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Maxillary Artery Blood Supply to the Orbit: Normal and Pathological Aspects

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Summary. Both normal and pathological orbital vascularization appears to be partially dependent on three deep maxillary artery branches. The authors use selective angiograms and microradiographs of injected specimens to describe the orbital branches of the middle meningeal, anterior deep temporal and infraorbital arteries. Variable embryological developments determine the orbital contributions of the middle meningeal artery via the recurrent meningeal and meningolacrimal branches. The anterior deep temporal artery supplies constant branches to the inferior and lateral lacrimal territories. The infraorbital artery sends branches to the inferomedial portion of the orbit and the inferior lacrimal territory. Selective external carotid angiography may opacify the whole ophthalmic arterial system and faintly opacifies the ophthalmic veins.

Vascularisation de l'orbite par l'artère maxillaire interne. Cas normaux et pathologiques

Résumé. La vascularisation normale et pathologique de l'orbitè dépend en partie de trois branches artérielles profondes de l'artère maxillaire. Les auteurs décrivent les branches orbitaires de l'artère méningeé moyenne, temporale antérieure profonde et sous-orbitaire sur des angiogrammes sélectifs et microradiographies avec opacification vasculaire. L'artère méningeé moyenne participe avec les branches récurentes méningée et méningolacrymale. L'artère temporale antérieure profonde donne des branches constantes pour le territoire lacrymal latéral et inférieur. L'artère sous-orbitaire donne des branches pour le territoire inferomédian de l'orbite et lacrymal inférieur. L'angiographie sélective de la carotide externe peut opacifier l'ensemble du système artériel ophtalmique mais ne visualise que faiblement les veines ophtalmiques.

Blutversorgung der Orbita über die A. maxillaris: normale und pathologische Aspekte

Zusammenfassung. Sowohl die normale als auch die pathologische Vaskularisation der Orbita ist teilweise abhängig von der Blutversorgung über drei tiefe Äste der A. maxillaris. Die Autoren führten bei ihren Untersuchungen selektive Angiographien und Mikroradiographien durch. Die embryonale Entwicklung wird besprochen. Es wird darauf verwiesen, daß die vordere tiefe Temporalarterie konstant Äste abgibt zu den unteren und lateralen Orbita-Abschnitten. Die infraorbitale Arterie versorgt den unteren-medialen Abschnitt der Orbita. Eine selektive Arteriographie der A. carotis interna kann das ganze arterielle Gefäßsystem im Orbita-Bereich mit Kontrastmittel füllen.

Due to newer radiological techniques (superselective angiography, serial direct magnification with fractional-millimeter focal spots), distal arteries from branches of the external carotid artery are now becoming visible [1, 2, 7, 10, 17, 21, 24, 26, 27, 28]. Their role in the arterial vascularization of the orbit and their anastomoses with the orbital branches of the internal carotid artery are increasingly more comprehensible. In cases of internal carotid artery stenosis or occlusion, these branches may be the major blood supply to the ischemic territory.

We wish to emphasize that angiographic study of the orbit must include both selective external and internal carotid angiograms, particularly in patients in whom the pathology is thought to represent occlusive disease or mass lesions.

Material and Methods

This study is based on orbital angiograms of 20 patients and microradiographs of 12 specimens of opacified orbits. The angiograms included selective internal and external carotid studies, among which there were three selective maxillary angiograms. These studies were performed through the percutaneous transfemoral approach using the Seldinger technique.

A total of 9 cc of contrast was used in the external carotid artery at the delivery rate of 3 cc per sec. Serial direct magnification angiography was performed in the AP and lateral projections using a Machlett Dynamax tube having a 0.1×0.3 mm focal spot. In the AP projection, the central beam was angled minus 15° to the orbitomeatal line. Photographic subtraction techniques were considered to be indispensible in evaluating the angiograms.

The orbital specimens were injected with radiopaque plastic[1] [28]. Both the external and internal carotid systems were opacified. Eight orbits were sectioned serially in frontal, sagittal or horizontal planes. The contents of four additional orbits were isolated from the bony structures and radiographed in three orthogonal projections.

Results

The blood supply from the external carotid artery to the orbit may be divided into two groups:

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1 Documents from Neurobiological Research Unit, National Institute for Health and Medical Research (INSERM), Prof. G. Salamon, Marseille, France.

The first group consists of a superficial anastomotic circle around the eyelids, and the anastomosis between the sphenopalatine artery and the ethmoidal artery (Table 1).

The second group is deeply situated and supplies the lateral aspects of the orbit and muscle cone (lacrimal territory) with both nutritional and anastomotic components.

This communication concerns this latter group which includes three deep collateral branches of the maxillary artery: the middle meningeal artery, the anterior deep temporal artery and the infraorbital (suborbital) artery.

Table 1. *Extraorbital anastomotic channels between external carotid collaterals and branches of the ophthalmic system*

External carotid		Ophthalmic system
Primary trunk	Collaterals	Collaterals or terminal branches
Facial artery	Angular artery	Nasal artery
Superficial temporal artery	Transverse facial artery	Inferior palpebral artery
	Zygomatomalar artery	Lateral palpebral artery
	Parietofrontal branch — Medial frontal artery	Frontal artery
	— Lateral frontal artery	Supraorbital artery
Maxillary artery	Alveoloantral artery	Inferior palpebral artery
	Sphenopalatine artery	Anterior and posterior ethmoidal arteries

The Middle Meningeal Artery [3, 4, 11, 12, 13, 14, 15, 16, 19, 20, 22, 23, 26, 27]

The blood supply to the orbit from the middle meningeal artery provides two collateral pathways: the recurrent meningeal artery, which is anastomotic and the meningolacrimal artery (less preferably named the sphenoidal artery), which feeds a portion or all of the lacrimal territory.

The Recurrent Meningeal Artery

The recurrent meningeal artery is an adult remnant of a common meningoorbital vascular system which exists in the embryo and has not regressed completely.

