

## Anatomical basis of the surgical approach to the medial wall of the orbit

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**Summary.** The main neurovascular structures related to the medial wall of the orbit were studied in 70 orbits after injection of the orbital arterial bed with latex dye. The position, anatomical relations and variations of the ophthalmic and ethmoidal arteries and trochlear and nasociliary nerves are described. Some differences were noted in comparison to classical anatomical descriptions, notably regarding the position of the ophthalmic artery which was commonly found to lie medial to the obliquus superior muscle distal to the point where it crosses under the muscle. An important surgical landmark, the lateral orifice of the anterior ethmoidal canal which lodges the anterior ethmoidal artery, was noted and its position described.

### Bases anatomiques de l'abord chirurgical de la paroi médiale de l'orbite

**Résumé.** Les auteurs, à partir des résultats de 70 dissections orbitaires réalisées après injection du système artériel par du latex, étudient les principaux éléments vasculonerveux en rapport avec la paroi médiale de l'orbite : artère ophtalmique, artères ethmoïdales, nerfs trochléaire et nasal. Ils décrivent notamment leur situation, leurs rapports et les différentes variations rencontrées. Par rapport aux descriptions classiques, les auteurs ont noté quelques différences, notamment en ce qui concerne la situation de l'artère ophtalmique qui est habituellement placée en dedans du muscle oblique supérieur, après l'avoir croisé par au-dessous. Un repère chirurgical important, l'orifice latéral du canal ethmoïdo-frontal antérieur, site d'abord de l'artère ethmoïdale antérieure, a été noté et sa situation précisée.

### Key words :

Different clinical problems may require surgical approach to the medial wall of the orbit, e.g. fracture of the orbit, tumor of the orbital region or severe epistaxis requiring ligation of the anterior ethmoidal artery. The most commonly used approach involves the superomedial angle of the orbit via an arcuate incision which is often extended to the eyebrow. This route allows exposure of the bony wall of the orbit and the different neurovascular structures related to it. Injury to these structures can be avoided if the surgeon has full knowledge of their position and anatomical relations. Accordingly, the relations of these vessels and nerves to the medial wall of the orbit are described herein on the basis of observations made in the dissection of 70 orbits.

### Historical data

The medial wall of the orbit is lined on its lateral surface by the orbital periosteum and two muscles, i.e. the obliquus superior lying above at the junction of the medial and superior walls of the orbit, and the rectus medialis, lying farther down. The following structures are found in contact with the medial wall of the orbit : the ophthalmic artery (third segment of the artery which is medial to the optic nerve); the collateral branches of the ophthalmic artery (notably, the anterior and posterior ethmoidal arteries and the muscular branches); the nasociliary and trochlear nerves.

According to classical descriptions, the third segment of the ophthalmic artery, i.e. the segment distal to the point where the artery crosses the optic nerve, runs along the medial wall of the orbit. The artery continues away from the optic nerve to enter the medial part of the muscular cone formed by the rectus medialis and obliquus superior. The ophthalmic artery then runs along the lower margin of the obliquus superior according to Rouvière [8] or between the rectus medialis and obliquus superior according to Henry [5]. A similar description of

the ophthalmic artery was given by Soemmering [10] in 1804.

Many other studies have also been devoted to the description of the position of the ophthalmic artery, notably the reports published by Jayle [6] in 1937 and Hayreh and Dass [4] in 1962. Henry [5] reported that the third segment of the ophthalmic artery displays a pronounced loop and variable relations with the nasociliary nerve. Similarly, Saraux et al. [9] observed that the ophthalmic artery runs between the rectus medialis and obliquus superior proximal to its termination where it passes under the trochlea of the obliquus superior to anastomose with the angular artery. According to these different classical descriptions, the third segment of the ophthalmic artery remains in proximity of the muscles lining the medial wall of the orbit and in close relation to the nasociliary nerve.

## Material and methods

This study was based on the dissection of 70 human orbits from 35 cadavers (12 women, 23 men). All the subjects had donated their body to the Faculty of Medicine of Reims [1, 3].

