External Carotid Artery

The common carotid artery generally bifurcates into the internal and external carotid arteries at the level between the third and fourth cervical vertebrae. The external carotid artery often bifurcates in medial/ ventral directions and the internal carotid artery in lateral/ dorsal directions.

The proximal part of the external carotid artery is densely populated with the origins of branches including the superior thyroid artery, lingual artery, facial artery, ascending pharyngeal artery, and occipital artery. To include them adequately in the imaging range and to prevent backflow of contrast agent into the internal carotid artery, the tip of the contrast catheter must be placed in the most proximal site of the external carotid artery. However, it is not unusual for the tip of the catheter to slip into one of the branches, and the intended external carotid angiography may end up as a single branch contrast.

When using a multipurpose catheter with a small curve, the catheter should be placed at the level of the lingual artery with the catheter tip pointing laterally and ventrally to minimize the chance of straying into a branch.

If the tortuosity of the carotid artery is strong due to atherosclerotic changes, and JB-2 with a strong curve must be used, place the large curve of the catheter in the common carotid artery. Then insert only the tip of the catheter into the origin of the external carotid artery, and turn the tip laterally and ventrally for contrast imaging. This is the most stable position for JB-2 type, although reflux of contrast agent into the internal carotid artery is unavoidable. If

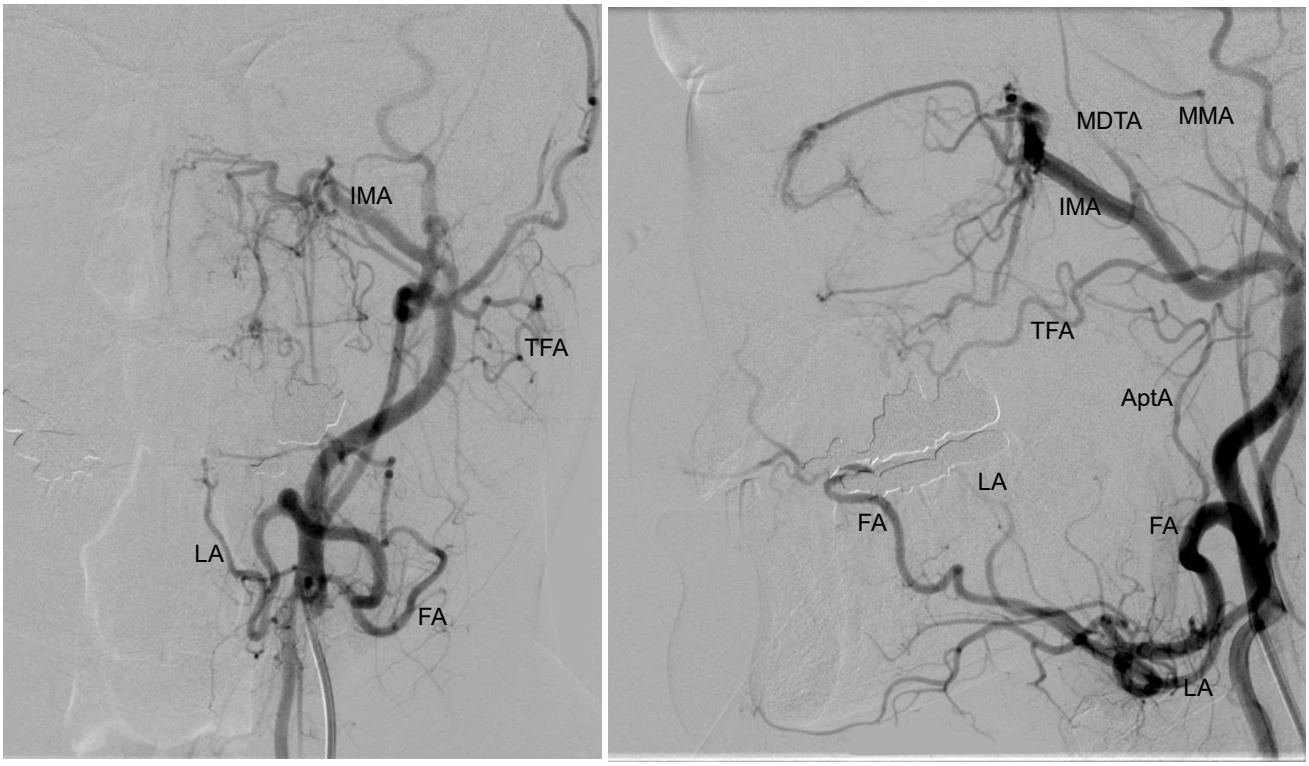

Fig. 12. An example of an external carotid artery showing the most typical anatomy. Frontal (left) and lateral (right) views. IMA: internal maxillary artery, MDTA: middle deep temporal artery, MMA: middle meningeal artery, TFA: transverse facial artery, AptA: ascending palatine artery, FA: facial artery, LA: lingual artery

treatment is continued in this position, rinsing with heparinized saline in the guiding catheter (GC) should never be discontinued. Another area where the JB-2 type is stable is where the above-mentioned branches are completed and transition to the horizontal site is made. Although it is suitable for examining branches in higher positions, such as the internal maxillary artery, the implantation of GC will be in a quite high position, and the possibility of vasospasm is high. Backup at this site may be necessary in cases of high origin of the facial artery or in cases where the length of the microcatheter is insufficient.

Internal Maxillary Artery

The term "internal" maxillary artery is a remnant from the time when the facial artery used to be called the external maxillary artery~~, and is now simply called the maxillary artery, not the internal maxillary artery~~. It is one of the terminal branches of the external carotid artery along with the superficial temporal artery.

The internal maxillary artery (IMA) is divided into three segments: the 1st segment, which runs anteriorly and slightly inferiorly between the mandibular joint and the sphenomandibular ligament; the 2nd segment, which runs around the pterygoid muscle and then turns anteriorly superiorly and slightly anteromedially; and the 3rd segment, which enters the pterygopalatine fossa, meanders medially, and ends in the four branches.

The optimal imaging direction for each segment of the IMA varies widely. Frontal views are suitable for the terminal portion of the external carotid artery that separates the superficial temporal artery (lateral) from the IMA (medial), from the end of the 1st segment to the first half of the 2nd segment, and from the 3rd segment onward, while lateral views are useful for the rest of the artery.

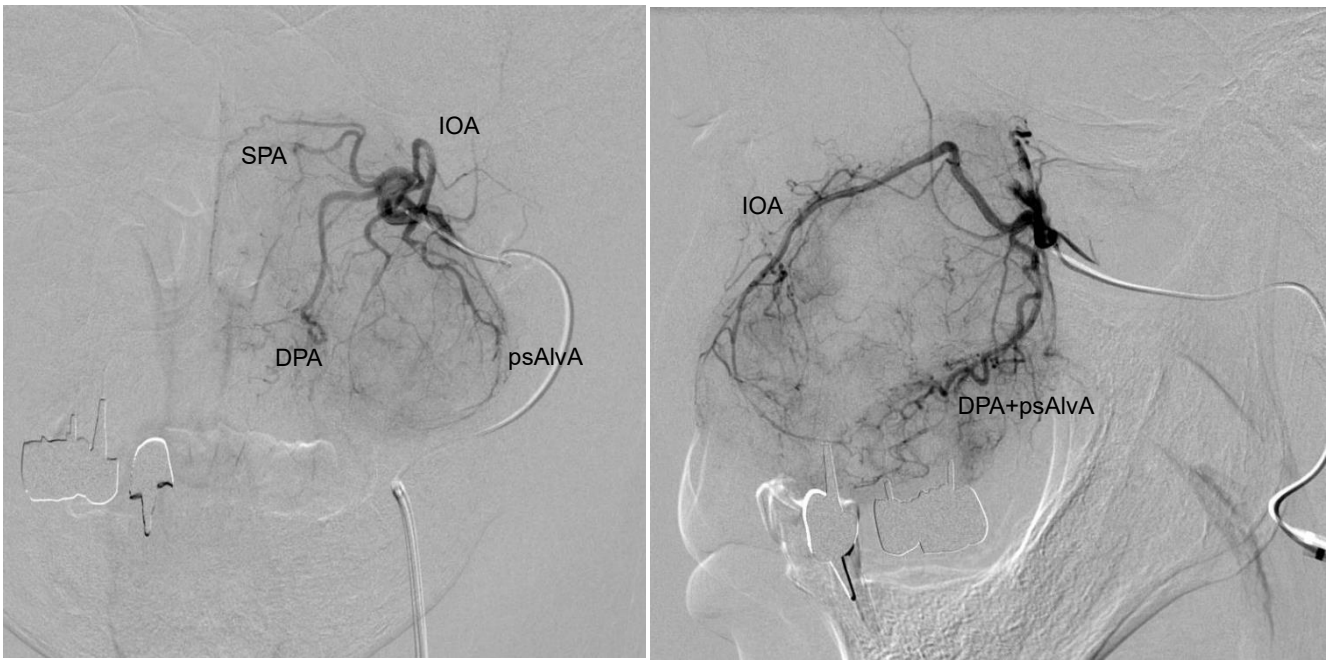

Fig. 13. Left internal maxillary artery, frontal (left) and lateral (right) views; IOA: infraorbital artery, SPA: sphenopalatine artery, DPA: descending palatine artery, psAlvA: posterior superior alveolar artery. In the frontal view, it is possible to identify the terminal branches that branch medially and laterally, but in the lateral view, it takes some skill to identify the run of each branch. Tumor

If only a single-plane angiography is available, it is best to perform all imaging in a frontal view. Although textbook schematic drawings depict the branches of the external carotid artery more clearly in the lateral view, the frontal view is often more useful for the actual procedure.

For IA chemotherapy, after performing angiography of the external carotid artery, digital subtraction angiography (DSA) is performed from the 1st segment of the IMA. After confirming the anatomy of each branch, a microcatheter is advanced to the 3rd segment, and DSA is performed again, which is often followed by IA-CT and cisplatin infusion.