Embryology [18, 19, 25, 31]

a) At the 12 to 14 mm embryonic stage, the distal blood supply is the primitive ophthalmic artery originating from the internal carotid. This vessel has three terminal branches: the common nasociliary artery (medial ciliary artery), the hyaloid artery (central retinal artery) and the common temporociliary artery (lateral ciliary artery). This primitive system consists of neurosensory (ocular) branches and depends in its entirety on the internal carotid artery (Fig. 1a).

b) At the 14 to 16 mm embryonic stage, the orbital branch of the supraorbital artery (stapedial artery) becomes annexed to the ophthalmic system. This orbital artery likewise branches into three terminal arteries: the ethmoidonasal artery (which will later give rise to the third portion of the definitive ophthalmic artery and the ethmoidal arteries), the frontal artery (which will give rise to the adult supraorbital artery) and the lacrimal artery (which remains as the adult lacrimal artery). An anastomosis between the orbital system and the primitive ophthalmic system takes place and later constitutes the second portion of the definitive ophthalmic artery (Fig. 1b).

c) After partial regression of the proximal portion of the orbital artery it is called the recurrent meningeal artery. The stapedial artery will simultaneously become the maxillary artery after its annexation by the ventral pharyngeal artery (external carotid). Later the supraorbital artery is named the middle meningeal artery (Fig. 1c).

The recurrent meningeal artery connects the lacrimal artery with the anterior branch of the middle meningeal artery via the superior orbital fissure. This vessel may be abnormally developed in the following situations:

i) When the proximal portion of the ophthalmic artery regresses instead of the embryonic orbital artery, the adult ophthalmic artery then "originates" from the middle meningeal artery (Fig. 1d).

ii) When the embryonic supraorbital artery regresses instead of the trunk of the orbital artery, the middle meningeal artery "originates" from the ophthalmic artery (Fig. 1e).

iii) When the orbitoophthalmic anastomosis does not take place, the orbit is then supplied by two trunks: one issued from the internal carotid for the optic nerve and retina; the other one issued from the middle meningeal artery supplying the rest of the orbit coursing as the third portion of the ophthalmic artery [5].

Angiographically, the recurrent meningeal artery is thin, tortuous and poorly visible (Fig. 2). In the AP projection it is found in the most lateral part of the

superior orbital fissure. In the lateral projection it joins the anterior branch of the middle meningeal artery (which delineates the anterior aspect of the temporal fossa) to the proximal part of the lacrimal artery. Thus the lacrimal artery may fill from both the external and internal carotid systems.

The Meningolacrimal Artery (Sphenoidal Artery)

The meningolacrimal artery originates from the anterior branch of the middle meningeal artery as also does the recurrent meningeal artery. The diameter of the meningolacrimal artery and the territory supplied by this vessel depend on the development of the lacrimal branch of the ophthalmic artery [6, 9, 15, 30]. The lateral portion of the orbit or lacrimal territory is thus supplied either by both these vessels or mainly by one. The lacrimal territory includes three regions (Fig. 3): an upper one, for the lacrimal gland, a middle one, for the gland and the eyelid and an inferior one for the muscles (anastomosing with the infraorbital artery and branches of the anterior deep temporal artery).

When the lacrimal territory is completely supplied by the meningolacrimal artery, this vessel is quite well visualized (Fig. 1f). It leaves the anterior branch of the middle meningeal artery before it reaches the lesser wing of the sphenoid bone (Fig. 4). It then runs transversely and enters the orbit through the canal of Hyrtl (meningolacrimal foramen) situated several millimeters lateral to the superolateral portion of the superior orbital fissure. In these cases the lacrimal artery, originating from the ophthalmic artery, is not visible on selective internal carotid angiograms. The meningolacrimal artery will give rise to all three collaterals for the corresponding lacrimal territories mentioned above (Fig. 5).

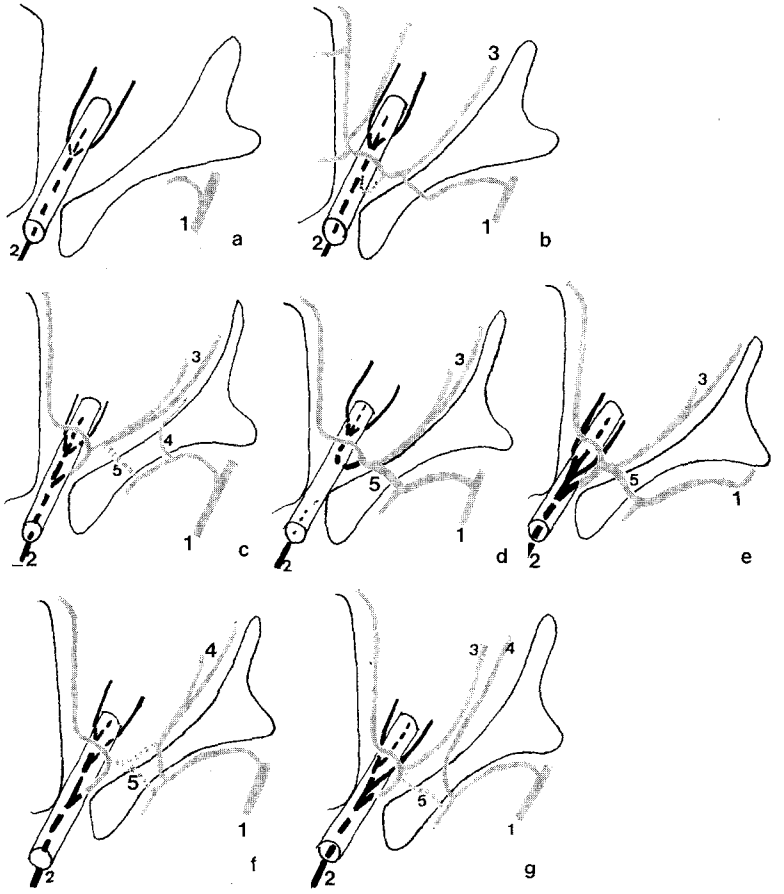


Fig. 1. Schematic drawings of the different pedicles nourishing the lacrimal territory (axial projections of the left orbit). a) Embryo-12 mm stage; b) embryo-16 mm stage; c) adult-classical pattern; d) adult-ophthalmic artery originating from the middle meningeal; e) adult-middle meningeal artery originating from the ophthalmic; f) adult-lacrimal region supplied exclusively by the middle meningeal artery; g) adult-lacrimal region supplied equally by the ophtalmic and middle meningeal arteries. 1) Stapedial artery, supraorbital division (middle meningeal artery); 2) ophthalmic artery with its three collaterals: medial ciliary, lateral ciliary, central retinal; 3) lacrimal artery; 4) meningolacrimal artery; 5) orbital ramus (recurrent meningeal artery) of the supraorbital division of the stapedial artery

