



Arterial Anatomy of the Parasellar Area

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The arterial anatomy of the parasellar area is complex in that it deals with extracranial–intracranial anastomosis and supply to various cranial nerves in a small area. Pathologies such as hypervascular tumors and shunts are not uncommon and require good knowledge of anatomy in planning the treatment. In this article, the basic anatomy of the arterial supply in this region is discussed, covering the origins, territories, relation to the cranial nerves, and the connections among different systems.

Keywords ► parasellar area, cavernous sinus, arterial anatomy

Introduction

The parasellar area is the area surrounding the sellar turcica, including the cavernous sinus and its lateral border.¹⁾ In this article, the arteries relevant to the cavernous sinus and surrounding structures, and their connections among different systems, are described. The arterial system involved in the parasellar area comprises branches of the internal carotid artery (ICA), external carotid artery (ECA), and in some exceptional cases, the branches of the vertebral artery. Pathologies, including hypervascular tumors and shunts, of this area are usually supplied by these arterial systems. The area is also highly concentrated with cranial nerves from the second cranial nerve anteriorly, and as far as the seventh cranial nerve posteriorly. The proximity of these vital structures to the pathologies that occur in the area makes embolization procedures risky. Furthermore, the close connections between the systems also create a potential risk of inadvertent embolic material migration into the brain arterial system.²⁾

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Recent development of interventional tools has led us to be more aggressive in planning treatments. However, the use of more aggressive tools and strategy should be paralleled with a good knowledge of anatomy to ensure a good outcome.

Arteries Supplying the Cavernous Sinus

Internal carotid artery

The meningo-hypophyseal trunk (MHT) and the inferolateral trunk (ILT) (branches from the ICA), as well as the branches of the ophthalmic artery, participate in vascularization of the dura, cranial nerves, and the pituitary gland.^{3–8)} The ILT, located at the center of this area, can be considered as the main supplier. Despite this, the ILT is not a constant vessel, and its supply can be provided by the supply from another adjacent system, including the branches of the ECA.⁹⁾ However, the supply to the cranial nerves seems to be more constant.¹⁰⁾

Inferolateral trunk

The ILT is also referred to as the artery of the inferior cavernous sinus,^{5,11)} the lateral trunk,⁶⁾ and the lateral main stem.¹²⁾ The origin of the ILT is at the midportion of the horizontal portion of the intracavernous segment of the ICA^{3,5,6–9)}; it passes over the abducens nerve in more than 90% of cases³⁾ and then descends downward to the anterior and posterior ramus after sending out a tentorial branch as the superior ramus. This superior ramus is not a constant branch and has been observed in 6%–40% of cadaveric

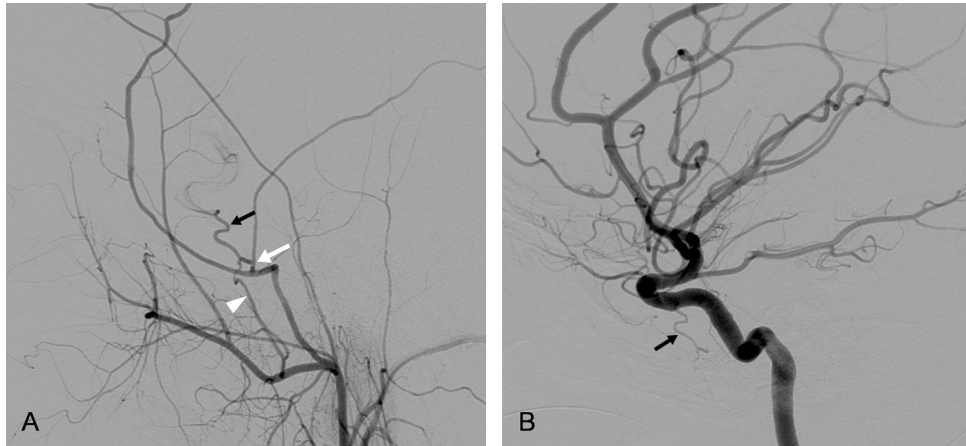


Fig. 1 (A) A left ECA angiography of a 14-year-old boy investigated for brain arteriovenous malformation in the frontal area, demonstrating a prominent connection from the accessory meningeal artery (white arrowhead) and the MMA (white arrow) to the ILT (black arrow). (B) The same connection is demonstrated in the internal carotid injection. ECA: external carotid artery; ILT: inferolateral trunk; MMA: middle meningeal artery

specimens.^{3,9} The superior ramus mainly supplies to the roof of the cavernous sinus dura mater and extends posteriorly to supply the medial part of the tentorium.^{3,5,8,9} The anterior ramus divides into the artery of the foramen rotundum (AFR) and the artery of the superior orbital fissure (ASOF), which have connections to branches of the distal internal maxillary artery and the artery in the orbit, respectively. The posterior ramus runs posterolaterally to anastomose with a branch of the accessory meningeal artery and also gives a smaller branch running posteriorly to connect with the middle meningeal artery (MMA), thus forming a potential extracranial–intracranial anastomosis (**Fig. 1**).⁹