Four Terminal Branches

When angiography is performed from the 3rd segment of the IMA, only the so-called four terminal branches of the infraorbital, sphenopalatine, descending palatine, and posterior superior alveolar arteries will be visualized. The 3rd segment of the IMA ascends in the pterygopalatine fossa and divides into the medial and lateral branches; the medial branch into the sphenopalatine artery and descending palatine artery; and the lateral branch into the infraorbital artery and posterior superior alveolar artery. The following sections discuss each of the branches, but if you are not yet familiar with IA chemotherapy, treatment starting with the 3rd segment should be sufficient. Since there will be no opportunity to perform further superselective IA infusions from the branches, a full understanding is not necessary at this time.

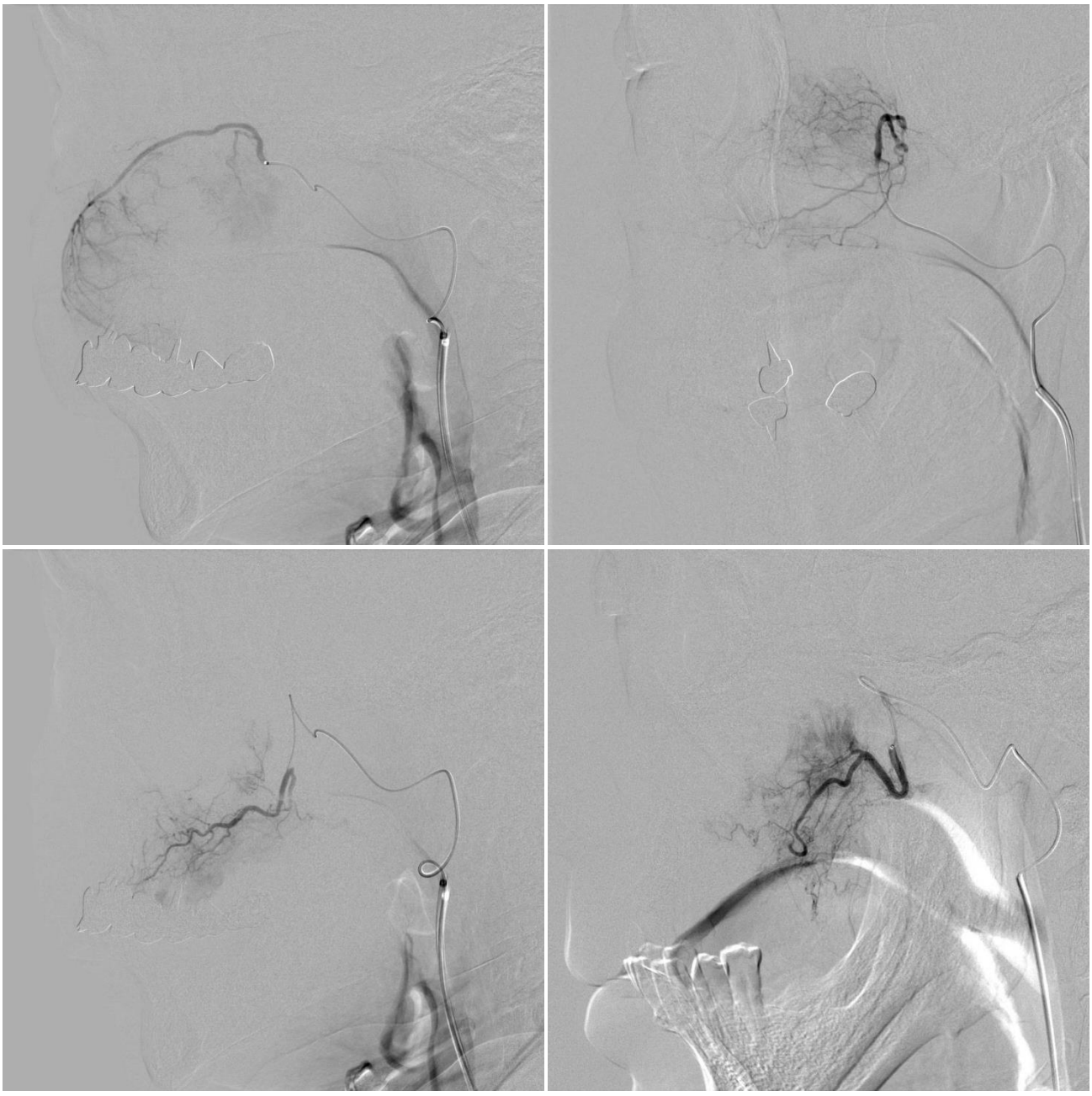

Fig. 14. Lateral view of the terminal branch of internal maxillary artery. Infraorbital artery (upper left), sphenopalatine artery (upper right), descending palatine artery (lower left), posterior superior alveolar artery (lower right).

Infraorbital Artery

This large artery is located at the border between the orbit and the maxillary sinus and can be easily identified in the lateral image. The infraorbital artery originates laterally in the 3rd segment of the IMA, and often forms a common trunk with the posterior superior alveolar artery. This artery is often in extensive contact with the superior and anterior surfaces of the maxillary sinus tumor and supplies blood to the tumor along its entire length.

After originating, it runs vertically upward for a short distance on the posterior surface of the maxillary sinus, then produces a branch to the maxillary tuberosity and immediately enters the orbit through the inferior orbital fissure. It travels horizontally across the orbital floor, enters the infraorbital groove, and then proceeds quickly to the infraorbital canal, showing a characteristic straight line. In the canal, two small anterior and posterior orbital branches and an alveolar branch are produced. The posterior orbital branch is thin and difficult to identify, while the anterior orbital branch is thick and easily identified, anastomosing with the muscular and lacrimal branches of the ophthalmic artery, and often feeding the orbital extension of the tumor.

In the lateral view of angiography, this anterior orbital branch and the trunk of the infraorbital artery may appear separated (Figure 16). This observation strongly suggests that the tumor originates from the upper part of the anterior wall of the maxillary sinus (infraorbital rim), and intensive treatment to the infraorbital artery will be effective. As the tumor shrinks, this separation angle becomes narrower (Figure 16).

The alveolar branch that branches distally from the infraorbital canal is called the anterior superior alveolar artery, which runs in the anterior alveolar canal within the anterior wall bone of the maxillary sinus. It anastomoses laterally with the posterior superior alveolar artery running in the posterior alveolar canal. They are the major feeding arteries to the alveolar extension of the tumor.

The infraorbital artery finally exits the infraorbital foramen, which opens just below the inferior eyelid, and contacts the muscular plane consisting of the orbicularis oris muscle and the levator labii superioris muscle from the bone wall. This branch is located deeper than the facial artery running subcutaneously and is more closely involved in the anterior wall extension of the tumor.

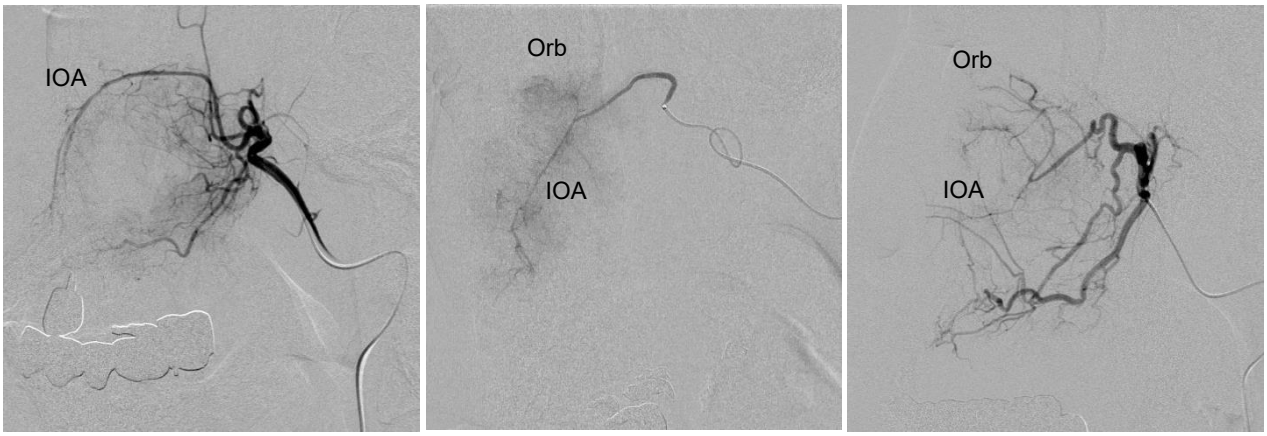

Fig. 15. Separation of the main trunk of infraorbital artery (IOA) and the anterior orbital branch (Orb). An example with no separation at all (left), a mild separation (center), and a wide separation (right). The case of separation strongly suggests the occurrence of a tumor in the upper anterior wall of the maxillary sinus.

Catheter insertion to the infraorbital artery can be performed up to its origin with 1.8F, and up to the inferior orbital fissure with 1.6F. The possibility of vasospasm increases if the catheter crosses inferior orbital fissure. In most cases, it is possible to adequately treat by catheter insertion up to the point where it ascends the posterior aspect of the maxillary tuberosity.

As treatments are repeated, the infraorbital artery may reopen after being narrowed initially due to tumor extension (Figure 17), or it may conversely become narrowed or obstructed. Accordingly, the pressure balance through the anterior buccal anastomosis with the facial artery and transverse facial artery changes significantly. It is advisable to reexamine the IA infusion CT and reset the cisplatin infusion rate according to changes in findings.