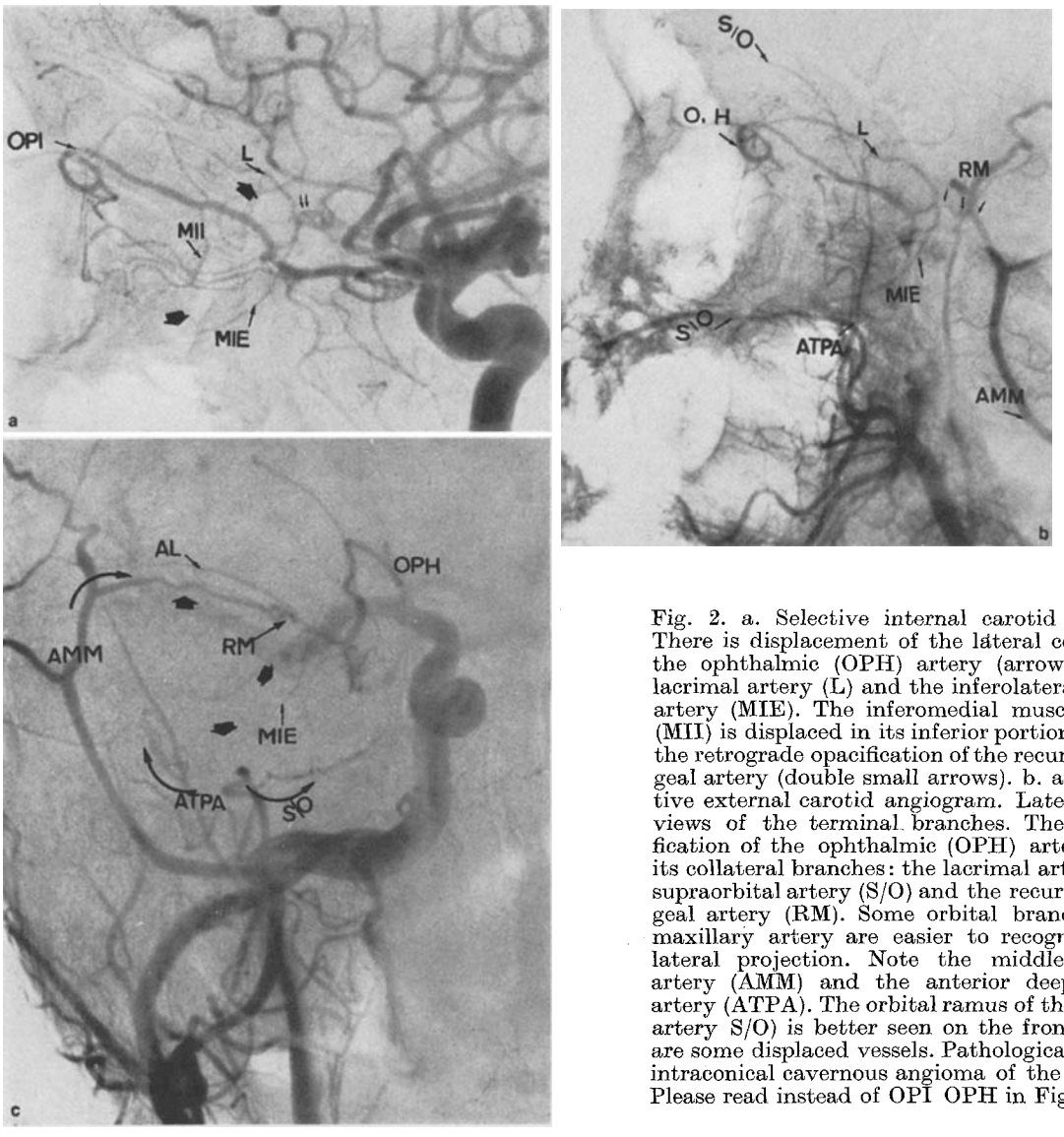


Fig. 2. a. Selective internal carotid angiogram. There is displacement of the lateral collaterals of the ophthalmic (OPH) artery (arrowheads): the lacrimal artery (L) and the inferolateral muscular artery (MIE). The inferomedial muscular artery (MII) is displaced in its inferior portion only. Note the retrograde opacification of the recurrent meningeal artery (double small arrows). b. and c. Selective external carotid angiogram. Lateral and AP views of the terminal branches. There is opacification of the ophthalmic (OPH) artery through its collateral branches: the lacrimal artery (L), the supraorbital artery (S/O) and the recurrent meningeal artery (RM). Some orbital branches of the maxillary artery are easier to recognize on the lateral projection. Note the middle meningeal artery (AMM) and the anterior deep temporal artery (ATPA). The orbital ramus of the suborbital artery S/O) is better seen on the frontal view as are some displaced vessels. Pathological diagnosis: intraconical cavernous angioma of the right orbit. Please read instead of OPI OPH in Fig. a

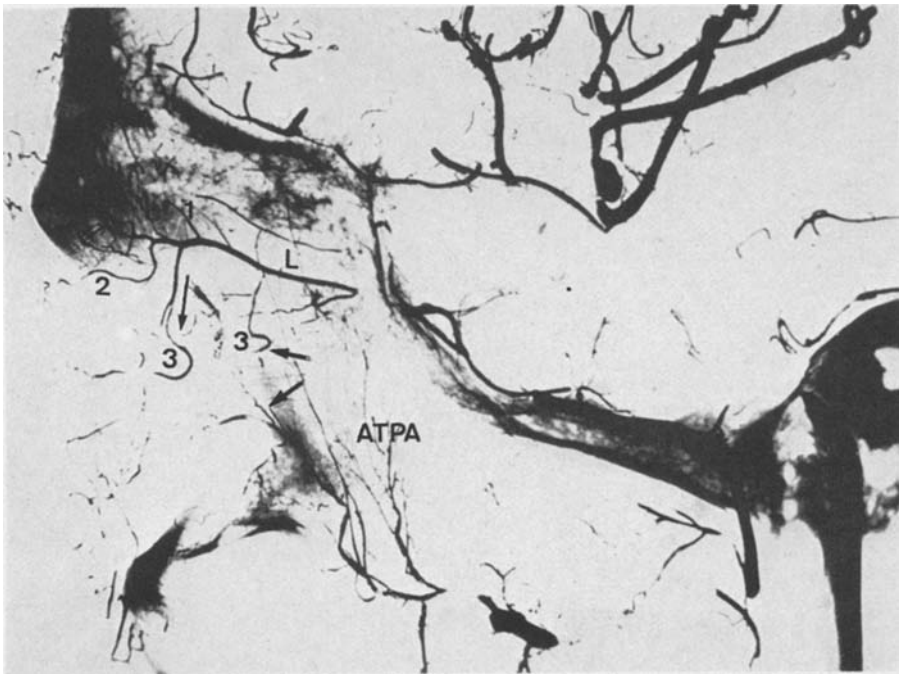


Fig. 3. Sagittal section of a specimen showing the vessels supplying the lacrimal (L) territory: 1) glandular ramus; 2) glandular and palpebral rami; 3) muscular and anastomotic rami (arrows) with the anterior deep temporal artery (ATPA)

The Anterior Deep Temporal Artery [1, 2, 6, 17, 21, 24, 28, 29]

The anterior deep temporal artery is the last ascending collateral branch of the maxillary artery. The orbital branches of the anterior deep temporal artery supply a portion of the lateral part of the orbit, namely the lacrimal territory. The branches enter the orbit either through the inferior orbital fissure or directly through the malar bone.