The ILT supplies the intracavernous portion of the trigeminal nerve, the oculomotor nerve, the trochlear nerve, and the abducens nerve, while at the same time supplying the lateral wall of the cavernous sinus.^{3,9} Hypervascular tumors and shunt lesions receive their blood supply from the arteries in this area to various extents.

Although the ILT cannot be identified in the majority of angiographic studies, in cadaveric studies, it can be identified in 65.8% to 90% of the specimens.^{6,9} When absent, the ECA, mainly the accessory meningeal artery, supplies the territory of the ILT.⁹

Meningohypophyseal trunk

The MHT typically arises at the posterior bend of the proximal ICA within the cavernous sinus. In its complete form, it gives out three branches: the inferior hypophyseal artery, the dorsal meningeal artery (clival artery), and the tentorial artery. The MHT is a more constant artery than the ILT, and is present in 88% to 100% of cadaveric specimens.^{3,6,13}

According to Harris et al,¹³ this artery can give out branches that belong to the system of the ILT. Although the MHT is considered to be a constant vessel, its branches, except for the tentorial artery, maybe absent; in these cases, the other branches will arise nearby, directly from the ICA.¹³ The MHT arises from the persistent trigeminal artery when this anomaly is observed,³ indicating that the MHT is part of the trigeminal artery embryologically.¹ However, some authors have demonstrated that these branches can rise separately.¹¹

The MHT takes part in the supply of the oculomotor nerve and the trochlear nerve. The inferior hypophyseal artery supplies the posterior lobe of the pituitary gland. The tentorial branch, in its complete form, divides into two branches, both supplying different areas of the tentorium. One branch runs to the free margin of the tentorium and supplies the medial portion of the tentorium and the oculomotor and trochlear nerves. This branch was first described on angiography by Bernasconi and Cassinari¹⁴ and is sometimes referred to as the artery of Bernasconi and Cassinari. Another branch, called the basal meningeal artery,¹⁵ basal tentorial artery,⁶ or the lateral tentorial artery⁵ supplies the area lateral to the territory of the artery of the free margin of the tentorium.

As mentioned earlier, the branches of the MHT supply the corresponding cranial nerves and the dura mater in their territory. Anastomoses are formed through these dural branches. The tentorial artery has an important anastomotic network to the ILT and the ophthalmic artery, and can even be supplied by the lacrimal branch of the ophthalmic artery.¹ The dorsal meningeal artery running downward on the clivus connects with the clival branches of the ascending pharyngeal artery.¹⁶