Subsequent to thorough rinsing in water, the arterial bed of the orbit was injected with red dye Neoprene Latex. Dissection was done by the superior approach after the roof of the orbit had been collapsed. In the course of dissection the different structures encountered and their position and anatomical relations were carefully noted.

## Results

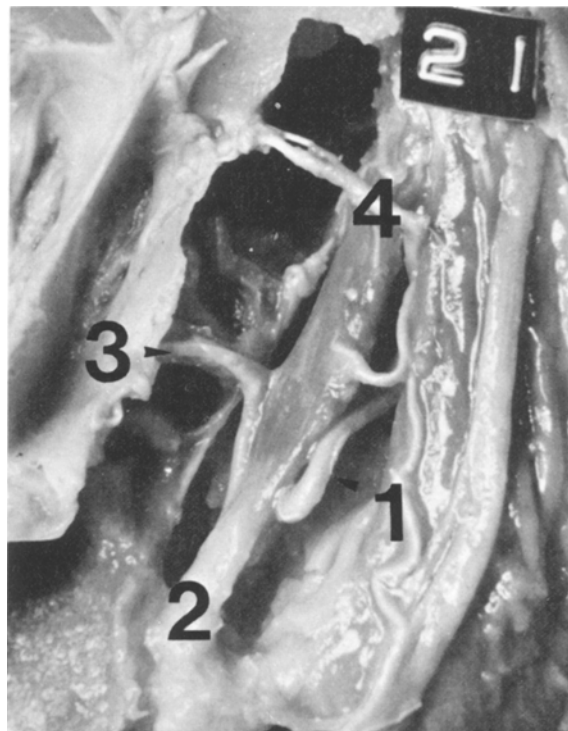
Described below are the relations of the medial wall of the orbit with the ophthalmic artery, its ethmoidal and muscular branches, the nasociliary nerve and its rami and the trochlear nerve (Fig. 1).

### *Osteomuscular components of the medial wall of the orbit*

The medial wall of the orbit comprises three layers : an inner bony layer formed from front to back by the maxillary, lacrimal, ethmoidal and sphenoid bones; a middle adipofibrous layer formed by the orbital periosteum which is easily dissected free, and is covered by a thin sheet of fatty areolar tissue; an outer muscular layer formed by the obliquus superior and rectus medialis and their aponeuroses. This third layer constitutes the myofascial cone of the orbit.

### *Ophthalmic artery*

This artery lies in the myofascial cone of the orbit. Distal to the point where it crosses the optic nerve, the ophthalmic artery runs between the muscle layer lying medial to it and the optic nerve lying lateral to it. In this region the artery shows a mean diameter of 1.5 mm.