The main branch to the orbit is easily identified because of its characteristic bayonet course when it enters the orbit (Fig. 6). The other collateral orbital branch of the anterior deep temporal artery courses vertically and anastomoses with the artery of the inferior lacrimal territory either through the meningolacrimal artery or the lacrimal branch of the ophthalmic artery (Fig. 3).

In some pathological cases another branch of the anterior temporal artery may be seen crossing the malar bone and directly joining the upper lacrimal territory (Fig. 6).

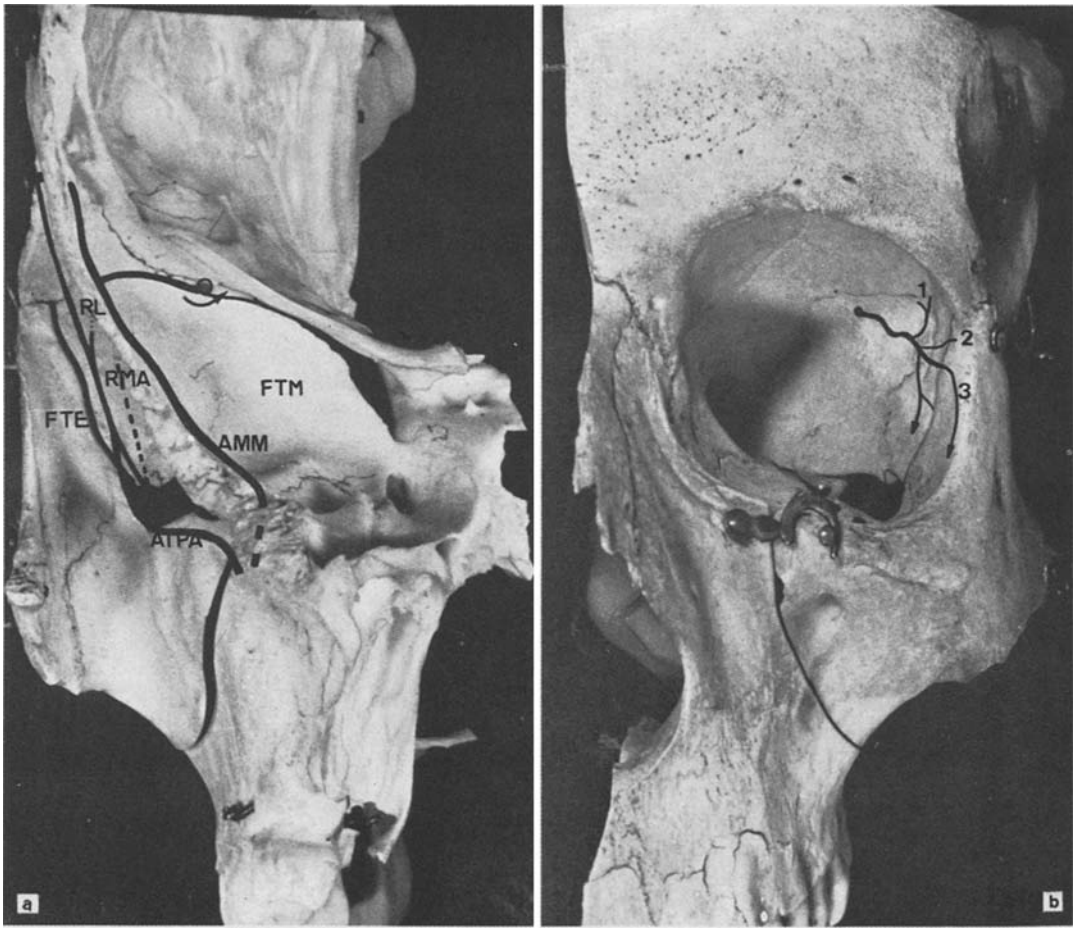


Fig. 4. a. Posterior view of a partially dissected skull including the left orbit. Note the relationship of the maxillary artery branches to the middle temporal fossa (FTM) and to the external temporal fossa (FTE). The orbital ramus of the middle meningeal artery (AMM) courses laterally to the orbit entering through the canal of Hyrtl or meningolacrimal foramen (curved arrow). The anterior deep temporal artery (ATPA) gives origin to its muscular-anastomotic branch (RMA) through the sphenopalatine fissure and its lacrimal branch (RL) coursing transmalarly. b. Anterior view of a partially dissected skull including the left orbit. Note the intraorbital course of the left meningolacrimal artery along with its three terminal branches: 1) glandular ramus; 2) glandular-palpebral ramus; 3) muscular and anastomotic rami

The Infraorbital Artery [1, 2, 6, 17, 21, 24, 28, 29]

The infraorbital artery, during its course below the orbit, gives rise to several orbital branches just before entering the infraorbital canal and appearing on the

face below the orbit. The infraorbital artery originates from the maxillary artery on the posterior aspect of the maxillary sinus and, while running on the roof of the sinus, delineates the inferior aspect of the orbit on the lateral projection.

There are two groups of branches supplying the orbit. A lateral one nourishes the inferior lacrimal territory and a medial one enters the inferomedial territory of the orbit where there is an anastomosis the inferomedial muscular artery (Fig. 7) and the inferior palpebral branches of the ophthalmic artery (Fig. 5). The medial group supplies the inferior eyelids and the nasolacrimal canal.

On the lateral projections, these two groups have a concave posterior course in the anterior portion of the orbit (Fig. 8). The lateral group may opacify lacrimal branches originating from the ophthalmic artery (Fig. 8); the medial group may opacify the third portion of the ophthalmic artery directly (Fig. 5).

On AP projections, these collateral branches of the infraorbital artery are inconstantly visible, particularly the lateral group which is often photographically washed out with the malar bone by subtraction techniques.

