REVIEW ARTICLE

ANATOMICAL LOCATION OF TMJ, WITH SPECIAL REFERENCE TO TEMPOROMANDIBULAR JOINT SURGERY- REVIEW OF LITERATURE

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ABSTRACT

The temporomandibular joint (TMJ) is composed of the temporal bone and the mandible, as well as a specialized dense fibrous structure, the articular disk, several ligaments, and numerous associated muscles. Anatomically the TMJ is a diarthrodial joint, which is a discontinuous articulation of two bones permitting freedom of movement that is dictated by associated muscles and limited by ligaments. As part of the stomatognathic system, the TMJ allows simple and complex movements such as free movement during phonation, swallowing, and breathing, as well as different types of load-bearing movements during incision and chewing.The innervation of the TMJ has been studied extensively and includes the auriculotemporal, masseteric, and deep posterior temporal nerves. Of these, the auriculotemporal nerve, because of its course, is at the greatest risk for irritation or entrapment.

The knowledge of the course and anatomical relation of facial nerve and its temporal branches is fundamental for successful temporomandibular joint (TMJ) surgery since these branches are susceptible to damage during this procedure. The risk of lesioning the facial nerve in this type of incision is approximately 5%. The proximal portion of the maxillary artery and the masseteric artery is in close relation with the subcondylar region of the mandible. The maxillary artery has a variable course which can be further distorted by the fibrotic changes or ossification process in the TMJ region in temporomandibular joint ankylosis. In this review article we have tried to discuss the surgical anatomy for a successful TMJ surgery.

KEY WORDS

ginglymoarthrodial, anterior and posterior deep temporal artery

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INTRODUCTION

The mandible and cranium make up the craniomandibular articulation, which frequently is referred to as the temporomandibular articulation. This articulation of the mandible consists of two synovial joints: left- and right-sided TMJs. The bony components include the mandibular condyles below and the squamous temporal bones above . The articular space of each TMJ is divided into upper and lower compartments because of the interposition of the fibrous articular disc between the temporal bone and the mandible. Gliding or translatory movements occur primarily in the superior compartment, while the inferior compartment functions primarily as a hinge or rotary joint[2].

The articular portion of the temporal bone is composed of three parts. The largest is the articular or mandibular fossa, a concave structure extending from the posterior slope of the articular eminence to the postglenoid process, which is a ridge between the fossa and the external acoustic meatus. The second portion, the articular eminence, is a transverse bony prominence that is continuous across the articular surface mediolaterally. The third portion of the articular surface of the temporal bone is the preglenoid plane, a flattened area anterior to the eminence. The mandible is a U-shaped bone that articulates with the temporal bone by means of the articular surface of its condyles, paired structures forming an approximately 145° to 160° angle to each other. The mandibular condyle is approximately 15 to 20 mm in width and 8 to 10 mm in anteroposterior dimension. The condyle tends to be rounded mediolaterally and convex anteroposteriorly.

On its medial aspect just below its articular surface is a prominent depression, the pterygoid fovea, which is the site of attachments of the lateral pterygoid muscle[7].

Access to the temporomandibular joint is indispensible for surgical success. The main potential anatomic problems in temporomandibular joint surgery are the facial nerve and the terminal branches of the external carotid artery[8].

It has also close proximity to the auriculotemporal nerve also. Several approaches to the TMJ have been proposed and used clinically[9].

Surgical visibility of the jaw joint and malar arch is often compromised by efforts to protect the facial nerve and its branches[10] .

Different approaches for temporomandibular joint

The various approaches are listed,

(1) Pre-auricular (Risdon, 1934; Blair & Ivy, 1936; quoted by Bellinger, 1940; Milch, 1938; McCann, 1965; Rowe & Killey, 1968; Giles, 1969; Thoma, 1969; Rowe, 1972).

(2) Submandibular (Risdon, 1934; Sleeper, 1952; Ward, 1961).