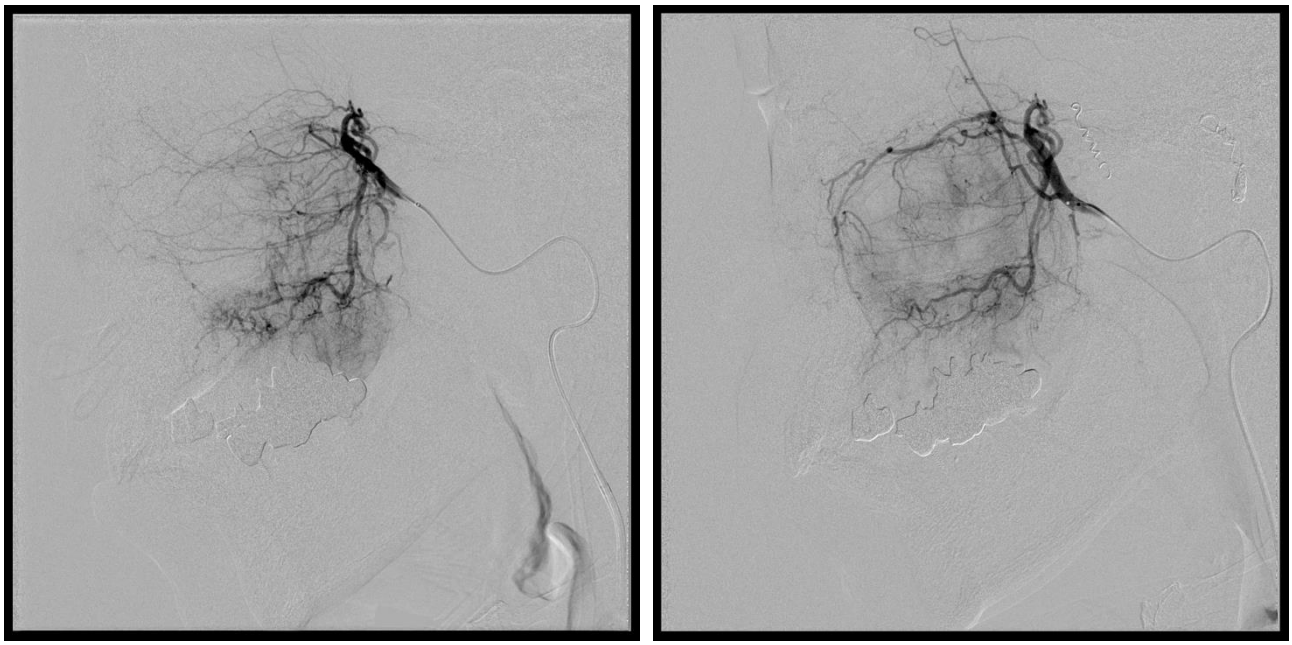

Fig. 16. Recanalization of the infraorbital artery in maxillary sinus cancer. Left: Lateral view of the third segment of the internal maxillary artery during the first course of IA infusion. Right: during the third course of IA infusion. The infraorbital artery may be reopened by shrinkage of the tumor component in the orbital floor or pterygopalatine fossa. The anterior wall of the maxillary sinus, which did not show tumor staining at first, has recovered staining. In this case, blood supply from the facial and transverse facial arteries is expected to be decreased.

Posterior Superior Alveolar Artery

It mainly runs in the bone canal (posterior alveolar canal) of the posterior wall of the maxillary sinus and is distributed in three locations including the maxillary sinus, alveolar, and buccal gingival surfaces. In the lateral view, it is difficult to identify since it overlaps with the descending palatine artery, but in the frontal view, it is easy to find since it descends in the most lateral part of the maxillary sinus. It can also be identified from other arteries by its distinct tortuosity.

The posterior superior alveolar artery generally divides from the lateral branch at the end of the 3rd segment of the internal maxillary artery together with the suborbital artery, but it is not uncommon that it originates alone slightly more proximally than these terminal branches. When this variation is present, there is a risk of excluding the posterior superior alveolar artery from the treatment range if the microcatheter is placed too far distal to the 3rd segment.

This artery is depicted as very thin in normal cases, but it is the most important feeding artery for tumors in the posterior wall of the maxillary sinus to the posterior alveolar region, and shows significant dilatation and tortuosity when involved.

Catheter insertion is relatively easy when using 1.8-2.0F, but safe distal advancement is difficult due to strong meandering. Superselective IA infusion of cisplatin from here may cause toothache. In most cases, treatment is performed from the parent artery, i.e., the 3rd segment of the IMA.

Sphenopalatine Artery

The sphenopalatine artery is one of the terminal branches of the IMA and feeds the medial and lateral walls of the nasal cavity, as well as the sphenoid sinus, ethmoid sinus, and maxillary sinus. In the lateral view, several fine vessels running parallel to the antero-posterior direction are depicted linearly, but they are often difficult to identify since they overlap with other arteries. In the anterior view, the medial and septal branches are clearly depicted. It plays an important role in tumors extending medially into the maxillary sinus, but is rarely treated superselectively, most often infused from the common trunk (medial branch) with the descending palatine artery. However, if the tumor has ethmoid sinus extension and dual perfusion with the ophthalmic artery (anterior and posterior ethmoidal artery), superselective and aggressive treatment may be necessary.

Descending Palatine Artery

The descending palatine artery is a feeding artery of the hard palate, whereas the soft palate is fed by the ascending palatine artery, a branch of the facial artery. In the lateral view, the 1st segment descending linearly in the greater palatine canal and the 2nd segment meandering anteriorly along the alveolar ridge of the hard palate are clearly identified (Note: Different from the segments of the internal maxillary artery). In the anterior view, the bifurcation with the sphenopalatine artery is easy to recognize.

This artery becomes the main feeding artery when the tumor involves the caudal side, i.e., the hard palate. For the proximal alveolus, blood supply from the alveolar artery is dominant, even if it is on the buccal side. In addition, if the tumor extends posteriorly, it seems that the 1st segment of the descending palatine artery would be involved, but in fact, the bone around this segment is thicker and rarely supplies blood to the tumor.

The descending palatine artery is also rarely treated alone; it is treated by IA infusion into the common trunk with the sphenopalatine artery.

Other branches distal to the internal maxillary artery

Anterior Deep Temporal Artery (Figure 18)

This is a feeding artery from the anterior portion of the temporalis muscle to the lateral orbital rim. This artery mainly forms a common trunk with the buccal artery, and even if they branch separately, their origins are always in proximity.

The anterior deep temporal artery originates in the 3rd segment of the IMA, i.e., on its way from the lateral to the medial pterygopalatine fossa along the maxillary tubercle. At this stage, the IMA is quite thin, and it is not uncommon for a microcatheter with an angled tip or a microcatheter to enter the anterior deep temporal artery unexpectedly when it is advanced toward the end of the IMA. The common trunk is very short and quickly divides into the straight ascending anterior deep temporal artery and the meandering descending buccal artery. Identifying this bifurcation makes it easier to follow the artery's travel.

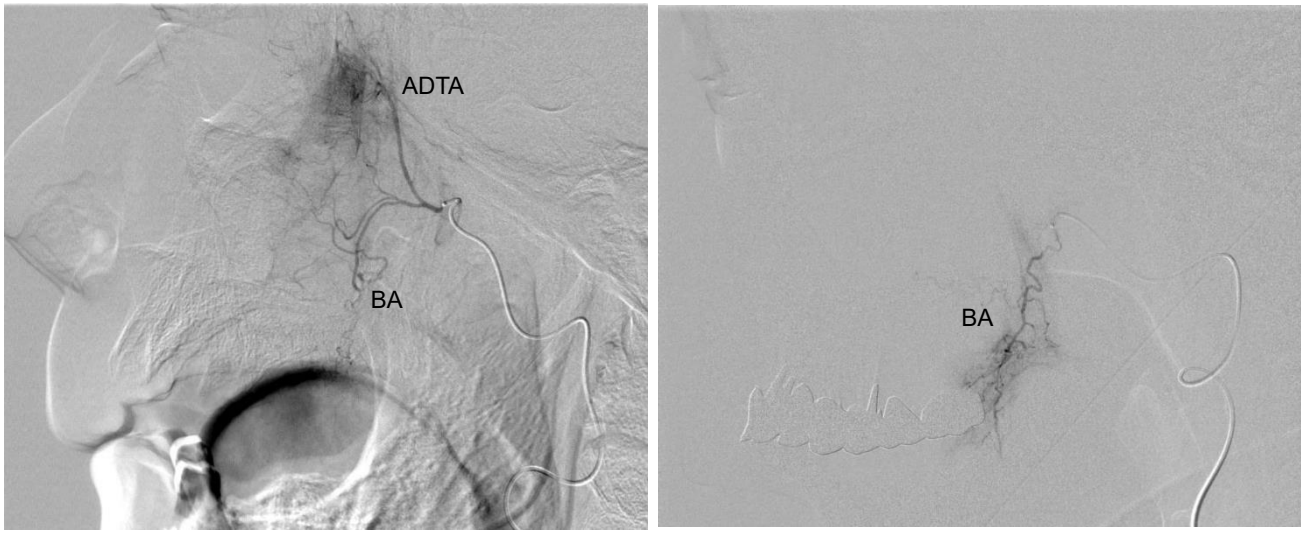

Fig. 17. Lateral view of common trunk of the anterior deep temporal artery (ADTA) and the buccal artery (BA) (left), and isolated image of the buccal artery (right). The anterior deep temporal artery shows dark staining at the lateral margin of the maxillary sinus tumor.

This artery is the first feeder when the tumor invades the temporalis muscle. It may also leave the temporalis muscle and supply blood to the tumor on the lateral margin of the maxilla through the orbit. It is not an artery that should be routinely imaged, but if a tumor with an anterior or posterior wall extension has a component that is not deeply stained by IA infusion CT from either the 3rd segment of the IMA or the transverse facial artery, its involvement should be considered first. Due to the distribution, it is better to perform global injection from the common trunk with the buccal artery prior to selective angiography .

The anterior deep temporal artery sometimes has branches in the orbit and anastomoses with the ophthalmic artery via multiple pathways, including the lacrimal gland branch. If this pathway is identified, superselective treatment should be avoided or be combined with blood flow modification with coils.

Catheter insertion to the common trunk is easy and can often be performed even with a microcatheter ahead of time.