The Orbital Venous Phase of External Carotid Angiograms

The late phase of a selective external carotid angiogram visualizes the venous drainage of the orbit, mainly by the blush of the nasal and sinus mucosa (Fig. 9, 10). The degree of opacification during the orbital venous phase of an external carotid angiogram is far inferior to the opacification obtained through direct injection of the venous system, but may be considered as a complementary technique.

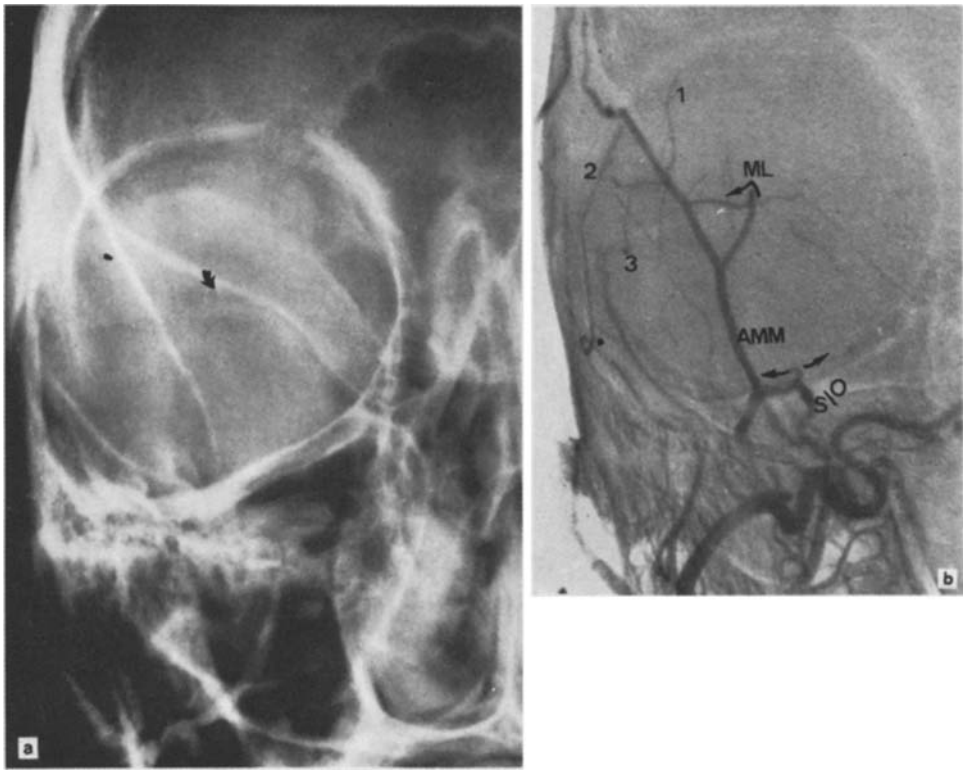


Fig. 5. a. Frontal radiograph of the orbit. Note the canal of Hyrtl (meningolacrimal foramen) just lateral to the superior orbital fissure (arrow). b. Frontal view of a selective external carotid angiogram. Note the meningolacrimal (ML) branch of the middle meningeal artery (AMM) and its branches: 1) glandular ramus; 2) glandular-palpebral ramus; 3) muscular-anastomotic ramus. The lateral branch (*) of the orbital ramus issued from the suborbital artery (S/O) is also well visualized

Conclusions

1. Selective external carotid angiograms (or, better yet, selective maxillary angiograms) are an indispensible complement to selective internal carotid angio-

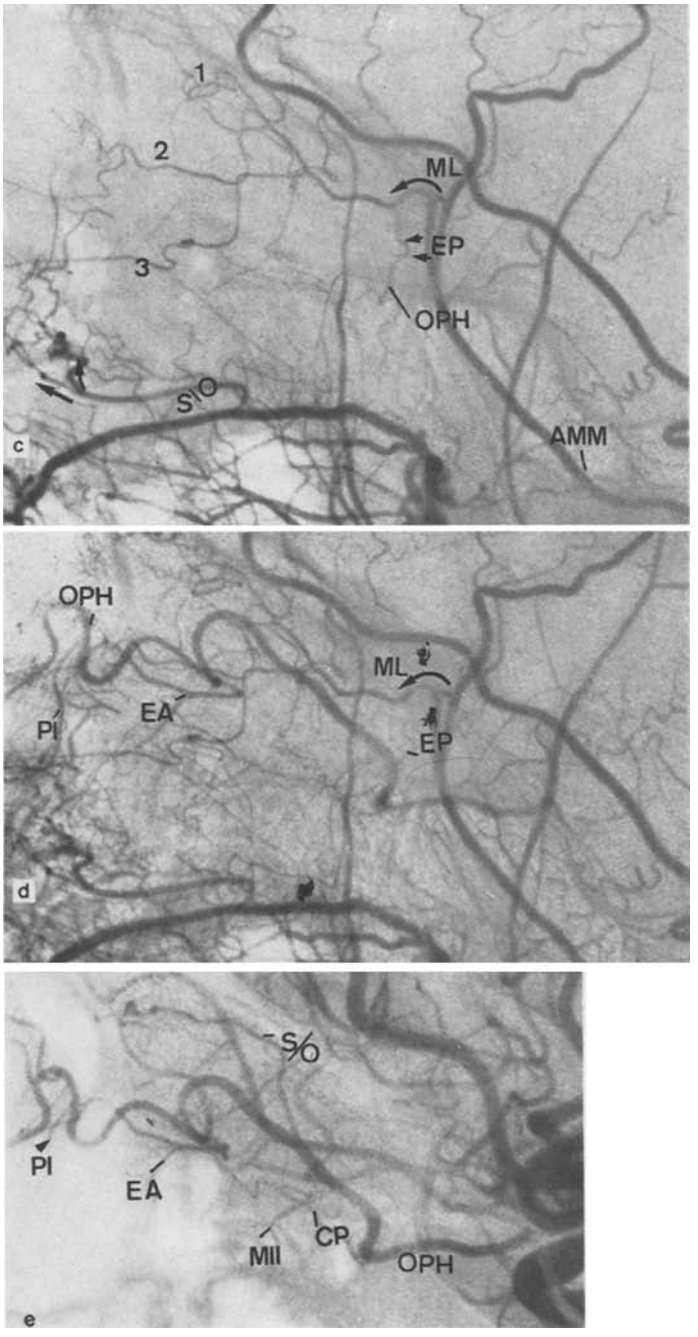


Fig. 5. c. and d. Lateral views of a selective external carotid angiogram. There is progressive filling of the ophthalmic (OPH) system through the inferior palpebral artery (PI), the anterior and posterior ethmoidal arteries (EA and EP) and the orbital branches of the suborbital artery (S/O). e. Lateral view of a selective internal carotid angiogram. The ophthalmic (OPH) branches are well seen. S/O = supraorbital artery. EA = anterior ethmoidal artery. PI = inferior palpebral artery. MII = inferomedial muscular artery. CP = posterior ciliary artery. Note that there is no opacification of the lacrimal artery

