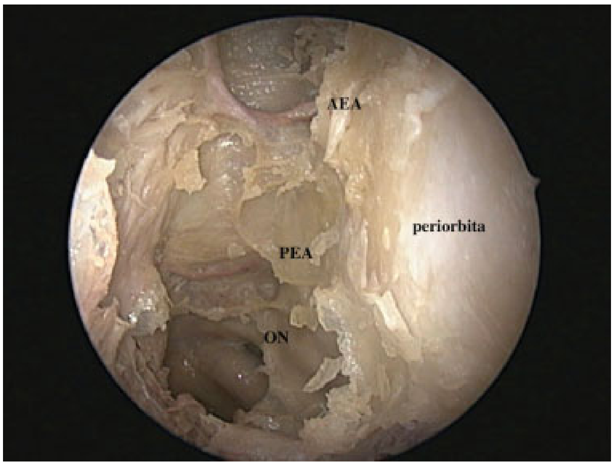

Fig. 8 The left medial orbital wall divided into three segments: the bulbar space, the retrobulbar space, and the orbital apex. AEA, anterior ethmoidal artery; ON, optic nerve; PEA, posterior ethmoidal artery.

The inferior branch of CN III emerges from the inferomedial part of the medial SOF, medial to the NCN. It divides into three branches: a branch for the MRM, a branch for the IRM, and a branch for the IOM.[27]

The trochlear nerve (CN IV) enters to the orbit through the SOF, outside the common annular tendon, crossing superior to the SRM to reach the SOM. It appears as a single trunk in 15% of the cases, as two trunks in 72%, and as three or more in 13% of the cases.[27] We could identify the CN IV in six nasal cavities. In four cavities, we identified two branches and a single trunk in the other two.

Conclusion

The EEAMO allows adequate exposure of the space between the MRM and the IRM. The location of the EC of the palatine bone, and its relationship with the MRM, is a useful anatomical landmark for this surgical approach. It is mandatory to locate the AEA and the PEA on the ethmoidal roof as they represent the superior boundary as well as the limit of the retrobulbar space.

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