(3) Post-auricular (Bockenheimer, 1920; Axhausen, 1931 ; Alexander, 1975).

(4) Closed condylotomy (Ward, 1961).

(5) Endaural (Rongetti, 1954; Davidson, 1956; Hosxe, 1972).

(6) Intra-oral (Keen, 1909; Silverman, 1925; Wielage, 1928; Lewis, 1953; Dingman

& Natvig, 1964; Sear, 1972; Quinn, 1977).

(7) Horizontal incision along the lower border of the malar arch (Balyeat, 1933; Dingman & Harding, 1951 ; Riessner, 1952; Hueston, 1959).

(8) Temporal (Gillies et al., 1927).

(9) Through soft tissue laceration or scars (Gillies et al., 1927; Bingham, 1955; Rowe & Killey, 1968).

Ideally, the selected approach should accomplish the following [8]:

- Maximize exposure for the specific procedure
- Avoid damage to the branches of the facial nerve
- Avoid damage to major vessels (e.g., internal maxillary artery, retromandibular vein)
- Avoid damage to the parotid gland
- Maximize use of natural skin creases for cosmetic wound closure.

Perhaps the most satisfactory and most commonly used method is the combination of a pre-auricular and endaural approach described by Rowe & Killey, (1968) and Rowe, (1972)[10].

Surgical Anatomy

Layers of the Temporoparietal Region

The temporoparietal fascia is the most superficial fascial layer beneath the subcutaneous fat. This fascia is the lateral extension of the galea and is continuous with the superficial musculoaponeurotic system (SMAS) layer. It is frequently called the superficial temporal fascia or the suprazygomatic SMAS. The blood vessels of the scalp, such as the superficial temporal vessels, run along its superficial aspect close to the subcutaneous fat. On the other hand, the motor nerves, such as the temporal branch of the facial nerve, run on the deep surface of the temporoparietal fascia. The subgaleal fascia in the temporoparietal region is well developed and it is generally used only as a cleavage plane in the standard preauricular approach The temporalis fascia is the fascia of the temporalis muscle. This thick fascia rises from the superior temporal line and fuses with the pericranium. The temporalis muscle rises from the deep surface of the temporal fascia and the whole of the temporal fossa. Inferiorly, at the level of the superior orbital rim, the temporal fascia splits into the superficial layer attaching to the lateral border, and the deep layer attaching to the medial border of the zygomatic arch. A small quantity of fat between the two layers is sometimes called the superficial temporal fat pad. A large vein frequently runs just deep to the superficial layer of temporalis fascia[11].

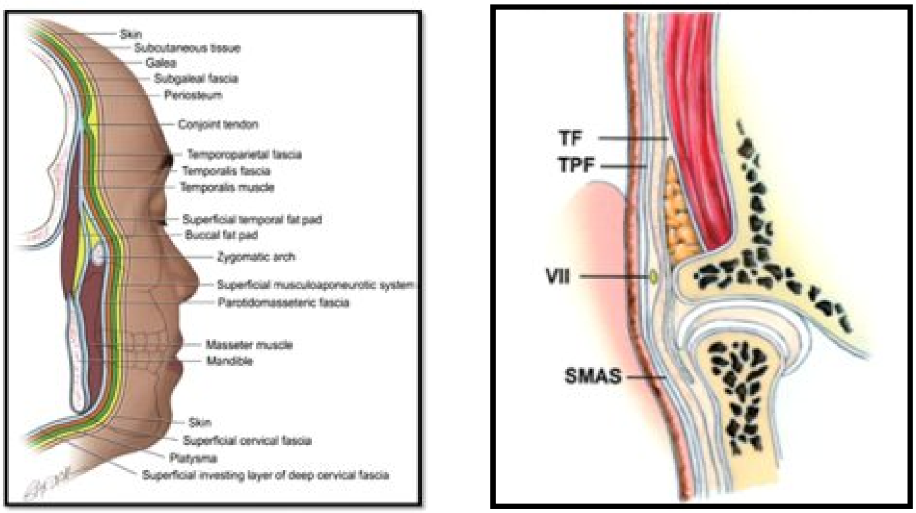
The temporalis muscle is covered by a thick temporalis fascia that splits into superficial and deep layers approximately 2 cm superior to the zygomatic arch. These 2 layers insert in the medial and lateral aspects of the zygomatic arch and eventually form the parotideomasseteric fascia. Between the superficial and deep fascia lies the superficial temporal fat pad. The deep temporal fat pad, an extension of the buccal fat pad, and the temporalis muscle lie beneath the deep temporalis fascia . Separating the temporalis fascia from the overlying TPF or the muscle underneath is relatively straightforward.