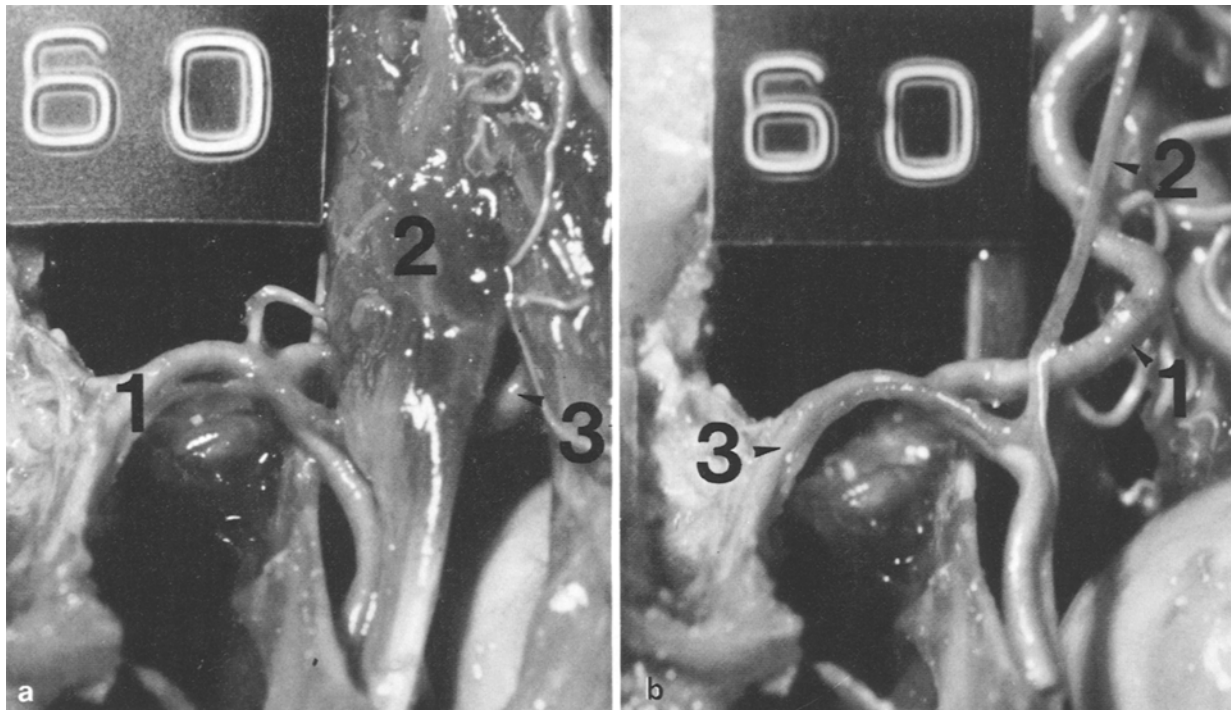
**Fig. 1**  
Overall view of the vascular relations of the medial wall of the orbit (left orbit, anterosuperior view). The ophthalmic artery (1) crosses under the obliquus superior where it gives off the anterior ethmoidal artery (3). The posterior ethmoidal artery (4) crosses over the obliquus superior

*Vue générale des rapports vasculaires de la paroi médiale de l'orbite (orbite gauche, vue supérieure et antérieure). L'artère ophtalmique (1) décrit une crosse qui l'amène sous le muscle oblique supérieur, où elle abandonne l'artère ethmoïdale antérieure (3). L'artère ethmoïdale postérieure (4) surcroise le muscle*

This third, so-called latero-optic segment of the ophthalmic artery can be divided into two main types according to whether or not it emerges from the myofascial cone of the orbit.

*In the type 1 variety*, the artery emerges from the cone as it passes under the obliquus superior. In this case, the ophthalmic artery runs successively lateral, under and medial to the muscle. The type 1 pattern was the most common in our series, i.e. 55 out of 70 orbits (78,6%).

The segment of the artery laying lateral to the obliquus superior runs forwards and upwards in the sagittal plane as it progresses away from the optic nerve. Accordingly, the artery approaches the obliquus superior and then runs close to the inferior margin of the muscle. The ophthalmic artery often shows a large loop which brings it close to the inferior margin of the obliquus superior. In many cases the loop is so pronounced that



**Fig. 2**

The elbow-like flexure of the ophthalmic artery is clearly visible on these 2 views of the same orbit (superior view of left side). **a** The anterior ethmoidal artery (1) is visible beneath the obliquus superior (2) which hides the ophthalmic artery (3). **b** Removal of the obliquus superior exposes the flexure of the ophthalmic artery (1). Distal to the flexure the artery runs in contact with the medial wall of the orbit. The nasociliary nerve (2) crosses over the ophthalmic artery three times. Distal to the third point of crossing the nerve gives rise to an internal nasal branch which accompanies the anterior ethmoidal artery into the anterior ethmoidal foramen

Le coude de l'artère ophtalmique est bien mis en évidence sur ces 2 vues de la même orbite (côté gauche, vue supérieure), **a** L'artère ethmoïdale antérieure (1), apparaît sous le muscle oblique supérieur (2) qui masque l'artère ophtalmique (3). **b** L'ablation du muscle oblique supérieur expose le coude qui amène l'artère ophtalmique (1) au contact de la paroi médiale. Le nerf nasal (2) croise 3 fois l'artère, avant d'abandonner sa branche nasale interne (3) qui accompagne l'artère ethmoïdale antérieure dans son canal

the artery appears to run backwards. This pattern was seen in 56 orbits. In 36 of these cases the loop was ventral with posterior concavity and in 20 cases it was horizontal with medial concavity (Fig. 2).