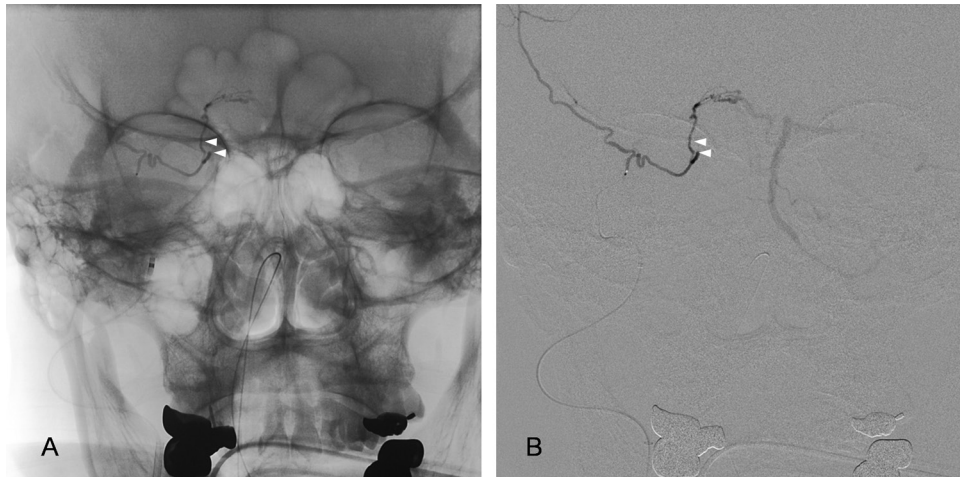


Fig. 2 A supraselective injection of the MMA in a patient with a dural arteriovenous fistula in the right tentorial incisura. A branch from the MMA runs along the roof of the cavernous sinus (arrowheads), substituting the usual territory of the superficial recurrent ophthalmic artery to become the artery of the free margin of the tentorium. (A) Non-subtracted image. (B) Subtracted image. MMA: middle meningeal artery

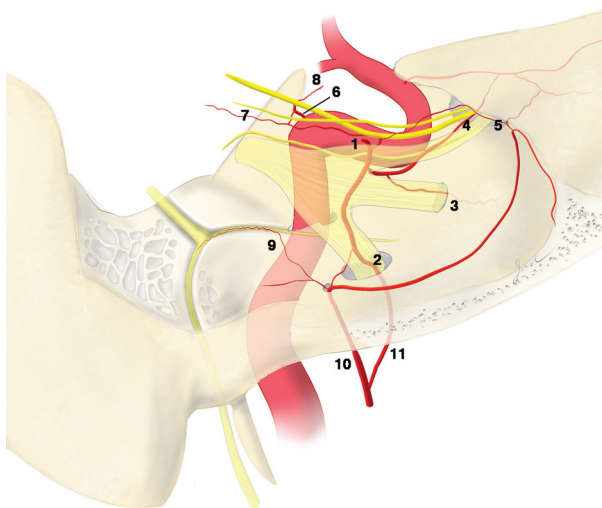


Fig. 3 An illustration of the arterial anatomy in relation to the cranial nerves in the parasellar area in lateral-oblique view. The three branches of the ILT (1) accompany the trigeminal branches, with connection to the internal maxillary artery through the foramen ovale (2) and through the AFR (3), and connection to the ophthalmic artery through the deep recurrent ophthalmic artery (4), which gives supply to the nerves along its course. Another important network is at the roof of the cavernous sinus, connecting the superficial recurrent ophthalmic artery anteriorly to the superior trunk of the ILT (5) and posteriorly to the MHT (6). This continues to become the artery of the free margin of the tentorium (7). The inferior hypophyseal artery branches off from the MHT (8). The petrous branch (9) of the MMA (10) supplies the facial nerve. The accessory meningeal artery is in hemodynamic balance with the ILT (11). AFR: artery of the foramen rotundum; ILT: inferolateral trunk; MHT: meningohypophyseal trunk

Ophthalmic artery

The ophthalmic artery mainly supplies the contents of the orbit. The branches of the ophthalmic artery that run from

the orbit back into the parasellar area are called the recurrent branches of the ophthalmic artery; these can be separated into the deep and superficial recurrent ophthalmic arteries.⁴⁾

The deep recurrent ophthalmic artery is a more constant branch of the two recurrent arteries. It originates from the first segment of the ophthalmic artery coursing posteriorly, passes through the superior orbital fissure supplying the abducens nerve along the way, and links by anastomosis with the anterior medial trunk of the ILT.⁴⁾ The deep recurrent ophthalmic artery also supplies the medial part of the cavernous sinus and can substitute the territory of the ILT. Moreover, it can participate in the supply of vascular tumors or shunt lesions in both the parasellar area and the area of the tentorium.

The superficial recurrent ophthalmic artery courses more laterally through the lateral part of the superior orbital fissure, reaching the roof of the cavernous sinus and running along the free margin of the tentorium posteriorly, supplying the oculomotor and trochlear nerves during its course in the cavernous sinus and more posteriorly supplying the medial portion of the tentorium.⁴⁾ The territory may be provided by the MMA having the artery of the free margin of the tentorium originating from the anterior branch of the MMA (Fig. 2).

External carotid artery

Several branches of the ECA system participate in vascularization of the parasellar area and have connections with the ICA that need to be recognized even if they are not observed on angiograms.