Vascular supply

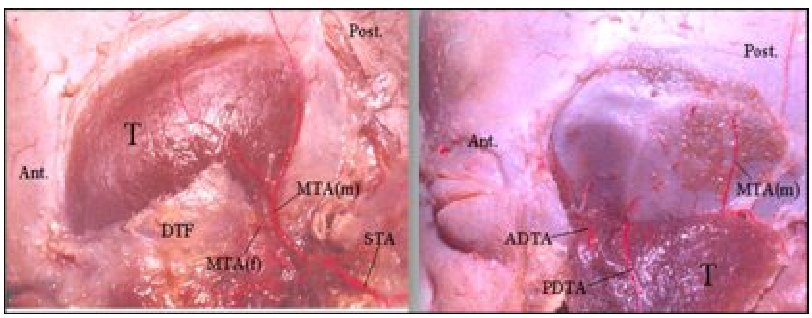
The deep temporal artery (branch of internal maxillary artery) and vein enter the medial surface of the muscle below the zygomatic arch, and the middle temporal artery (branch of superficial temporal artery) runs on the superficial surface of the muscle.

The deep temporal artery divides into anterior and posterior branches: the anterior deep temporal artery (ADTA) supplies the anterior 20% of the muscle, whereas the posterior deep temporal artery (PDTA) provides blood supply to the middle 40% of the muscle. The remaining muscle in the posterior region (40%) is supplied by the middle temporal artery. The ADTA is located 2 cm anterior to the coronoid process and 2.4 cm inferior to the arch, whereas the PDTA is located 1.7 cm posterior to the coronoid process and 1.1 cm inferior to the arch[12].

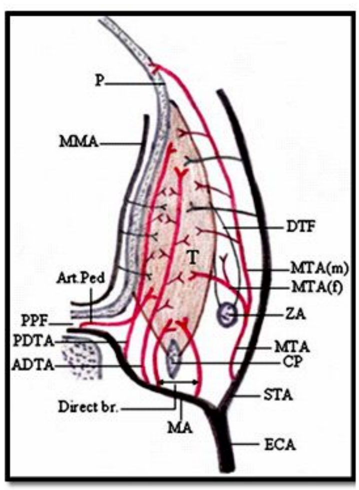
The arterial supply of the muscle from its lateral surface is constantly derived from the middle temporal artery (MTA) and the muscular branches of the STA. Occasionally (in 31.8%), direct branches from the second part of the maxillary artery, provided the supply to the lower third of the muscle near its insertion . The muscular branches of the STA arise either from its frontal or parietal branches and



Frontal diagram showing the tissue planes superficial and slightly anterior to TMJ