The segment of the artery which crosses under the obliquus superior runs between the latter and the rectus medialis. Passage of the artery under the obliquus superior was seen in 54 orbits. In most of these cases the ophthalmic artery showed a pronounced loop lateral to the muscle. The point where the artery crosses under the obliquus superior was found to lie 8 to 21 mm posterior to the trochlea of the muscle. In most cases this distance was 11 to 18 mm (Fig. 5).

The artery was often seen to cross under the muscle in a very oblique direction from front to back and lateral to medial to reach the lateral orifice of the anterior ethmoidal foramen. In this way, the ophthalmic artery comes to lie medial to the obliquus superior as it emerges from the myofascial cone of the orbit. This third part of the artery lying medial to the muscle then

returns to its initial anterior course and usually remains in this medial position until it reaches the trochlea of the obliquus superior. Thereafter, the artery crosses under the trochlea to terminate at the superomedial angle of the orbit. This pattern was seen in 50 orbits. However, in 5 cases the ophthalmic artery was seen to emerge from the myofascial cone of the orbit and then to enter it again at a slightly more anterior site by passing a second time under the obliquus superior.

One case in our series merits special mention. In this case, the ophthalmic artery emerged from the myofascial cone at a very proximal site as it crossed over and not under the obliquus superior. The point of crossing was at a posterior point lying 28 mm from the trochlea of the muscle. After crossing over the muscle the artery then ran medial to the obliquus superior.

*In the type 2 variety* the ophthalmic artery does not emerge from the myofascial cone of the orbit but over its entire course remains lateral to the obliquus superior.



**Fig. 3**

Three arterial pedicles can be seen to vascularize the rectus medialis. Note the ophthalmic artery crossing under the optic nerve

Les pédicules artérielles du muscle droit médial sont ici au nombre de trois. L'artère ophthalmique sous-croise le nerf optique

This pattern was seen in 15 orbits. In most of these cases the artery did not show a significant loop lateral to the obliquus superior.

In sum, of the 70 ophthalmic arteries studied, 54 were seen to cross under the obliquus superior. In 49 of these cases the artery then ran medial to the muscle, while in 5 it crossed again under the muscle. In one case the artery crossed over the obliquus superior and in the 15 remaining cases it remained lateral to the muscle over its entire course. These variations did not seem to be related to the type of crossing the ophthalmic artery showed with respect to the optic nerve.

Regardless of these anatomical variations, the ophthalmic artery passes under the trochlear of the obliquus superior in the anterior part of the orbit. Thereafter, the artery gives off the palpebral arteries and finally terminates by giving rise to angular and frontal branches.

#### *Posterior ethmoidal artery and trochlear nerve*

The posterior ethmoidal artery is not a constant finding and was absent in 12 of our cases. When present, this artery arose from the ophthalmic in 44 cases, usually distal to the point where the latter crosses the optic

nerve. The posterior ethmoidal artery arose from the supraorbital in 11 cases, the anterior ethmoidal in 2 cases and the lacrimal in 1 case. At its origin, the posterior ethmoidal artery was of small diameter, i.e. 0.3 mm in 25 cases, 0.4 to 0.8 mm in 27 cases, and >0.8 mm in 1 case.

Aside from the case where the posterior ethmoidal artery arose from its anterior homologue, the artery was seen to first run between the rectus superior and obliquus superior, then to emerge from the myofascial cone of the orbit and to finally pass perpendicular to the medial wall to enter the posterior ethmoidal foramen.