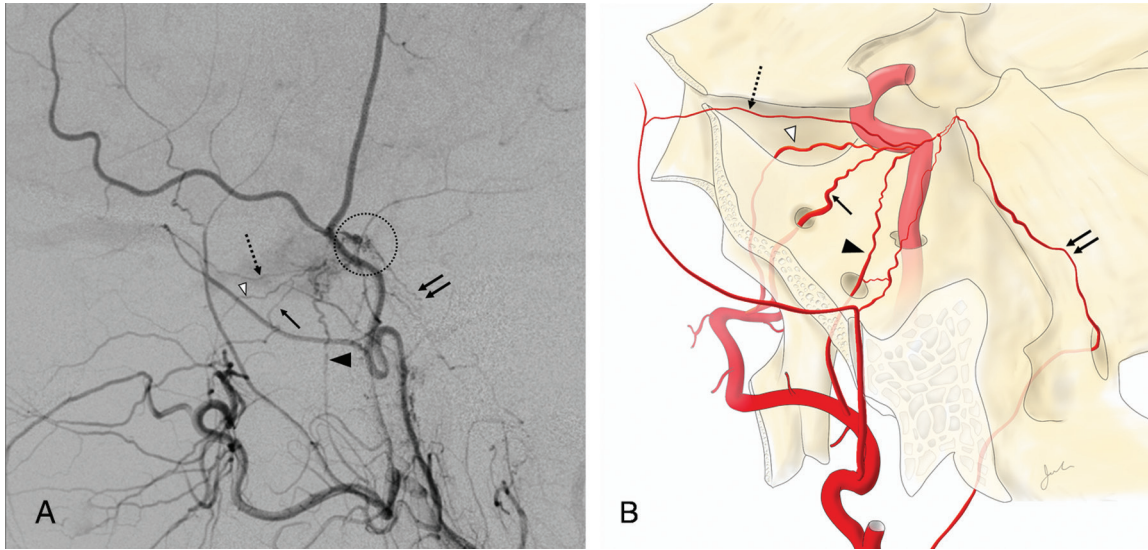


Fig. 4 (A) An angiogram showing the arterial supply to a cavernous sinus dural arteriovenous fistula. A selective injection into the ECA shows feeders arising from the internal maxillary artery converging to the shunt area (dotted circle). A clival branch (double arrow) arising from the hypoglossal branch of the ascending pharyngeal artery runs along the clivus. Other arteries course in the middle fossa joining one another and ultimately feed the shunt (dotted arrow: the recurrent branch of the MMA, white arrowhead: the ASOF, arrow: the AFR, black arrow head: the accessory meningeal artery). (B) An illustration in the posterior oblique view to show the same structures as in (A) in relation to the skull base. AFR: artery of the foramen rotundum; ASOF: artery of the superior orbital fissure; ECA: external carotid artery; MMA: middle meningeal artery

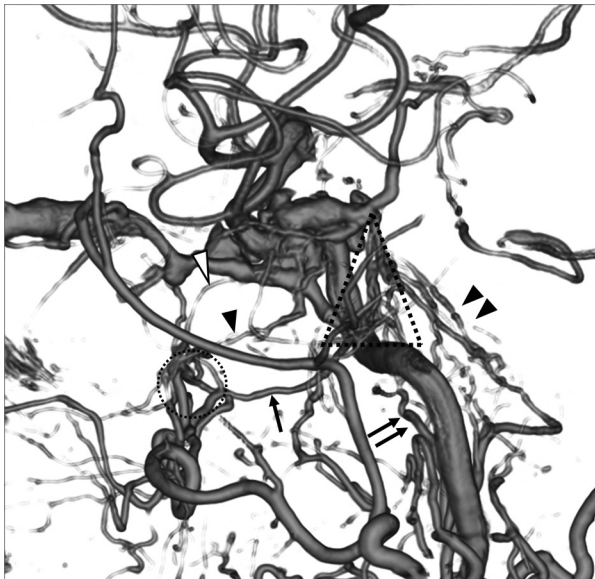


Fig. 5 A three-dimensional reconstruction image of a patient with dural arteriovenous fistula of the cavernous sinus. The arteries running along the skull base are the ASOF (white arrowhead), the AFR (black arrowhead) and the clival artery (double arrowheads) as a branch of the ascending pharyngeal artery. There is another important vessel arising from the sphenopalatine artery coursing posteriorly to the shunt. This artery is the artery of the pterygoid canal (arrow) and will have the potential to connect to the vidian artery of the ICA and the superior pharyngeal branch (double arrows) of the ascending pharyngeal artery. There are also transosseous branches of the superior pharyngeal branch shown here within the dotted triangle area also feeding the shunt. AFR: artery of the foramen rotundum; ASOF: artery of the superior orbital fissure; ICA: internal carotid artery

Middle meningeal artery

The MMA penetrates the skull base through the foramen spinosum. As the main supplier of the dura mater, it supplies most of the lateral part of the parasellar area and has rich anastomosis with other arterial systems in the vicinity. Anteriorly, it has connections with the ophthalmic artery or the lacrimal artery through the superior orbital fissure. In the middle cranial fossa around the cavernous sinus area, it is connected to the posterior branch of the ILT. Posteriorly, the MMA connects to the dural arteries of the posterior fossa.¹⁷ A branch to the superficial greater petrosal nerve participates in the supply of the facial nerve (**Fig. 3**).