Vascular anatomy of TMJ region



The temporal region showing the arteries supplying the temporalis muscle

then ran upward, describing an oblique course between the layers of the superficial temporal fascia and/or between the muscle and its overlying DTF . The range of their number was 3–6, while that of their external diameter was between 0.8 and 1.4 mm. The MTA, originating from the deep aspect of the STA below the posterior edge of the ZA, ascended superficial to the arch, piercing the deep lamina of the superficial temporal fascia to run upward in the loose areolar plane. Its external diameter at its origin ranged from 0.8 to 1.54 mm. At this station, it gave off fascial and muscular branches. The fascial branch pierced the DTF 1 cm above the ZA to supply the two split layers of the DTF (temporal fascia) with the intervening pad of fat. Throughout its course, multiple muscular branches pierced the DTF supplying the lower part of the temporalis muscle. The arterial supply of the muscle from its medial surface was by six arteries namely: the ADTA, the PDTA, the MTA, middle meningeal artery (MMA), direct branches from the second part of the MA and occasionally, an arterial pedicle arising from the third part of MA.[13]

Chen et al. confirmed that a dense vascular plexus zone existed within 1.8 cm below the superior temporal line, and that the vascular plexus further perfused the ADTA, the PDTA and the MTA(m) via a vascular arcade to supply the reverse temporalis-muscle flap. the MTA(m) was found to supply the pericranium above the temporalis muscle. This finding has practical importance, because it contributes to the blood supply of the pericranial and the cranial bone flaps. The fascial branch of the MTA [MTA(f)], is the main arterial supply to the DTF and give off multiple small branches to the lower part of the temporalis muscle. In addition, the MTA sent no branches to the superficial temporal fascia. The vascular supply, derived from the branches of the MTA, is generally considered to be of minor importance, since they are usually disconnected during the flap-harvesting procedure. the territory occupied by the cut MTA to be replaced by the vascular flow from the PDTA having a wider mean diameter. So the contribution of the MTA to the temporalis muscle might not be important in antegrade flow, but becomes significant in the retrograde flow. Hence, it is important to include the MTA(m), while raising the reverse temporalis-muscle flap[13].

Once inside this pocket, the periosteum of the malar arch can be safely incised and turned forward as one flap with the outer layer of temporal fascia, superficial fascia containing the nerves and skin . The pocket can be developed anteriorly as far as the posterior border of the frontal process of the malar bone and posteriorly joined to the preauricular dissection which follows closely the cartilagenous external auditory canal beneath the glenoid lobe of the parotid gland and the superficial temporal vessels. A small tortuous branch, the auricular artery, runs backwards from the superficial temporal artery to the ear.

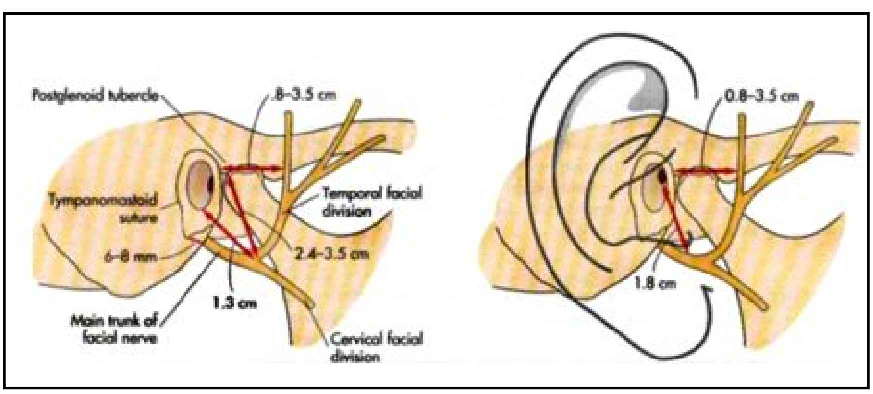
The middle temporal artery which comes off the superficial temporal artery perforates the temporal fascia to supply temporalis muscle. These should be divided and ligated. Proceeding downwards from the lower border of the arch and articular fossa, the tissues lateral to the joint capsule are dissected and retracted. The base of the neck of the condyle can be exposed. The bifurcation of the facial nerve is not nearer than 2.4 cm in an infero-posterior direction from the post-glenoid tubercle.[10]