As the artery approaches to posterior ethmoidal foramen it crosses the obliquus superior. In 52 cases it crossed over the superior margin of the muscle, while in 4 cases it crossed under the inferior margin of the muscle. Thus, the posterior ethmoidal artery usually crosses over, and not under, the obliquus superior. The trochlear nerve terminates near the upper margin of the obliquus superior. This nerve enters the orbit via the superior orbital fissure at a site lateral to the myofascial cone of the orbit. A short segment of the nerve runs above the tendinous insertion of the levator palpebrae superioris after which the nerve immediately terminates in the obliquus superior. In most of our dissections (50 cases) the posterior ethmoidal artery crossed over the obliquus superior and consequently over the trochlear nerve as well. However, in 2 cases the artery was seen to run between the upper margin of the obliquus superior and the trochlear nerve and thus crossed beneath the latter. Finally, in 2 cases the posterior ethmoidal artery arose medial to the obliquus superior and consequently did not cross the muscle. In these 2 observations, the posterior ethmoidal artery originated from the anterior ethmoidal.

Proximal to its point of entry in the posterior ethmoidal foramen the posterior ethmoidal artery gives off numerous muscular branches. In our series, this artery contributed to the vascularization of the obliquus superior in 43 orbits, the levator palpebrae superioris in 29 orbits, the rectus medialis in 8 orbits and the rectus superior in 7 orbits.

#### *Anterior ethmoidal artery*

This artery, which is practically constant, almost always arises directly from the ophthalmic, as seen in 67 orbits studied. In 2 cases, the anterior ethmoidal artery originated from the posterior ethmoidal and in 1 case it was absent [2].

At its origin, the diameter of the anterior ethmoidal artery is usually greater than that of the posterior ethmoidal. In our series the diameter of the anterior ethmoidal was <0.5 mm in 9 cases, 0.6 to 1.0 mm in 43 cases and >1.0 mm in 10 cases.

Regarding the course of the ophthalmic artery, the two different patterns described earlier on account for the finding that the anterior ethmoidal artery may arise in one of two different positions with respect to the obliquus superior. In some cases, the anterior ethmoidal artery arises from the ophthalmic at a point medial to the obliquus superior in cases where the ophthalmic crosses under the muscle. This pattern was seen in 52 orbits. In these cases, the anterior ethmoidal artery often originates in contact with the bony medial wall of the orbit or even within the anterior ethmoidal foramen since the ophthalmic artery often enters the foramen. In such cases, the intraorbital segment of the anterior ethmoidal artery was very short or even non-existent.

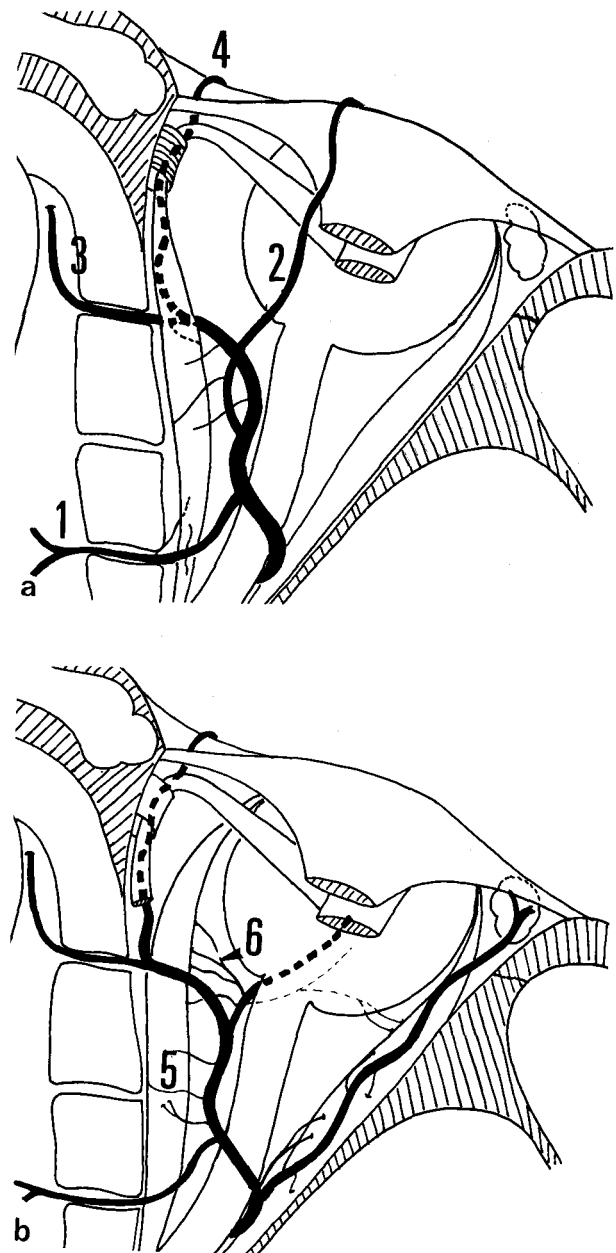
In other cases, the anterior ethmoidal artery originates lateral to the obliquus superior, especially when the ophthalmic artery remains within the myofascial cone of the orbit, as seen in 15 of our cases. When this pattern is observed, the anterior ethmoidal artery can be seen to cross the obliquus superior before entering the anterior ethmoidal foramen. In our 15 cases, the artery usually crossed under the muscle (13 orbits) and rarely over it (2 orbits).