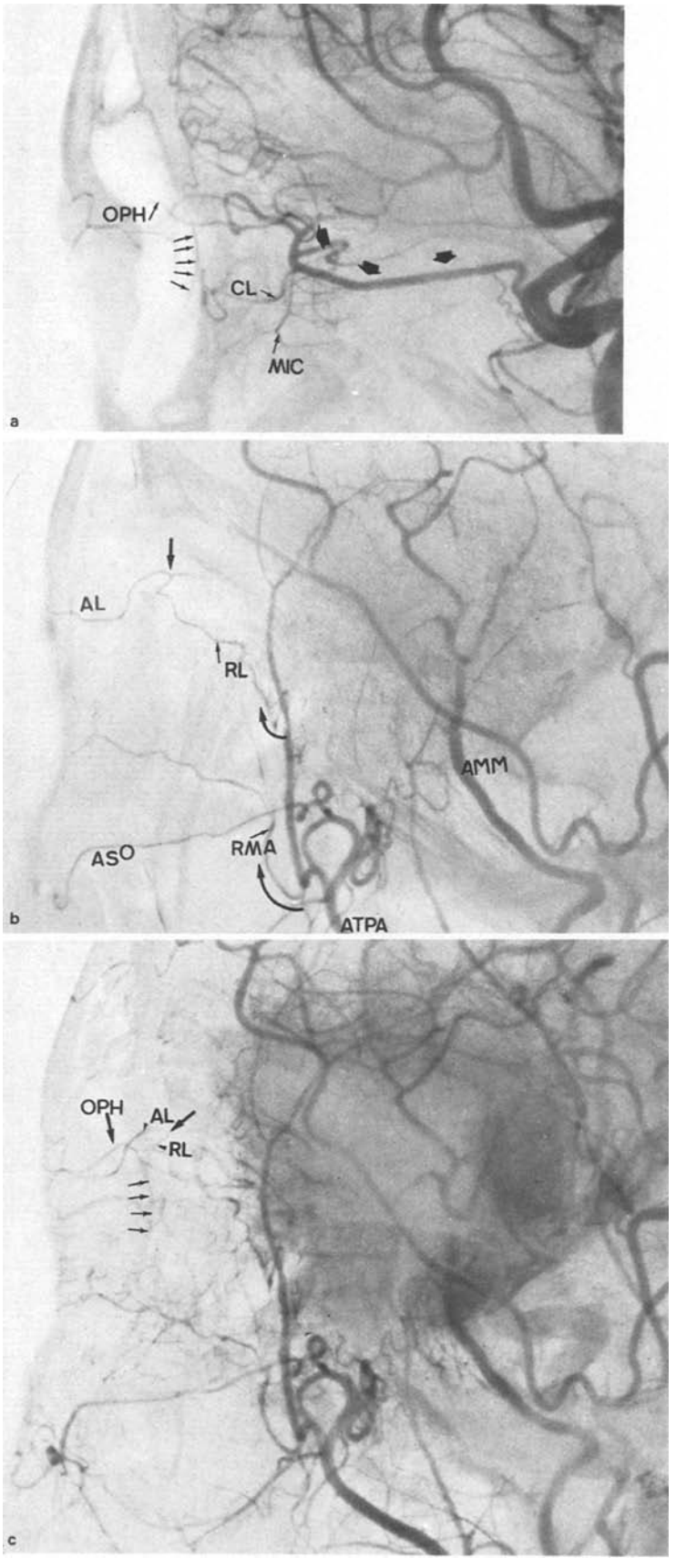
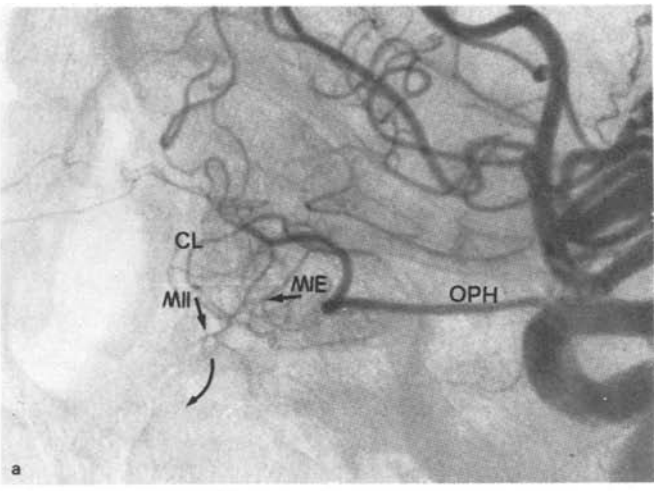
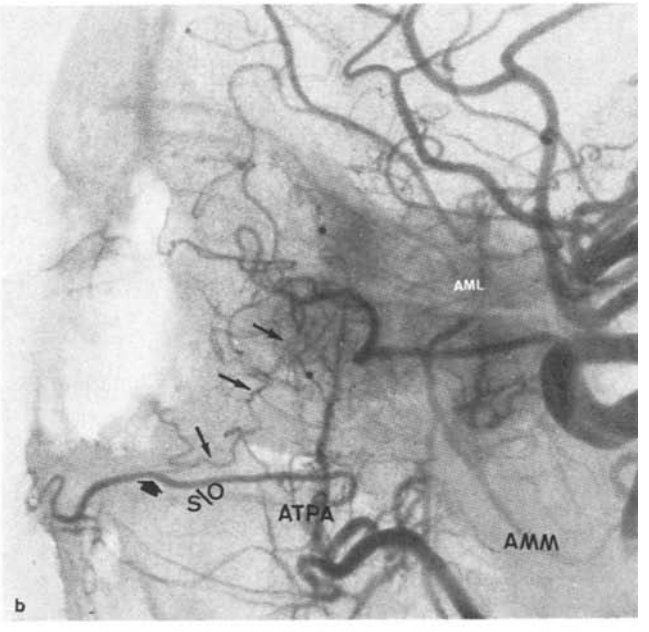