Accessory meningeal artery

The accessory meningeal artery, contrary to its name, mainly supplies the pharynx, and only inconsistently supplies the dura mater.^{1,17} The intracranial portion passes through the foramen ovale to supply the lateral wall of the cavernous sinus, and its intracranial territory is in hemodynamic balance with the ILT.⁹ The connection to the ILT can be prominent in the normal state, acting as a potential ECA–ICA anastomosis (**Figs. 1 and 3**). As a meningeal branch, the accessory meningeal artery also has a potential connection to the MMA at the skull base and can share a common origin at the internal maxillary artery.^{1,17}



Fig. 6 Angiograms showing a branch from the PCA participating in a cavernous sinus dural arteriovenous shunt. (A) Anterior–posterior view of the vertebral artery injection. (B) Lateral view of the same injection. (C) Three-dimensional image showing the path of the branch of the PCA into the posterolateral part of the cavernous sinus in superior view. The white arrows show the entry to the shunt point. PCA: posterior cerebral artery

Ascending pharyngeal artery

The ascending pharyngeal artery normally arises from the proximal part of the ECA.¹⁷⁾ The superior pharyngeal branch and the clival branches of the neuromeningeal trunk are the branches that concern the parasellar area.¹⁶⁾

The carotid branch of the ascending pharyngeal artery arises from the superior pharyngeal branch of the ascending pharyngeal artery. It anastomoses with the current branch of the ICA and also with the ILT or MMA near the entrance to the skull base.¹⁾

The neuromeningeal branch of the ascending pharyngeal artery gives out to ascending meningeal branches after it passes through the hypoglossal canal as the medial clival artery and through the jugular foramen as the lateral clival artery. Both clival arteries have the potential to anastomose with the dorsal meningeal artery of the MHT.^{16,17)}

Other branches of the ascending pharyngeal artery that have the potential to supply a dural fistula in the area of the cavernous sinus are the transosseous branches of the pharyngeal trunk, mainly the superior branch, which has anastomosis with the vidian artery of the ICA and the artery of the pterygoid canal of the sphenopalatine artery. These ‘pharyngeal’ branches usually do not give out dural branches in normal situations, but in dural fistula cases, there can be prominent transosseous branches serving as feeders to these lesions (**Figs. 4 and 5**).

Artery of the foramen rotundum and artery of the superior orbital fissure

The AFR and the ASOF represent the branches of the distal internal maxillary artery with a recurrent course. Along

with the maxillary nerve, the AFR has a recurrent course from the pterygopalatine fossa. The AFR passes through the foramen rotundum to anastomose with the anterior lateral branch of the ILT.^{1,14)}

Another recurrent branch of the distal internal maxillary artery is the recently described ASOF.¹⁸⁾ This artery is not uncommon but is sometimes mistaken for the AFR despite having a course that is distinguishable from that of the AFR. The ASOF also connects with the ophthalmic artery and can supply lesions at the lateral wall of the cavernous sinus.¹⁸⁾

Vertebral artery

Normally the branches that belong to the vertebral artery do not actively participate in the supply of normal structures in the parasellar area, except for the vascularization of the cranial nerves at their proximal portion. However, in cases of shunt around the area of the cavernous sinus, branches arising from the posterior cerebral artery may exist and become part of the feeder to the lesion. These branches may be part of the supply to the oculomotor nerve extending from its subarachnoid segment to the entrance of the dura (**Fig. 6**).

The arterial network in the parasellar area is summarized in **Figs. 3 and 7**.