Buccal Artery (Figure 18 and 19)

This artery feeds the superficial lobe of the buccinator and the skin overlying it, the molar gland and parotid ducts, and the buccal fat pad. As mentioned above, it often forms a common trunk with the anterior deep temporal artery.

This artery is also not routinely imaged, but is a branch that must be examined if the tumor is extending posteriorly to the retromolar area. The buccal artery is also involved when the tumor extends posteriorly through the posterior wall of the maxillary sinus. In this case, instead

of a superselective IA infusion, IA infusion is often performed from the distal part of the 2nd segment of the IMA so that the artery is included in the perfusion area.

In most cases, the main trunk of the buccal artery runs straight down between the posterior wall of the maxillary sinus and the mandibular branch, but it often turns around and ascends in the middle to give off a branch that runs along with the anterior deep temporal artery (Figure 19). Note that this branch may feed the lateral margin of the orbit. When there is lateral orbital invasion of maxillary sinus carcinoma, if blood supply from the anterior deep temporal artery or the frontal branch of the shallow temporal artery is excluded, involvement of the buccal artery should be suspected. However, since the anterior deep temporal artery and the buccal artery are relatively thin branches, treatment from the common trunk (or from the IMA immediately before it) is often sufficient without selecting individual branches.

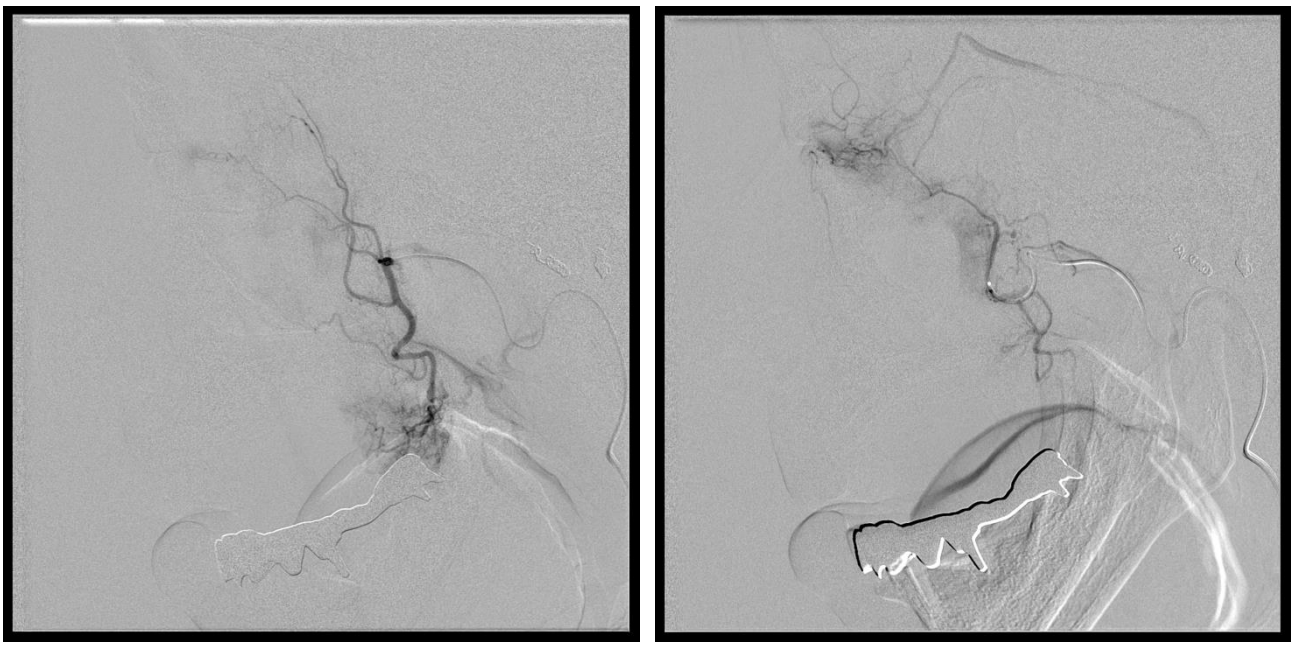

Fig.18. Right: lateral view of buccal artery. Left: lateral view of selective angiography of recurrent branch of the buccal artery, ADTA: anterior deep temporal artery, BA: buccal artery, Rec: recurrent branch. Apart from the main trunk of the buccal artery, which feeds the retromolar region, there is a branch that runs recurrently ascending to the infraorbital region.

Pterygoid Branch (Figure 20)

Djindjan & Merland refer to this as the lateral pterygoid branch. It originates caudally in the 2nd segment of the IMA, meandering and supplying abundant blood to the pterygoid muscles. Since there is a constant blood supply not only to the pterygoid muscles anteriorly (the accessory meningeal artery feeds it posteriorly) but also to the retromolar area, imaging should be performed if there is tumor extension to the area.

Fig 19. Left: contrast angiography from the distal part of the 2nd segment of the internal maxillary artery (IMA). Right: selective contrast of pterygoid branch (Pter). Dark staining is seen in the retromolar region.

Middle Meningeal Artery (Figure 21)

The middle meningeal artery (MMA) itself is rarely involved in maxillary sinus carcinoma (if it is, it is when it has intracranial extension). In the field of IA chemotherapy, this artery is often the target of catheter insertion as the parent artery of the accessory meningeal artery. Incidentally, both arteries can form a common trunk in most Japanese people.

The MMA is not difficult to identify since it has a characteristic course in both frontal and lateral views, starting linearly from the 1st segment of the IMA, entering the cranium through the foramen spinosum, and turning at a sharp angle. In the lateral view, it appears as if it starts straight and obliquely upward, and seems to be easy to approach. However, this artery originates radially medial to the axis of rotation at the area where the IMA transitions from the 1st segment to the 2nd segment and runs around the pterygoid muscle, rotating in a spiral fashion. Therefore, the MMA should be approached in the frontal view.

This artery is known to have a developed recurrent branch that enters the orbit and often completely replaces the ophthalmic artery. A choroidal crescent should be confirmed during angiography. Although very rare, it may originate from the shallow temporal artery (Figure 25).

Accessory Meningeal Artery

The accessory meningeal arteries are small arteries that constantly feed the pharynx and Eustachian tube, and in some cases, the meninges. In most Japanese people, it forms a common trunk with the middle meningeal artery. Although it is a thin branch that 1.8F catheter can barely fit into, if the approach to the MMA is successful in the frontal view, it often follows the path of the MMA into the accessory meningeal artery.

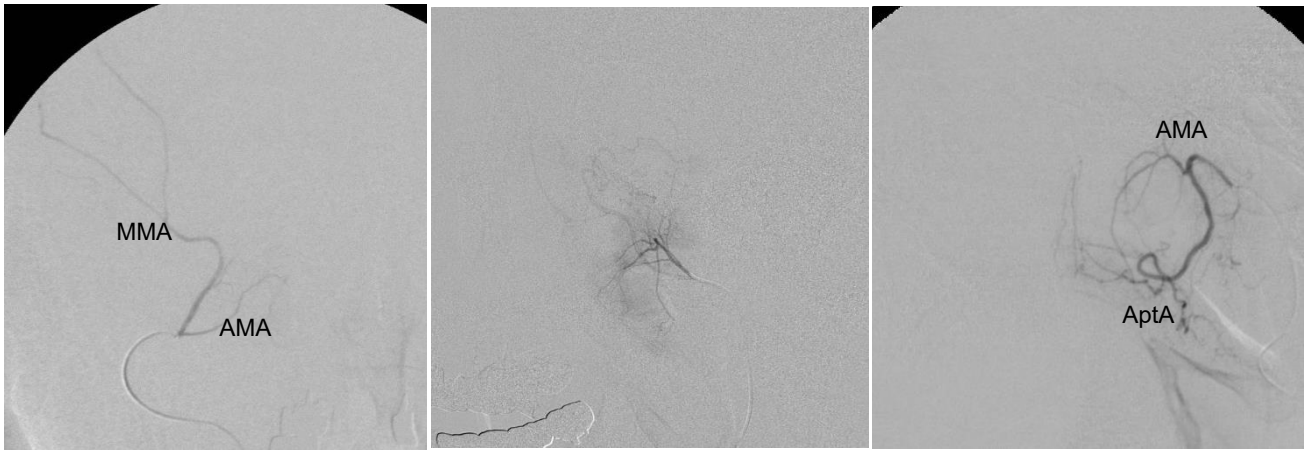

Fig. 20. Left: frontal view of the middle meningeal artery (MMA), Middle: lateral view of accessory meningeal artery (AMA), Right: lateral view of the ascending palatine artery (AptA) originating from AMA.

This artery first runs anteriorly toward the lateral plate of the pterygoid process, where it divides into two branches. The anterior branch runs along the Eustachian tube and terminates in the pharynx, feeding the mucosa of the area, the lateral pterygoid muscle, and the tensor veli palatini muscle. The posterior branch is the meningeal branch, which runs posteriorly upward through the foramen ovale and anterior to the mandibular nerve. It feeds the lateral wall of the cavernous sinus, the trigeminal ganglion area, and the anterior superior surface of the pyramidal bone.

Clinically, the accessory meningeal artery is important as it feeds the lateral pterygoid muscle from behind, and becomes a target for examination and treatment when the pterygoid muscle is affected by a posterior extension of a maxillary sinus tumor. If the approach is difficult, coil embolization of the distal portion of the MMA can be done from the beginning (Embolize the MMA by deploying three or four 2/2 mm platinum coils in a proximal direction from just below the foramen spinosum). Superselective IA infusion of cisplatin from either the accessory or MMA may cause complaints of pain deep in the ear. Therefore, a slow infusion (0.1 mL/sec) is recommended. There have been very few reports of trigeminal neuropathy occurring after treatment from this artery.