Fig. 6. a. Selective internal carotid angiogram. There is marked displacement (arrowheads) of the firstportion of the ophthalmic (OPH) artery and its collateral the inferior common muscular artery (MIC). There is only minute opacification of the choroidal blush (multiple small arrows) through a long ciliary artery (CL). b. Selective external carotid angiogram, early phase. The following vessels can be identified: the orbital ramus of the middle meningeal artery (AMM), the muscular-anastomotic ramus (RMA) of the anterior deep temporal artery (ATPA) and its lacrimal ramus (RL) which is seen to fill the lacrimal artery (AL) following a transmalar course. c. Selective external carotid angiogram, late phase. There is a large tumor blush representative of a sphenoorbital meningioma. Note the retrograde visualization of the ophthalmic (OPH) artery and the better visualization of the choroidal blush (multiple small arrows)

Fig. 7. a. Selective internal carotid angiogram. The major trunk of the ophthalmic (OPH) artery is displaced minimally. Note the normal ophthalmic branches: the inferior lateral muscular artery (MIE), the inferior medial muscular artery (MII and a long ciliary (CL). b. Common carotid angiogram. There is opacification of a large sphenoorbital meningioma through the meningolacrimal artery (AML) originating from the middle meningeal artery (AMM). Note the tumor supply through the orbital branches (**) of the anterior deep temporal artery (ATPA). There is an anastomosis (multiple arrows) between the inferior medial muscular artery and the orbital ramus of the suborbital artery (arrowhead) (S/O)





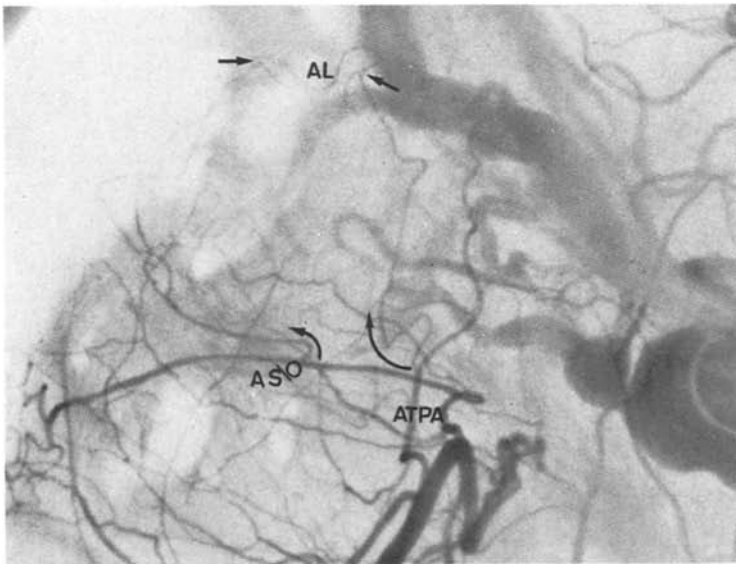
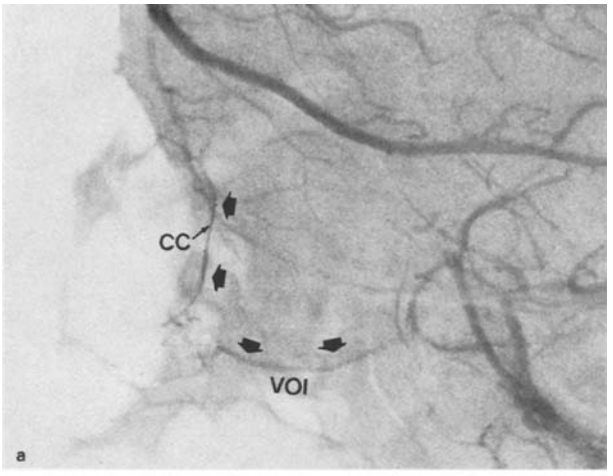
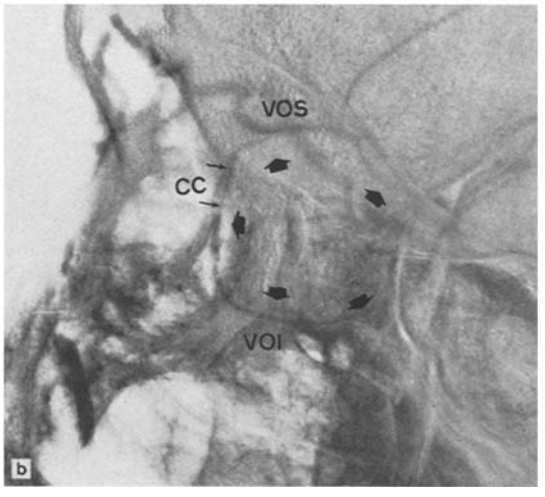


Fig. 8. Common carotid angiogram. Carotid cavernous fistula. There is filling of the lacrimal artery (AL) via two anastomotic rami (arrows) with the anterior deep temporal artery (ATPA) and suborbital artery (AS/O)





grams for a complete arteriographic exploration of the orbit.

2. The recurrent meningeal artery normally connects the anterior branch of the middle meningeal artery with the lacrimal artery. The ophthalmic artery may originate from the middle meningeal artery, or the anterior branch of the middle meningeal artery may originate from the ophthalmic artery.

3. The meningolacrimal (sphenoidal artery) supplies a portion or all of the lacrimal territory.

4. The anterior deep temporal artery constantly supplies the orbit and anastomoses with the lacrimal territory.

5. The infraorbital artery supplies the inferior and lateral portions of the orbit. It anastomoses with lacrimal territory branches, with the inferior muscular artery and with the inferior medial palpebral artery.