The anterior ethmoidal artery shows a rather modest contribution to the muscular vascularization. Branches to the obliquus superior were seen in only 24 of the 70 orbits we examined. The anterior ethmoidal artery is consistently associated with the anterior ethmoidal nerve which, like the artery, enters the anterior ethmoidal foramen where it usually lies anterior, or less often inferior, to the artery.

In cases where ligation is indicated, the anterior ethmoidal artery is approached at its point of entry in the anterior ethmoidal foramen. Accordingly, the lateral orifice of this foramen is an essential surgical landmark. Kirschner et al. [7] studied the position of this orifice in 150 bony orbits. In 64% of the cases they studied, the lateral orifice of the anterior ethmoidal foramen was found to lie 14 to 18 mm posterior to the lacrimomaxillary suture. In our study, the position of this orifice was measured with respect to the trochlea of the obliquus superior. In most cases the lateral orifice of the anterior ethmoidal foramen was seen to lie 12 to 25 mm posterior to the trochlea (range : 9-34 mm) (Fig. 4). These results are in agreement with the routine surgical finding that the anterior ethmoidal artery lies approximately 2 cm posterior to the orbital ridge.

#### *Vascularization of the rectus medialis and obliquus superior*

These two muscles lying at the level of the medial wall of the orbit are supplied by numerous muscular arterial branches (Figs. 5, 6).



**Fig. 4**

Illustration of the vascular relations of the medial wall of the orbit before (a) and after (b) removal of the obliquus superior. The posterior ethmoidal (1), supraorbital (2) and anterior ethmoidal (3) arteries supply the obliquus superior. The anterior part of the ophthalmic artery can be seen to lie in contact with the medial wall of the orbit. The rectus medialis is vascularized by branches of the ophthalmic (5) and inferior muscular (6) arteries

Vue schématique des rapports vasculaires de la paroi médiale, avant (a) et après (b) ablation du muscle oblique supérieur. L'artère ethmoïdale postérieure (1), l'artère supra-orbitaire (2) et l'artère ethmoïdale antérieure (3) participent à la vascularisation du muscle oblique supérieur. A sa partie antérieure, l'artère ophtalmique (4) est appliquée sur la paroi médiale. Le droit médial est vascularisé par des rameaux de l'artère ophtalmique (5) et de l'artère musculaire inférieure (6)