Rarely, an anterior branch of the accessory meningeal artery may develop and replace the ascending palatine artery. If the ascending palatine artery does not originate from the facial artery, ascending pharyngeal artery, or external carotid artery when the involvement of the ascending palatine artery is strongly suspected due to the posterior extension of the tumor and soft palate involvement, a search for the accessory meningeal artery should be performed. Needless to say, this is a variation that should be identified in the preoperative 3D-CTA.

Middle Deep Temporal Artery (Figure 22)

The middle deep temporal artery is the largest of the three arteries that feed the temporalis muscle, and is easy to identify since it originates obliquely upward in the 2nd segment of the internal maxillary artery and runs in a straight line. When advancing a microcatheter or microguidewire into the distal IMA, if the tip is pointing upward, it is more likely to enter the middle deep temporal artery than the main trunk. A blind procedure in the area should be avoided. In cases of posterior extension of tumors in the maxillary sinus, cisplatin IA infusion is often performed by placing a microcatheter just after the point where the distal part of 2nd

segment of the IMA, i.e., the middle deep temporal artery, arises. It is important to check the catheter carefully because the injection pressure may cause kickback of the catheter into the middle deep temporal artery.

There are not many cases in which the temporalis muscle is so posteriorly involved by a tumor that the main trunk of the middle deep temporal artery becomes the feeding artery. However, a branch that passes through the deep lobe of the temporalis muscle often arises at a site across the inferior temporal crest, which sometimes shows good development and reaches the lateral margin of the anterior maxillary sinus tumor. This branch is difficult to detect on preoperative 3D-CTA since it follows the medial aspect of the zygomatic arch. It is better to investigate possible involvement based on DSA findings and confirm the anatomy with a postoperative IA infusion CTA review.

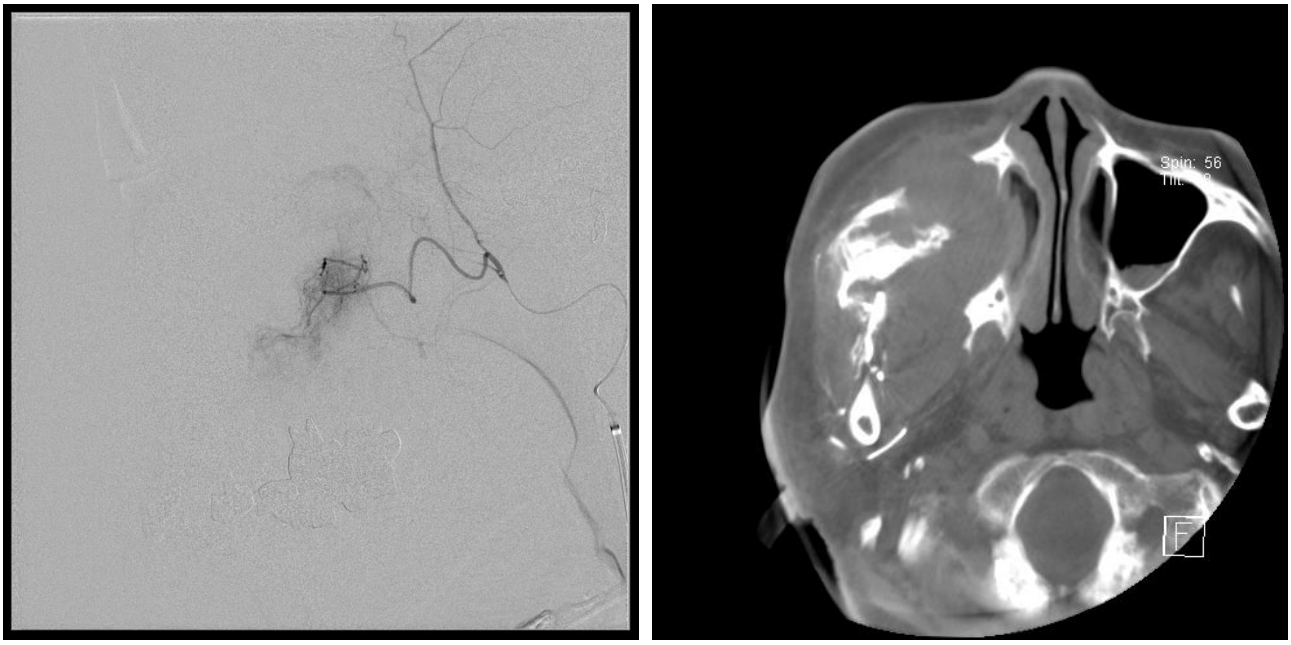

Fig. 21. Left: lateral view of the middle deep temporal artery. Right: IA infusion CT from the middle deep temporal artery. The middle deep temporal artery feeds mainly on the central part of the temporalis muscle, but in rare cases, it also has a branch that runs anteriorly on the back of the zygomatic arch and feeds the maxillary sinus tumor.

Transverse Facial Artery

The transverse facial artery (TFA) is the first branch of the superficial temporal artery (STA), which is the last branch of the external carotid artery. It branches before the STA leaves the parotid gland and meanders gently anteriorly along the zygomatic arch. It has various anastomoses with the facial and buccal arteries and widely feeds the lateral part of the superior half of the face.

This artery feeds the lateral surface of the maxillary sinus tumor as it develops from anterior to posterolateral. If the infraorbital artery is obstructed, it may be retrogradely contrasted by anastomosis and perfused broadly to the anterior component of the maxillary sinus tumor. It is an artery that should never be skipped for IA infusion CT unless the tumor is clearly medially distributed, and it is often the second most common artery to be examined after the internal maxillary artery.

The TFA is most prone to vasospasm (as with the lingual artery). This artery appears to run straight anteriorly in the lateral view, but its origin is laterally protruding (as shown in the frontal view), and it can sometimes it originates slightly posteriorly on the lateral side and then runs a steep angle anteriorly (Figure 22). The approach to this origin is very challenging in some cases. It is advisable to avoid blind manipulation and to take full advantage of the roadmap of the frontal view and the reverse oblique position (imaging with a single-plane device, which is very useful).

The facial artery and TFA have a reciprocal relationship; if the facial artery is hypoplastic, the TFA may develop (Figure. 23); conversely, if the TFA is very thin, the facial artery (especially the buccal branch) may feed widely on the superior lateral face. Therefore, in the treatment of maxillary sinus cancer, it is important to first confirm this developmental balance and determine whether IA infusion should be performed from both the facial and transverse facial arteries or from only one of them.

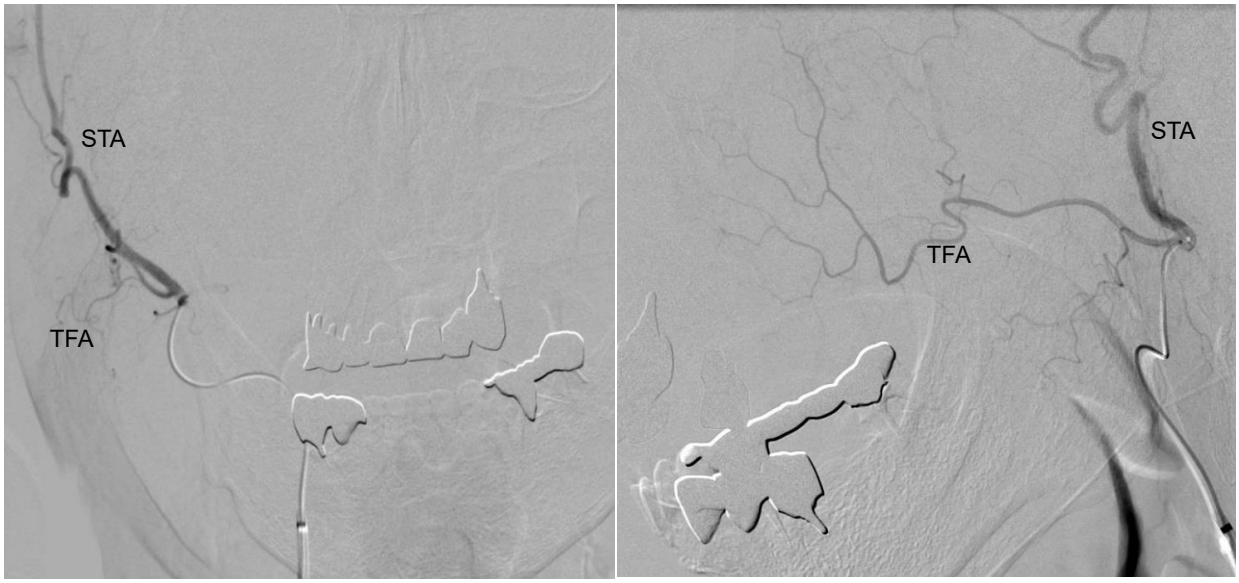

Fig. 22. The left transverse facial artery (TFA), frontal (left) and lateral (right) views. It branches from almost the origin of the superficial temporal artery (STA). The main direction of travel is from posterior to anterior, but only at the origin it branches laterally, while the tip of the microcatheter is pointing posteriorly. This is a relatively typical image of the transverse facial artery.

Coil Embolization of the Superficial Temporal Artery

If selective catheter insertion into the TFA is difficult, or if the microcatheter is expected to cause vasospasm when advanced distally and much of the cisplatin is expected to backflow into the STA when kept proximally, it is recommended to coil embolize the STA in advance.

The coil should be placed neither too high nor too low. After embolization of the STA, the microcatheter must be guided as far as the proximal part to the origin of the TFA for the second and subsequent IA infusions. In cases where it is extremely difficult to insert the microguidewire into the TFA, the catheter can be brought up to the TFA by advancing the wire toward the STA (an easier insertion). If the STA is embolized just above the TFA, the wire has nowhere to go and the catheter cannot enter the STA, let alone the TFA. Therefore, it is preferable to place the coil distally with some extra margin rather than directly above the origin of the transverse facial artery.

Fig. 23. The facial artery (left) and transverse facial artery (right) are complementary. In this case, the angular ophthalmic artery, a terminal branch of the facial artery, was hypoplastic, and the well-developed transverse facial artery complemented the area.