APPLIED ANATOMY

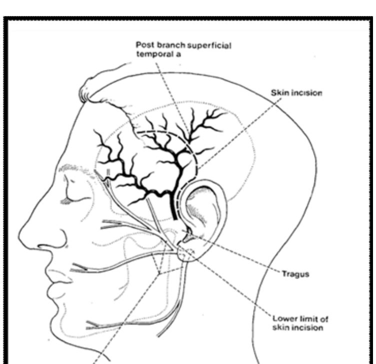
Facial Nerve

The main trunk of the facial nerve exits from the skull at the stylomastoid foramen. The suture line between the tympanic and mastoid portions of the mastoid bone is a reliable anatomic landmark because the main trunk of the facial nerve lies 6 to 8 mm inferior and anterior to this tympanomastoid suture. Approximately 1.3 cm of the facial nerve is visible until it divides into temporofacial and cervicofacial branches[8].

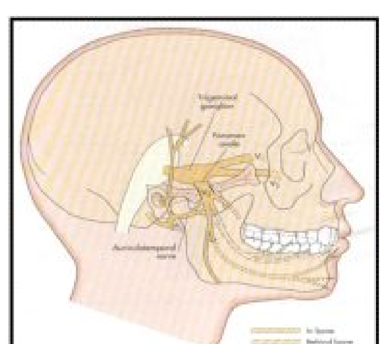
In the classic article by Al-Kayat and Brantley (1980), the distance from the lowest point of the external bony auditory canal to the bifurcation was found to be 1.5 cm to 2.8 cm (mean, 2.3 cm), and the



Surgical landmarks for identifying location of main trunk of the facial nerve and its variability



Skin incision of Alkayat Bramley



Surgical anatomy of trigeminal nerve

distance from the lowest point of postglenoid tubercle to the bifurcation was 2.4 cm to 3.5 cm (mean, 3.0 cm). The most variable measurement was the point at which the upper trunk crosses the zygomatic arch. It ranged from 8 mm to 35 mm anterior to the most anterior portion of the bony external auditory canal (mean, 2 .0 cm). By incising the superficial layer of the temporalis fascia and the periosteum over the arch inside the 8 mm boundary, surgeons can prevent damage to the branches of the upper trunk[10].

The temporal branch of the facial nerve emerges from the parotid gland and crosses the zygoma under the temporoparietal fascia to innervate the frontalis muscle ("corrugaror muscle") in the forehead. Postsurgical palsy manifests as an inability to raise the eyebrow and ptosis of the brow. Damage to the zygomatic branch results in temporary or permanent paresis to the orbicularis oculi8. 22.5 mm posterior to the frontal branch of the facial nerve as it intersects the zygomatic arch (range, 16 to 29 mm), and 15.6 mm from the bifurcation of the facial nerve main trunk (range, 12 to 20 mm)[17].

The distance of the nearest anterior branch of the facial nerve to the lateral pole of the condyle ranged from 3 to 14 mm with a mean of 10.8 mm, and the distance of the nearest inferior branch was 12.8 mm with a range of 3 to 17 mm. The closest anterior branch to the postglenoid tubercle was 17.3 mm (range, 13 to 21 mm), and the nearest inferior branch was a mean distance of 19 mm below PG (range, 13 to 27 mm)[17]

The skin incision is question mark-shaped and begins about a pinna's length away from the ear, antero-superiorly just within the hair line and curves backwards and downwards well posterior of the main branches of the temporal vessels till it meets the upper attachment of the ear[10].