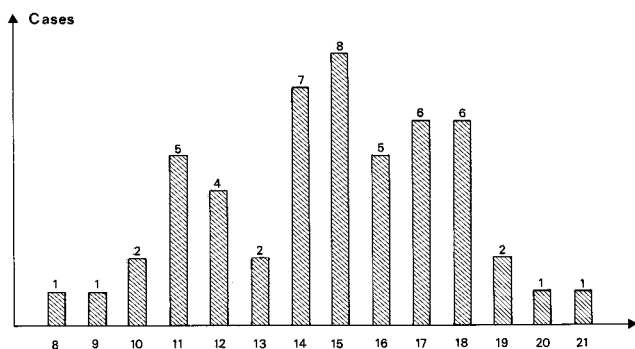


Fig. 5

Position of the crossing of the ophthalmic artery and obliquus superior with respect to the trochlea

Situation du croisement artère ophtalmique-muscle oblique supérieur par rapport à la poulie de réflexion

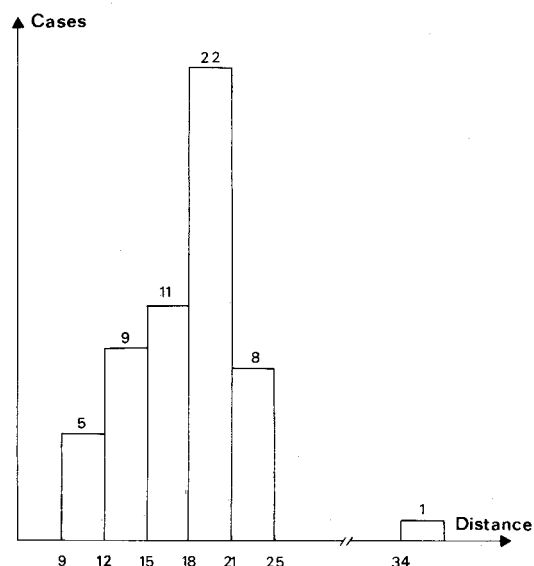


Fig. 6

Distance between the trochlea of the obliquus superior and lateral orifice of the anterior ethmoidal foramen

Distance entre poulie de réflexion du muscle oblique supérieur et orifice latéral du canal ethmoïdo-frontal antérieur

*The rectus medialis* is mainly supplied by branches of the inferior muscular artery (100% of our cases) and branches of the ophthalmic artery (58 cases). Other sources of arterial supply are less common, including the posterior ethmoidal (8 cases), medial muscular (5 cases), anterior ethmoidal (3 cases), superior muscular (2 cases) and supraorbital arteries (1 case). These arteries mainly enter the posterior or middle thirds of the lateral surface of the muscle and the 2 margins of the muscle, especially the inferior margin (Fig. 7).

In rare cases (8 orbits in our series), an arterial branch pierces the medial surface of the *rectus medialis*. In sum, the arteries supplying the muscle show very

little contact with the medial wall of the orbit which is separated from these vessels by the muscle itself.

*The obliquus superior* is vascularized by arterial branches of various origin, including muscular branches from the ophthalmic artery (47 cases), posterior ethmoidal (43 cases), anterior ethmoidal (24 cases) and supraorbital (23 cases). These branches enter the muscle at various sites, the most frequent being the upper and lower margins and lateral surface of the muscle (Fig. 8).

#### *Nasociliary nerve and its branches*

The nasociliary nerve enters the orbit via the superior orbital fissure. After passing through the ligament of Zinn (annulus tendineus communis) the nerve runs forwards and medially. Its anatomical relations to the ophthalmic artery are variable. The nasociliary nerve usually crosses over the ophthalmic artery in cases where the latter crosses the optic nerve, after which it comes to lie lateral to the third segment of the ophthalmic artery.

The nasociliary nerve crossed over the ophthalmic artery at least a second time in 43 of 50 orbits in our series, thereby coming to lie on the medial side of the artery. This second point of crossing was frequently seen to lie near the origin of the supraorbital artery. Finally, the nasociliary nerve frequently crossed over the ophthalmic artery a third time in our series in cases where the artery showed a loop to the obliquus superior. The nerve then divides into 2 branches, one internal accompanying the anterior ethmoidal artery and one external, running along the terminal part of the ophthalmic artery. In the area of the trochlea, the external branch of the nasociliary nerve was found lateral to the ophthalmic artery in 47 cases, medial to it in 2 cases and superior to it in 1 case.