Conversely, the STA runs in a relatively shallow layer after it turns laterally in the frontal view and then close to the pterion, so if embolization is performed too distally, the patient may feel the coil subcutaneously. Specifically, in frontal fluoroscopy, the STA runs obliquely upward passing the head of the mandible (temporomandibular joint), and in many cases it emerges in the superficial layer in an S-shaped meander at the level of the skull base (about the same level as the foramen spinosum, the sharp bend of the middle meningeal artery). The site just below this point is suitable for embolization. The coil size should be about 2/2 to 2/4. Note that the STA varies in size depending on the case, so there is a risk of migration if a coil with the smallest diameter is used. Occasionally, the frontal branch of the superficial temporal artery may extend a feeding branch to the lateral orbital extension of the maxillary sinus cancer. In this case, blood flow modification is not indicated (Embolization of all branches of the STA other than the feeding branch is a possibility, but the technique is quite challenging). Although extremely rare, there is a variation in which the middle meningeal artery originates as the first branch of the superficial temporal artery, rather than as a branch of the internal maxillary artery (Figure 24). In this case, if cisplatin is infused under

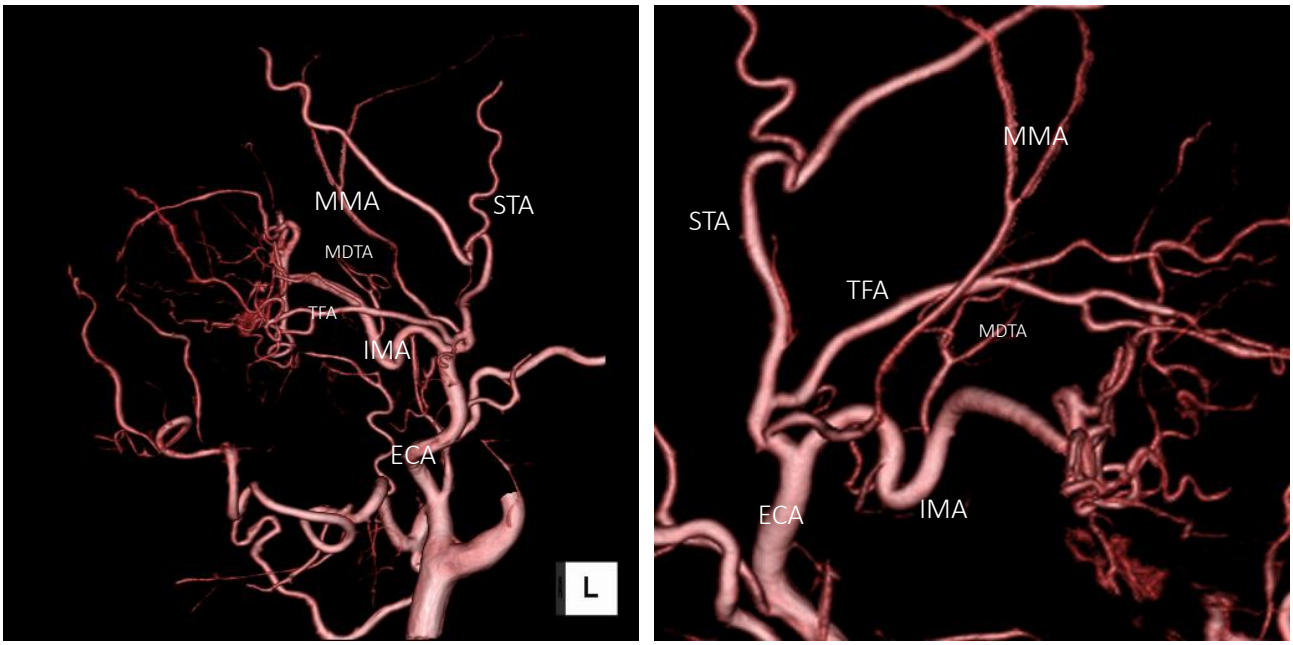

Fig. 24. The middle meningeal artery originates from the superficial temporal artery. Left: External carotid artery, lateral view. Right: External carotid artery, medial view. ECA: external carotid artery STA: superficial temporal artery MMA: middle meningeal artery TFA: transverse facial artery IMA: internal maxillary artery MDTA: middle deep temporal artery
The middle meningeal artery originates as the first branch of the superficial temporal artery, not as a branch of the internal maxillary artery. The transverse facial artery branches immediately after it.

embolization of the distal portion of the STA, some amount of the drug may also flow into the MMA. Although it is a nonselective infusion and is unlikely to cause problems in most cases, it may cause serious complications (blindness) in patients with a variation in which the ophthalmic artery originates from the MMA. Furthermore, if the proximal portion of the STA develops a vasospasm and the infusion becomes an overpressure, the drug may flow into the tympanic branch of the middle meningeal artery that feeds the geniculate ganglion, causing facial nerve palsy. In the presence of this variation, it may be safe to coil embolize the MMA in advance (Unless there is a blood supply from the MMA due to the tumor extension to the middle cranial fossa).

Facial Artery

The facial artery is embryologically formed by fusion of multiple functional arteries, and as a result, anatomical variations occur very frequently. It is important to follow the course of the run, focusing on where each branch ultimately reaches and what it feeds, rather than on the textbook order of branching.

In the lateral view, it overlaps with the lingual artery, making it difficult to follow the course of the artery if one is not accustomed to it. It is better to first understand that in the frontal view the lingual artery shows a run that starts mainly from the medial side and approaches the median line, while the facial artery runs toward the lateral side.

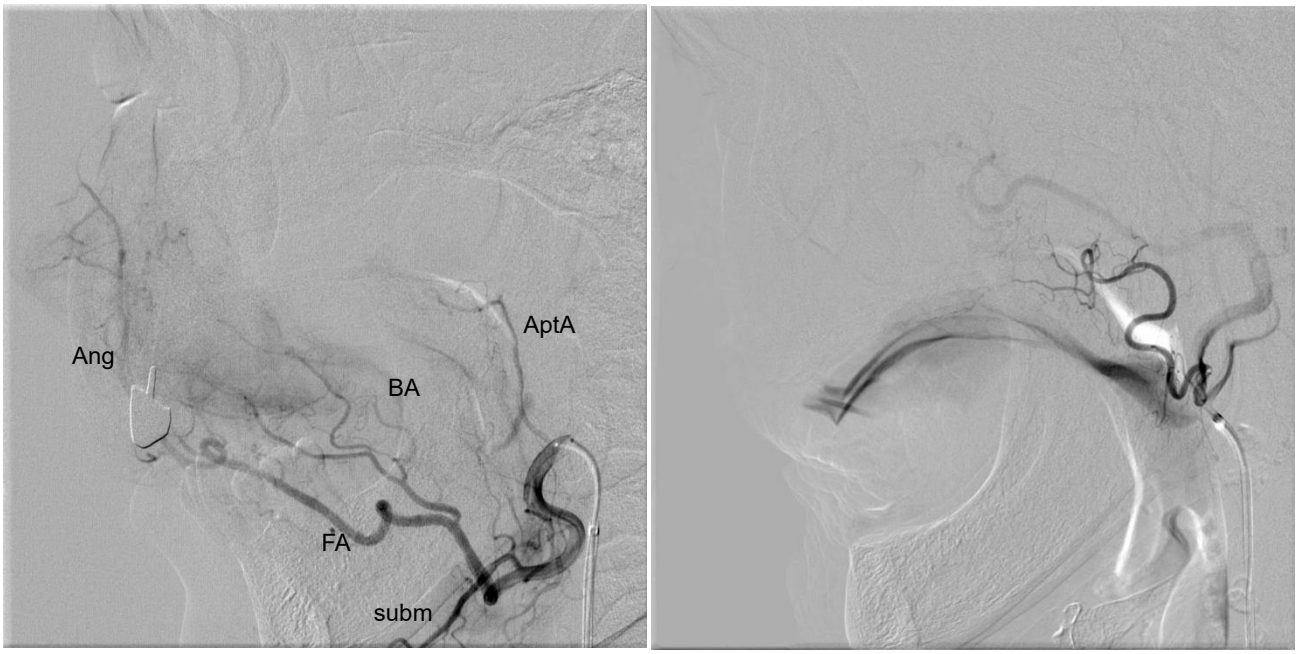

Fig. 25. Lateral views of facial artery (left) and ascending palatine artery (right). FA: facial artery, AptA: ascending palatine artery, subm: submental artery, BA: buccal artery, Ang: angular artery
In addition to the ascending palatine artery, the tonsillar and glandular branches also originate from the most proximal part of the facial artery, and they often form a common trunk with each other.

This artery is routinely imaged along with the internal maxillary artery and transverse facial artery for IA infusion to maxillary sinus cancer since it is involved in maxillary sinus cancer through various pathways via its branches. The angular artery, the terminal branch, supplies blood to the anterior wall component of the tumor, the superior labial branch to the anterior alveolar region, the buccal branch to the posterior wall and posterior molar region, and the ascending palatine artery to the soft palate. It also functions as the main feeding artery for the submandibular lymph nodes. This is the artery that requires the most accurate judgment as to the level at which to place a microcatheter for IA transfusion.

The facial artery has a common trunk with the lingual artery in 20% of cases and a high origin in 10-15% of cases (Figure 26). The latter originates inferiorly at the point where the

ascending external carotid artery trunk turns laterally. The external carotid artery in this area is much larger than the width of the curve of the microguidewire tip, so it is sometimes impossible to secure the microguidewire even at the origin of the facial artery. It is advisable to reshape the tip into a large curve or raise the guiding catheter to the closest point (at the risk of vasospasm).