The temporal incision must be carried through the skin and superficial fascia to the level of the temporal fascia. The nerve filaments run in the superficial fascia and it is very important that the full depth of this fascia is reflected with the skin flap. Blunt dissection in this plane is carried downwards to a point about 2 cm above the malar arch where the temporal fascia splits. Starting at the root of the malar arch, an incision running at 45 ° upwards and forwards is made through the superficial layer of the temporal fascia (Temporoparietal fascia)[10]

The auriculotemporal nerve

The auriculotemporal nerve is the first branch off the third division of the trigeminal nerve after it exits the foramen ovale. The auriculotemporal nerve courses from a medial to a lateral direction behind the neck of the condyle and supplies sensation to the skin in the temporal and preauricular region, the anterior external meatus, and the tympanic membrane. The auriculotemporal nerve provides most of the innervation to the capsule of the temporomandibular joint itself. The anterior portion of the joint also receives innervation from the masseteric nerve and the posterior deep temporal nerve. The articular cartilage on the surface of the condyle and the glenoid fossa and the avascular meniscus itself have no innervation[8]. The auriculotemporal nerve branching pattern around the middle meningeal artery, and a single trunk was evident along the medial aspect of the condylar neck . The horizontal distance between the nerve and the condyle is 0 mm in all cases (cadaveric study) . The average vertical distance between the superior aspect of the condyle and the nerve was 7.06 mm (-/+ 3.21 mm), with a range of 0 to 13 mm. Injury to the auriculotemporal nerve is the most commonly reported complication following arthroscopy and represents nearly 60% of neurologic injuries.[3]

Trigeminal nerve

The third division of the trigeminal nerve was measured at 35 mm (SD ± 4.9 mm; range, 24 mm to 46 mm) from the outer aspect of the zygomatic arch. The mean AP distance of the third division of the trigeminal nerve from the height of the glenoid fossa was 9.2 mm (SD ± 5.6 mm; range, 1 mm to 25 mm) . The mean width of the glenoid fossa was 18.7 mm (range, 16 mm to 23 mm)[20] .

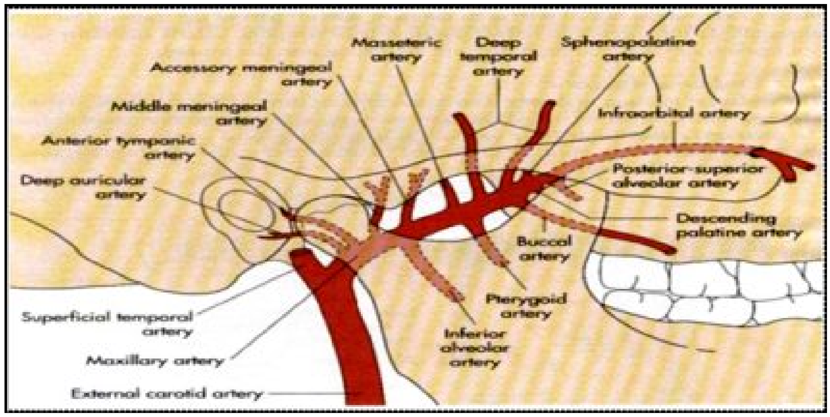
Vascular relation

The external carotid artery terminates in two branches: the superficial temporal and internal maxillary arteries. The superficial temporal artery and vein are routinely ligated daring preauricular approaches, and the internal maxillary is usually not encountered unless condylectomy is performed.

Superficial temporal artery and vein, which run just below the subcutaneous tissue anterior to the tragal cartilage. Before the external carotid artery terminates as the superficial temporal, it gives off the internal maxillary artery, which runs deeply below the neck of the condyle. It is usually just at or below the level of the sigmoid notch but can run in a more superior plane and must be protected during procedures that present a high risk for arterial damage (e.g., condylectomy).

Maxillary artery

- The mean distance between the maxillary artery and the medial border of the subcondylar portion of the mandible was 6.8 mm (range, 4.06 to 8.47 mm).
- The branching point of the maxillary artery was 16.2 mm (range, 14.97 to 16.80 mm) anterior and 21.4 mm (range, 19.14 to 23.53 mm) deep to the tragal pointer.
- The branching point of the maxillary artery was 22.4 mm (range, 21.66 to 23.99 mm) from the tip of



Surgical anatomy of maxillary artery

the condyle in the vertical plane.