6. The ophthalmic artery has numerous anastomoses with branches of the maxillary artery and thus may be opacified by selective maxillary angiograms. In these

Fig. 9. Venous phases of carotid angiograms. Same case as Fig. 2. a. Venous phase of the selective internal carotid angiogram. There is flattening and forward displacement (upper arrowheads) of the posterior portion of the choroidal crescent (CC). There is downward displacement (lower arrowheads) of the inferior ophthalmic vein (VOI). b. Venous phase of the selective external carotid angiogram. The same veins are opacified and show identical displacements (arrowheads). In addition, there filling of the superior ophthalmic vein (VOS)

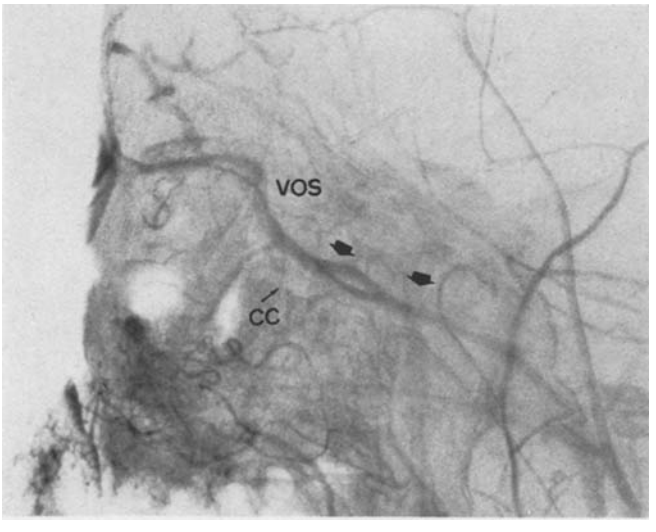


Fig. 10. Venous phase of a selective external carotid angiogram. The choroidal crescent (CC) appears to be normal. However, note the downward displacement (arrowheads) of the superior ophthalmic vein (VOS) due to an extraconical mass

cases, the AP projections allow a better identification of the ophthalmic system since there is no overlap of intracranial vesssels.

7. The venous phase of a selective external carotid angiogram faintly opacifies the ophthalmic veins.

References

1. Aaron, C., Doyon, D., Fischgold, H., Metzger, J., Richard, J.: L'arteriographie de la carotide externe. Paris: Masson, Editeurs 1970
2. Allen, W.E., Kier, E.L., Rothman, L.G.: The maxillary artery: normal arteriographic anatomy. Amer. J. Roentgenol. **118**, 512–527 (1972)
3. Bernasconi, V.: Abnormal origin of the middle meningeal artery from the ophthalmic artery. Neurochirurgia (Stuttg.) **8**, 81–85 (1965)
4. Brucher, J.: Origin of the ophthalmic artery from the middle meningeal artery. Radiology **93**, 51–52 (1969)
5. Chanmugem, P.K.: Note on an unusual ophthalmic artery associated with other abnormalities. J. Anat. **70**, 580–582 (1936)
6. Clay, C., Vignaud, J.: Vasularisation de l'orbite. Encyclopedie Médico-chirurgicale (Paris) **21**, 6 (1971)
7. Combelles, R.: Les collaterales et les terminales de la carotide externe. Thèse de Médecine, Toulouse (1970)
8. Daly, R., Potts, G.: Demonstration of the ophthalmic artery and the choroid plexus of the eye by carotid angiography. Neurology **13**, 120–122 (1963)
9. DiChiro, G.: Ophthalmic arteriography. Radiology **77**, 948–957 (1961)
10. Djindjian, R., Pansini, A.: Malformations fronto-orbitaires irriguees par l'artère ophtalmique. Sem. Hôp. Paris **38**, 2043–2046 (1962)
11. Gabriele, O.F., Bell, D.: Ophthalmic origin of the middle meningeal artery. Radiology **89**, 841–844 (1967)
12. Galligioni, F., Nori, A.: Rilievi anatomoradiologia sul ramo meningeo dell arteria lacrymale. Quad. Radiol. 484–491 (1960)
13. Galligioni, F., Pellone, M., Bernardi, R. Iraci, G.: Further observations on the meningeal branch of the lacrimal artery. Amer. J. Roentgenol. **101**, 22–27 (1967)
14. Guyot, J.F., Vouyouklardis, D., Pertuiset, B.: Meningiomes de l'arête sphénoidale. Neuro-Chirurgie **13**, 571–584 (1967)
15. Hayreh, S.S., Dass, R.: The ophthalmic artery. I. Origin and intra-cranial and intra-canalicular course. Brit. J. Ophthal. **46**, 65–98 (1962). II. Intra-orbital course. Brit. J. Ophthal. **46**, 165–185 (1962). III. Branches. Brit. J. Ophthal. **46**, 212–247 (1962)
16. Kuru, Y.: Meningeal branches of the ophthalmic artery. Acta radiol. Diagn. **6**, 241–251 (1967)
17. Lemarque, J.L., Ginestie, J.F., Serrou, B., Fabre, J. M., Senac, J.P.: Apport de l'artériographie carodidienne externe dans l'exploration radiologique des tumeurs du sinus maxillaire. J. Radiol. Électrol. **52**, 357–366 (1971)
18. Lie, T.A.: Congenital anomalies of the carotid arteries. Amsterdam: Excerpta Medica Foundation 1968
19. Lombardi, G.: Ophthalmic artery anomalies. Ophthalmologica (Basel) **157**, 321–327 (1969)
20. Lombardi, G., Cecchini, A., DeDonato, E.: L'artère ophtalmique dans les méningiomes peri-orbitaires. Ann. Radiol. **111**, 165–172 (1960)
21. Lurje, A.: On the topographical anatomy of the internal maxillary artery. Acta anat. (Basel) **2**, 219–231 (1946)
22. McLennan, J.E., Rosenbaum, A.E., Haughton, V. M.: Internal carotid origins of the middle meningeal artery. Neuroradiology **7**, 265–275 (1974)
23. Newton, T.H., Hoyt, W.F.: Dural arteriovenous shunts in the region of the cavernous sinus. Neuroradiology **1**, 71–81 (1970)
24. Newton, T.H., Kramer, R.A.: Clinical uses of selective external carotid arteriography. Amer. J. Roentgenol. **97**, 458–472 (1966)
25. Padget, D.H.: The development of the cranial arteries in the human embryo. Contr. Embryol. Carneg. Institn **32**, 205–261 (1948)
26. Pribram, H.F.W.: Selective catheterization of the external carotid artery. Radiology **87**, 315–320 (1966)
27. Salamon, G., Grisoli, J., Paillas, J.E., Faure, J., Giudicelli, G.: Étude artériographique des artères méningées. Neurochirurgia (Stuttg.) **10**, 1–19 (1967)
28. Salamon, G., Guerinel, G., Demard, F.: Étude radio-anatomique de l'artère carotide externe. Ann. Radiol. **11**, 199–215 (1968)
29. Testut, L.: Traité d'anatomie humaine. Sixième édition Paris: Octave Doin et Fils, Éditeurs 1911
30. Vignaud, J., Clay, C., Aubin, M.L.: Orbital arteriography. Radiol. Clin. N. Amer. **10**, 39–61 (1972)
31. Vignaud, J., Hasso, A.N., Lasjaunias, P., Clay, C.: Orbital vascular anatomy and embryology. Radiology **111**, 617–626 (1974)

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