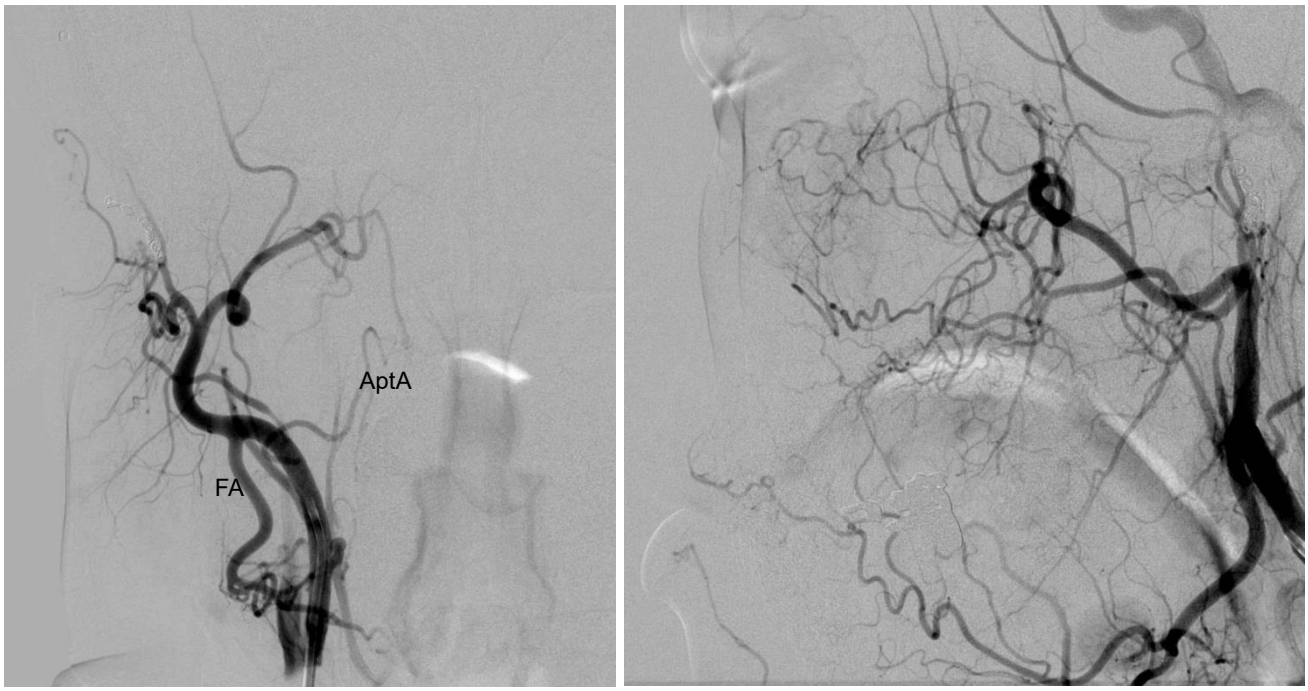

Fig. 26. High origin of the facial artery. The facial artery often originates inferiorly from the main trunk of the external carotid artery as it gradually turns laterally. Referring to the frontal view (left), the diameter of the mother vessel (external carotid artery) and the starting angle of the facial artery should be carefully observed before procedures. Note that the ascending palatine artery (AptA) originates independently from the site where the facial artery should have originated.

Ascending Palatine Artery (Figure 25)

The ascending palatine artery is usually the first branch of the facial artery and feeds the soft palate, velum, uvula, and the posterior margin of the hard palate on the same side. IA infusion CT imaging is easy to understand since it neatly contrasts only half of the uvula.

In the lateral view, it originates at or just past the top of the first upward curve of the facial artery and meanders as it ascends, creating a dark stain in the capillary phase that matches the shape of the soft palate. It may be possible to identify it in the frontal view if one has the experience.

This artery is not often the target of treatment in IA infusion for maxillary sinus cancer. It is only when the soft tissues near the soft palate are involved with the tumor's posterior descending extension, or when the descending palatine artery (which is a complementary artery) is involved and has reduced blood flow, that the artery becomes a target.

However, once involvement is suspected, some knowledge and skill are required to examine this artery. The ascending palatine artery has a number of variations, including independent origin from the external carotid artery, common trunk formation with the ascending pharyngeal artery, common trunk formation with the accessory meningeal artery,

and duplicated origin with these and the facial artery. Especially when the facial artery has a high origin, the ascending palatine artery originates independently from the external carotid artery at the height where the facial artery usually originates. The first three major branches originating from the proximal portion of the facial artery, namely the ascending palatine artery, the tonsillar branch, and the glandular branches, also often form a common trunk. Among them, a common trunk formation with the ascending palatine artery and tonsillar branch is common.

It is nearly impossible to read these variations only by intraoperative DSA (Digital subtraction angiography), and it is essential to understand the anatomy using preoperative 3D-CTA. This requires initial preoperative evaluation with contrast-enhanced CT or MRI to assess tumor extension into the perfusion area of the artery.

Even if the vascular anatomy can be accurately identified, the ascending palatine artery is often difficult to approach as it is thin and often makes a sharp turn immediately after its origin. In this case, coil embolization of the more distal facial artery can achieve the same effects as superselective IA infusion, even if IA infusion is performed from the main trunk of the facial artery (a relatively large diameter coil (specifically, 4-7 mm) must be used, otherwise it will migrate easily). In the case of common trunk formation with the ascending pharyngeal artery, the neuromeningeal branch must be coil embolized (the branch is so thin that even a 2-2 mm coil will not coil, but will stop blood flow).

Manual compression of the area where the facial artery intersects the mandible (facial artery notch, or antegonial notch instead of coil embolization can achieve the same results as the blood flow alteration technique. The disadvantages are that complete occlusion requires some practice and that it is difficult to perform IA infusion CT at the same time, but it is a technique that should be kept in mind for its simplicity.

Submental Artery

The submental artery feeds the muscles and skin of the mandible, and sends several branches to the submandibular lymph nodes. It also functions as a collateral circulation via the sublingual artery when the proximal portion of the facial artery is occluded (submental-sublingual anastomosis).

The facial artery forms an upward convex loop immediately after its origin, then runs laterally producing branches such as the ascending palatine artery, tonsillar branch, and glandular branches, and then meanders downward to the inferior border of the mandible.

The main trunk of the facial artery emerges to the surface of the mandible, and the submental artery enters behind the mandible. Accordingly, it is effective to assess the

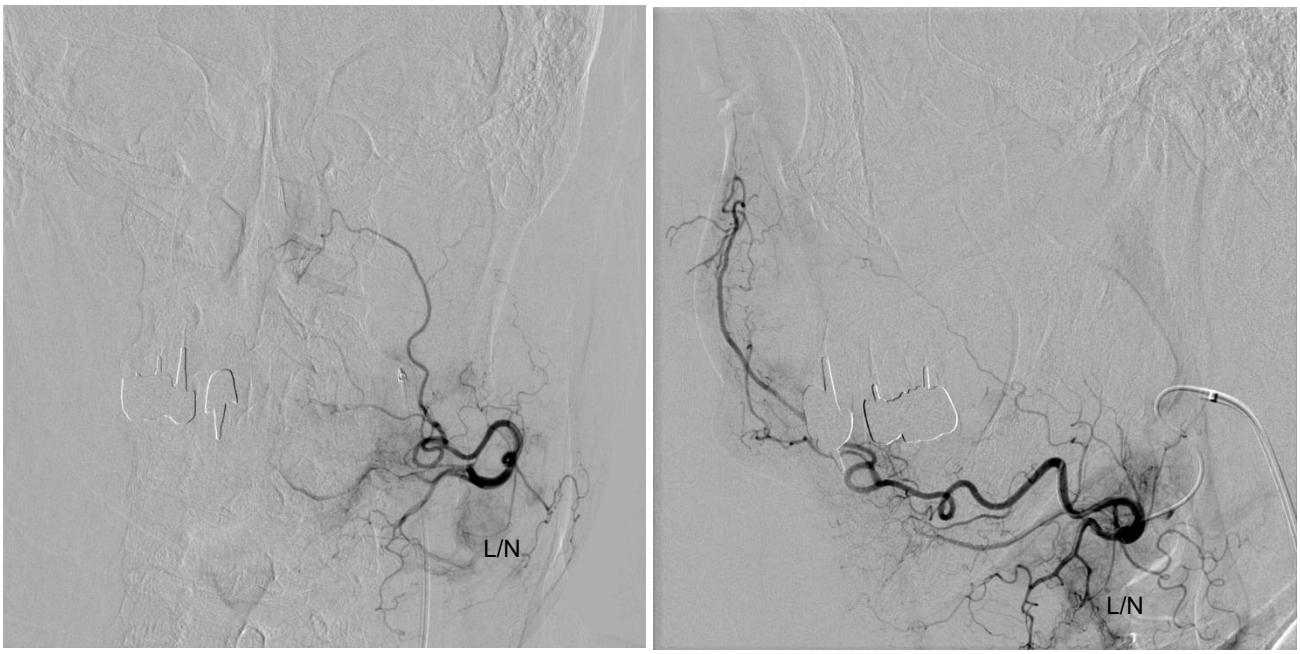

Fig. 27. Frontal (left) and lateral (right) views of the left facial artery. Feeding arteries to the submandibular lymph node are shown. The main feeding artery in this region is often considered to be the submental artery. However, it is not uncommon for a branch separating from the main trunk of the facial artery, which passes over the mandibular notch and extends to the surface of the mandible, to once again run around the submandibular area to supply blood to the lymph node.

bifurcation of the two by the frontal image.

This artery feeds the metastatic lymph nodes in the submandibular region, but is rarely the target of superselective IA infusion. This is because the main trunk of the facial artery also has multiple feeding branches for lymph nodes, and it is more efficient to infuse from a more proximal location (Fig. 28).

Buccal Branch

It is sometimes referred to as the buccal artery, the same name as a branch of the maxillary artery. It is an artery that feeds the deep region along the mandible and the mandibular branch, and nearby muscles and mucous membranes.

In the lateral view, the facial artery originates obliquely upward on the surface of the zygomatic body, meanders upward, and finally anastomoses with the buccal artery derived from the maxillary artery. Although it is an artery that cannot be missed in DSA images taken from the origin of the facial artery, it often falls out of the imaging range if the microcatheter is advanced too far to show the proximal origin.