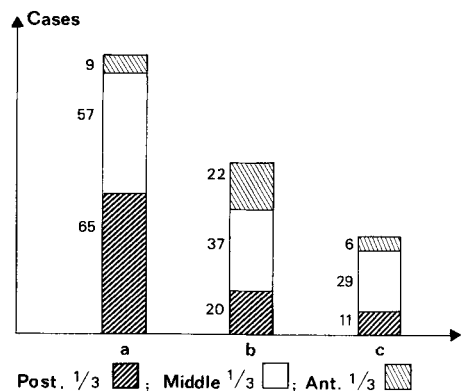
According to classical descriptions, the intraorbital segment of the nasociliary nerve gives off a posterior ethmoidal branch (Luschka's nerve) which accompanies the posterior ethmoidal artery as it penetrates the posterior ethmoidal foramen. In our series the presence of the posterior ethmoidal nerve was a rare finding.

#### *Venous structures*

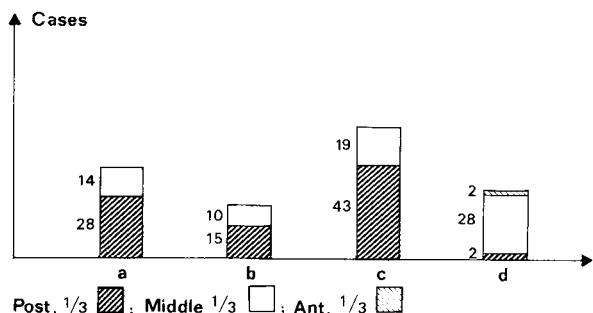
Aside from the muscular veins, few venous structures show relations to the medial wall of the orbit. Indeed, the superior and inferior ophthalmic veins, which lie close to the medial wall at their origin, soon leave the orbital wall as they run towards the superior orbital fissure.

#### **Conclusion**

The results of this study lead us to underline some variations with respect to classical descriptions of the



**Fig. 7**  
 Site of penetration of the arterial pedicles supplying the rectus medialis. **A** lateral surface, **B** inferior margin, **C** superior margin  
 Point d'entrée des pédicules artériels dans le muscle droit médial **A** face latérale, **B** bord inférieur, **C** bord supérieur



**Fig. 8**  
 Site of penetration of the arterial pedicles supplying the obliquus superior. **A** lateral surface, **B** medial surface, **C** superior margin, **D** inferior margin  
 Point d'entrée des pédicules artériels dans le muscle oblique supérieur. **A** face latérale, **B** face médiale, **C** bord supérieur, **D** bord inférieur

medial neurovascular structures of the orbit. One of these variations concerns the ophthalmic artery, which was often seen to pass beneath the obliquus superior and then to run between this muscle and the medial wall of the orbit. According to classical descriptions, the ophthalmic artery and medial wall of the orbit are separated by a layer of muscles, whereas in our observations only the periosteum separates these 2 structures. This is an important finding to be taken into account when the commonly used extraperiosteal route is done to approach the medial wall of the orbit.

Another important variation was seen with respect to the anterior ethmoidal artery which often arose within the anterior ethmoidal foramen at a point lying on average 2 cm posterior to the orbital ridge. Ligation of the artery is easily achieved at this point via the subperiosteal approach. In this respect, it is important to bear in mind that this artery is accompanied by the anterior ethmoidal nerve.

According to classical descriptions, vascular supply to the rectus medialis and obliquus superioris from a single vessel, the superior muscular artery. However, the results of our study demonstrate that these muscles are supplied by several vessels originating directly from the ophthalmic artery or its branches. Conservely, a true superior muscular artery was rarely seen in our dissections.

Finally, the posterior ethmoidal nerve was not consistently present in our series.

Knowledge of these variations should allow the surgeon to avoid damage to the vessels and nerves in the course of surgical approach to the medial wall of the orbit.

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