Arterial Supply of the Cranial Nerves

The oculomotor, trochlear, trigeminal, abducens, and a part of the facial nerve are the cranial nerves that are involved in the parasellar area. The spatial relationship and connections

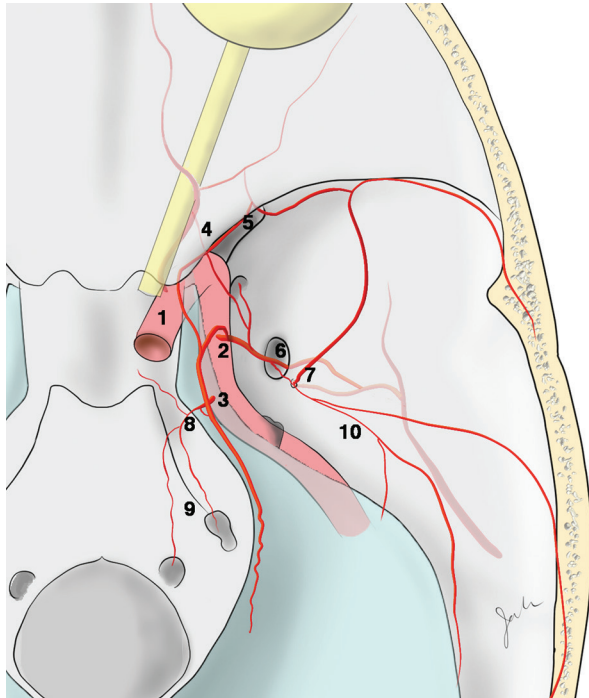


Fig. 7 Illustration of the arterial anatomy of the right parasellar area in superior view. The branches of the ICA (1) in the cavernous sinus: the ILT (2) and the MHT (3). From the ophthalmic artery arise the deep (4) and the superficial recurrent ophthalmic arteries (5). The ILT has connections with the accessory meningeal artery (6) through the foramen ovale and with the MMA (7) at the middle skull base and around the superior orbital fissure. The MHT gives out three branches, of which the most caudal one, the dorsal meningeal artery (8), connects with the clival arteries (9) from the ascending pharyngeal artery. Another important artery to be noted in this area is the petrosal branch of the MMA (10); this is part of the so-called facial arcade and participates in the supply of the facial nerve illustrated in **Fig. 3**. ICA: internal carotid artery; ILT: inferolateral trunk; MHT: meningohypophyseal trunk; MMA: middle meningeal artery

between different arterial sources mean that the suppliers to the nerves in this area have similar origins. Owing to the rich supply to the cranial nerves in this area, transarterial embolization carries high risk of cranial nerve deficits.^{19–21} The arterial supply of each nerve in the parasellar area is summarized as follows^{10,22}:

- Oculomotor nerve: The MHT and the ILT inside the cavernous sinus, and the ophthalmic artery anteriorly.
- Trochlear nerve: The MHT and mainly the superior trunk of the ILT, and the ophthalmic artery branches.
- Trigeminal nerve: The trigeminal artery covers a large territory in the face. In the cavernous sinus area, at the trigeminal ganglion, the nerve receives supplies from the AFR, MMA, accessory meningeal artery, and ILT.
- Abducens nerve: The branches of the intracavernous ICA mainly from the medial side of the nerve.

- Facial nerve: In the parasellar area, the petrosal branch of the MMA supplies the superficial greater petrosal nerve. This branch becomes the supply of the tympanic segment of the facial nerve and forms an anastomosis with the stylomastoid artery of the posterior auricular artery, creating what is known as the facial arcade.²³

Any attempt of embolization via these arteries with potential nerve supply should be performed with strict indication while considering the possibility of cranial nerve deficit in this area.^{20,22,23}

Anastomosis between Different Arterial Systems

As mentioned earlier, the parasellar area contains cranial nerves, and branches of the ICA and ECA participate in the blood supply to these cranial nerves and the adjacent dura mater. These various supply sources lead to a rich connection of different arterial systems (**Figs. 3 and 7**). These can act as potential ECA–ICA collaterals² and are more commonly observed when there is an occlusion of the proximal ICA. They are also a source of inadvertent migration of embolic materials from the branches of the ECA to the intradural ICA territory, and from the ascending pharyngeal artery system^{2,24} and the branches of the internal maxillary artery, which should be considered when dealing with pathologies in this area.

Conclusion

The arterial anatomy in the parasellar area is complex and involves arteries that supply both the dural and the cranial nerves in a small area. Some of the branches are small and difficult to observe on angiography. Thus, one must be vigilant about the cranial nerve supply and ECA–ICA anastomosis in order to avoid complications when managing lesions in this area.

Disclosure Statement

The author declares no conflict of interest.

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