This artery becomes a subject of close examination when the tumor extends to the retromolar area. If the tumor is entirely circumferential, it may be best to treat it from the main trunk of the facial artery. However, if the tumor extends only posteriorly or to the retromolar, and not anteriorly or laterally, the angular ophthalmic artery does not contribute to the tumor; and if IA infusion is performed from the main trunk of the facial artery with the expectation of a therapeutic effect on the buccal branch area, most of the anticancer drug

will flow into the unrelated periphery of main trunk. In this case, superselective IA infusion via the buccal branch is required.

When approaching the buccal branch, it should be noted that the facial artery leading to the site is tortuous. The microcatheter deflection in this tortuous area is large, making it very difficult to follow the microguidewire. The insertion of an over-the-wire catheter will not be successful unless a microguidewire is placed to the periphery of the buccal branch, even at the risk of vasospasm. If superselective IA infusion from this branch is required, the 3F system should not be used because of the lack of backup force.

Angular Artery

The angular artery of the eye is the terminal branch of the facial artery and feeds the anterior cheek, nose, and lips (Fig. 28?). It has abundant anastomoses with the ophthalmic artery, infraorbital artery, transverse facial artery, and superficial temporal artery around the infraorbital margin and inner canthus. It is a terminal branch and is rarely difficult to identify on DSA images.

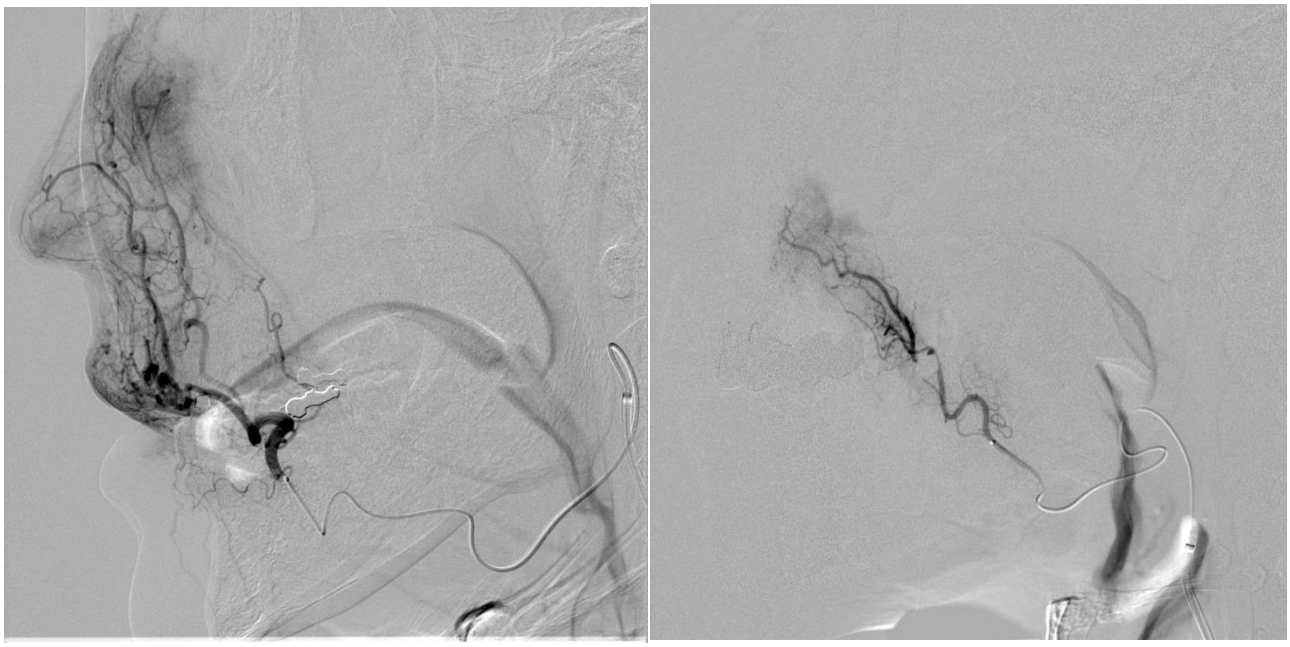

Fig. 28. The microcatheter was advanced to the angular artery, a terminal branch of the facial artery (left). While the treatment intensity for anterior buccal lesions is increased, the buccal branch area is out of the treatment range. The buccal branch (right) is often difficult to find since it originates in a relatively proximal part of the facial artery. It perfuses not only the buccal mucosa but also the retromolar region, and plays a crucial role in posterior wall invasion of maxillary sinus cancer.

This artery is a strong feeder of the protruding component of the anterior wall of the maxillary sinus from the inferior surface (while the infraorbital artery feeds from the superior surface, and the transverse facial artery feeds from the lateral surface). Unlike the maxillary and transverse facial arteries, where relatively selective IA infusion to the tumor is possible, if an IA infusion is performed from the proximal part of the facial artery, a large amount of the anticancer drug may flow into the various lateral branches and may not reach the angular artery adequately. However, relying solely on superselective IA infusion from the angular

artery is not the best treatment strategy as it means losing the treatment effect of on the alveolar region via the labial branches and on the retromolar region via the buccal branch.

Even when the angular artery is the main target of treatment, it is advisable to consider the involvement of the buccal and labial branches and to perform IA infusion just above the facial artery notch (just before the buccal branch originates), or to perform a distal-proximal two-stage IA infusion. If submandibular node metastasis is detected, the infusion should be started just before the bifurcation of the submental artery, which is a more proximal site. Even when considering treatment from the distal part of the angular artery, it is appropriate to place the microcatheter just before the origin of the superior labial branch, as it often feeds the tumor component of the anterior margin of the nasal cavity, as well as of the anterior superior alveolar region. The labial branches also have rich anastomoses with the contralateral side, as it has another name, coronal labial artery, and may feed the nasal region bilaterally from one side (Fig. 30?).

Although rare, the contralateral angular artery may feed the medial superior part of the anterior wall of the angular region on the affected side (so-called "go over a mountain"). Anastomosis of the external carotid artery system is generally ipsilateral dominant, but contralateral involvement is a possible exception in this region. It is worth considering examination of the contralateral angular artery if the feeder cannot be identified. In such cases, selective catheter insertion is desirable to some extent, since contrast from the main trunk of the facial artery may not be sufficient to determine the presence or absence of involvement due to lack of perfusion pressure in the periphery.

The dental crown often interferes with fluoroscopy when approaching this branch. In the frontal and lateral views, the technique is completely blinded from the anterior and posterior side of inferior labial artery. By having the patient hold a rolled gauze in the lightly opened

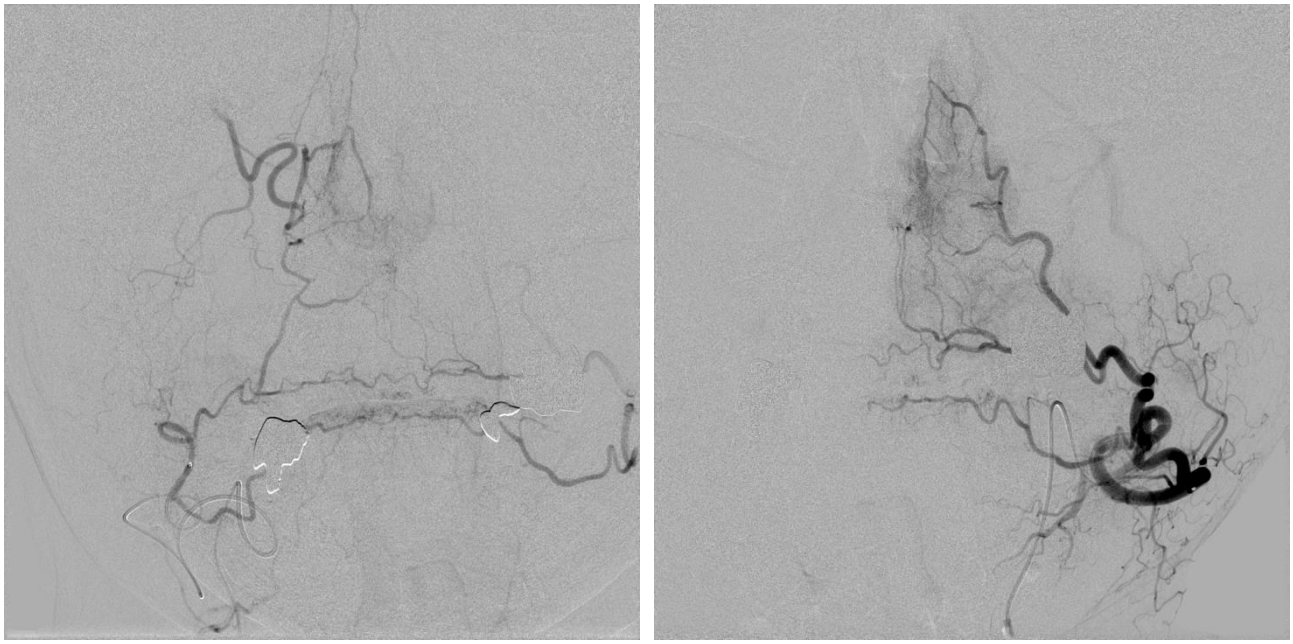

Fig. 29. The labial branch of the facial artery. Left: Frontal view of the right facial artery. When contrast agent is injected through the catheter that was advanced to tThe right inferior labial branch, is contrasted via anastomosis with the left inferior labial branch, and also the segment from the left facial artery to the left angular artery are shown in the contrast image. Right: Frontal view of the left facial artery. The angular artery is providing feeding branches to the nasal component of the tumor, and the superior labial branch is also seen to be extending multiple feeders into the nasal cavity.

mouth in an oblique position, the hidden pathway can be found. The proximal portion of the angular artery is easily displaced from the dental crown when the C-arm is just barely in contact with the abdomen in the inverted Towne position and moved to a mildly inverted oblique position.