- The vertical distance of the branching point of MA to the Frankfort horizontal plane (FHP) was found to be 25.7 mm (range, 24.86 to 27.47 mm).
- The mean of the distance between the deepest point of the sigmoid notch and the junction of the maxillary artery and the sigmoid notch was 5.1 mm (range, 4.97 to 5.95 mm).
- The mean distance of the maxillary artery–sigmoid notch junction to the tragal pointer in the horizontal plane was 22.9 mm (range, 20.95 to 25.05 mm). So, The maxillary artery crosses the sigmoid notch at a point 5.1 mm anterior to the deepest point of the sigmoid notch and 22.9 mm anterior to the tragal pointer[5].
- The MA could be located as far as approximately 20 mm from the apex of the condyle and surgery at any point which is less than 16 mm from the apex of the condyle would avoid injury to the MA[16]
- The maxillary artery have. an average of 20.3 mm above the superior aspect of the condyle (range, 15 to 25 mm)[17].
- The average vertical distances between the MA and the most inferior point of the articular eminence is 1.67±0.48 mm.
- The average vertical distances between the MA and the mandibular notch were determined 2.94±0.52 mm[18].
- Distance from the superior margin of the external auditory canal to the origin of the maxillary artery is 23.4 ± 5.1 mm on the right side and 22.6 ± 4.5 mm on the left[21].

To avoid accidental puncture of the artery, the tip of the needle should be inserted approximately 2 cm anterior to the tragus and just below the zygomatic arcus, with 20 degrees of angle posteriorly. The tip of the needle should be directed toward the sigmoid notch just after entering the skin. When the bone is felt at the tip of the needle, the tip of the needle is elevated slightly superiorly and passed through the sigmoid notch right toward the branches of the mandibular nerve. The needle should be bent 45 degrees posteriorly after entering from the same point to block the pterygomaxillary ganglion[5].

Carotid artery

The mean distance from zygomatic arch to the carotid artery was 37.5 mm (SD ± 5.0 mm; range, 29 mm to 48 mm). The AP distance was –6.5 mm (SD ± 15; range, –21 mm to 6 mm). The carotid sheath is also close to the joint and therefore at risk for injury. There are several cases of sinus bradycardia associated with the close proximity of the TMJ to the carotid artery, reported in the literature[20].

TMJ involves collaterals from the opposite external carotid, the internal carotid, and the vertebral arteries(through collaterals), which would explain continued blood loss despite ligation of the external carotid artery[19].

Rosenberg et al. reported that unilateral ligation of the external carotid artery below the level of the lingual and facial arteries leads to only a 40 percent decrease in maxillary artery blood flow. This means that contralateral blood flow through the anastomoses may lead to persistence of the hemorrhage. They therefore concluded that ligation of the external carotid artery in the retromandibular fossa distal to the origin of the posterior auricular artery is the most effective method. The procedure can be performed bilaterally when necessary. If the hemorrhage occurs late in the postoperative course, angiographic embolization is a valuable tool for treatment[14].

Middle meningeal artery

The mean distance from the outer aspect of the zygomatic arch to the middle meningeal artery was 31 mm (SD ± 4.9 mm; range, 21 mm to 43 mm). The AP distance from the artery to the height of glenoid fossa is 2.4 mm (SD ± 2.9 mm; range, –2 mm to 8 mm)[20,22].

Among branches of the maxillary artery, the luminal diameter was largest for the middle meningeal artery (1.2 ± 0.3 mm)[21]. Injury to this artery can be particularly catastrophic, as retraction of the vessel can result in a subdural hematoma . In addition, the medial location of this vessel renders clamping or cautery difficult. As such, great care should be taken to avoid violation of the medial capsule during TMJ surgery[22].

IJV

The distance to the internal jugular vein was 38.3 mm (SD ± 4.9 mm; range, 31 mm to 49 mm). The AP distance measured at -8.7 mm (SD ± 6.3; range,-20 mm to 7 mm)[20].

The masseteric artery can be as little as 4 mm from the condylar neck, 2.8 mm from the articular tubercle (temporomandibular joint), and 1 mm from the depth of the sigmoid notch. The mean distance to the anterior-superior aspect of the condylar neck was 10.3 ± 4.4 mm; to the most inferior aspect of the articular tubercle, 11.47 ± 4.6 mm; and to the most inferior aspect of the sigmoid notch, 3.00 ± 1.2 mm[6].

STA

The posterior aspect of the tragus has a mean distance of 12.8 mm from the superficial temporal vessels (range, 8 to 15 mm)[17].

The pterygoid venous plexus

The pterygoid venous plexus is a network of valveless veins located between the medial aspect of the temporal muscle and the lateral aspect of the pterygoid muscles. This plexus of veins communicates with the cavernous sinus superiorly and the retromandibular and facial vein inferiorly. The pterygoid venous plexus is situated within a fat pad . Though uncommon, the operating surgeon may encounter this venous plexus in cases where the condyle has been displaced anteriorly or anteromedially such as in trauma or persistent dislocation[22].

So, in massive bony ankylosis where vertical distance from post glenoid tubercle to maxillary artery (branching point) -

1. Condylar tip to post glenoid tubercle vertical distance -1.7 mm.

2. Vertical distance from post glenoid tubercle to MA (branching point)-22.4+1.7 mm.

3. Depth of MA from tragal pointer-21.4 mm.

4. Horizontal distance from tragal pointer to ma-16.2 mm.

5. Articular eminence to ma vertical distance-1.67 ± 0.48 mm.

6. Vertical distance from fhp to maxillary artery branching pattern-25.7 mm (24.86 to 27.47 mm).

The mean thickness of the glenoid fossa (middle cranial fossa) was 0.9 mm with a range of 0.5 to 1.5 mm. The tympanic plate (anterior osseous boundary of the bony EAC) was intact in all specimens with a mean thickness of 1.5 mm (range, 0.8 to 3 mm). The tympanic plate was 25.4 mm deep to the perpendicular skin puncture (range, 19 to 32 mm), while the posterior tragus was 7 mm posterior to the puncture (range, 6 to 9 mm). The midpoint of the lateral pole of the condyle was a mean distance of 8.4 mm anterior to the anterior margin of the bony EAC (range, 7 to 9 mm). The bony external auditory canal was 7 mm wide (range, 5 to 9 mm), with a mean of 9.9 mm in height (range, 9 to 11 mm)[17].

Anatomical Relations in TMJ Ankyloses

Hakim et al proposed that ankylosed joints can be grouped according to the relation of the ankylosed mass to the surrounding vital structures, especially at the base of the skull as follows:

Class I: includes unilateral and bilateral fibrous ankylosis. The condyle and glenoid fossa retain their original shape, and the maxillary artery is in normal anatomical relation to the ankylosed mass.

Class II: there is unilateral or bilateral bony fusion between the condyle and the temporal bone. The maxillary artery lies in normal anatomical relation to the ankylosed mass.

Class III: the distance between the maxillary artery and the medial pole of the mandibular condyle is less on the ankylosed than in the normal side or the maxillary artery runs within the ankylotic bony mass. This is best seen on coronal CT.

Class IV: the ankylosed mass appeared fused to the base of the skull and there is extensive bone formation, especially from the medial aspect of the condyle to the extent that the ankylosed bony mass is in close relationship to the vital structures at the base of the skull such as the pterygoid plates, the carotid and jugular foramina and foramen spinosum and no joint anatomy can be defined from the radiograph. This is best visualized on axial CT[15].

Conclusion

From this elaborate review it is evident that before performing TMJ surgery these anatomical proximity of TMJ should be kept into mind to avoid serious morbidity.

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