**Stereological Studies on Several Ducts and Vessels
By Injection Method of Acrylic Resin**

**XXII. On the superficial temporal artery
of *Macacus cynomolgus****

By

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(With 17 Figures in 2 Plates)

Preface

A d a c h i (1928) has surveyed the superficial temporal artery in detail in his classic publication.

In the monkey, however, no detailed report has yet been done because this artery might be under-developed. The present paper has dealt with stereological studies of the artery by the plastic injection method.

Materials and Methods

Animals used for observations were 20 monkeys. After they were sacrificed by depletion, colloidal acrylic resin was injected through cannulae inserted into the common carotid arteries by injection method of acrylic resin by Taniguchi, Ohta and Tajiri (1952 and 1955). Soft tissues of the injected heads were dissolved away with sodium hydroxide solution to make corrosion specimens, while several injected heads were preserved in 10% formalin for dissection. Dissection and observations of the corrosion specimens were performed under the binocular magnifier and microscope.

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Observations

The superficial temporal artery (0.59–0.75, M. 0.65 mm) arises from the superior or lateral wall of the external carotid artery (1.49–1.79, M. 1.60 mm) almost attached to the posterior margin of the ramus of the mandible (fig. 1). Giving off the transverse facial artery behind the neck of the mandible, the superficial temporal, covered with the parotid gland, runs upward crossing over the capsule of the temporomandibular joint lateral to the postarticular process of the temporal bone (Hartman and Straus, 1933). The superficial temporal emerges at the superior margin of the posterior root of the zygomatic arch and immediately divides into branches between the external acoustic meatus and the mandibular fossa.

Branches are as follows:

1. The transverse facial artery

The artery (0.45–0.75, M. 0.59 mm) arises from the anterior wall of the superficial temporal in 12 cases of 20 sides (fig. 2), from the superior wall of the maxillary near the origin of the superficial temporal, behind the posterior margin of the condylar neck of the mandible in 7 cases, and from the lateral wall of the maxillary, medial to the ramus of the mandible in one case (fig. 3). In the last case, the artery runs backward once, and after going round the posterior margin of the ramus of the mandible, it reaches the lateral side of the ramus of the mandible (fig. 3).

Of 12 cases in which it arises from the superficial temporal, the transverse facial artery is one in number in 8 cases (fig. 2), and in addition to it, its accessory artery is observed in 4 cases (fig. 4).

Of 8 cases in which it arises from the maxillary, the transverse facial artery is one in number in 5 cases, and in addition to it, one or two accessories are observed in 3 cases (fig. 5).

The transverse facial appears from the posterior margin of the masseter onto its fascia, covered with the parotid gland, between the zygomatic arch and the parotid duct. At the lateral surface of the zygomatic bone, it finally divides into many branches which supply the skin with peripheries of the facial, buccal and infraorbital arteries (fig. 6).

In 7 cases in which two transverse facial arteries are found, one (0.45–0.75, M. 0.59 mm) is thicker than the other (0.35–0.59, M. 0.41 mm). The thinner one arises from the anterior or lateral wall of the superficial temporal 3.0 mm distal to the origin of the thicker

one, and runs forward in parallel to the thicker one which supplies the skin around the coronoid process of the mandible (fig. 6). The thinner, before its termination, gives off following branches from the superior wall of it, and they supply the skin above the zygomatic arch.

(1) The parotid branch

The branch (0.29–0.45, M. 0.43 mm) arises from any walls of the transverse facial (figs. 2 and 7). It meanders, gives off a lot of twigs and supplies the parotid gland with the parotid branches (vid. infra) which leave the superficial temporal artery.

(2) The masseteric branches

They are three in number.

The proximal branch (0.30–0.45, M. 0.40 mm) arises, behind the posterior margin of the ramus of the mandible, from the inferior wall of the transverse facial near its origin. It runs forward and downward on the superficial layer of the masseter muscle and supplies the lower half of it and the skin around it with twigs of the premasseteric branch of the facial artery (fig. 8).

The middle branch arises from the lateral or inferior wall of the transverse facial about 3.0 mm distal to the origin of the parotid branch. It runs forward and downward, dividing into two, the superior and the inferior (fig. 9). The superior (0.29–0.45, M. 0.37 mm) runs forward on the fascia of the masseter muscle and is distributed to the skin around the anterior margin of the masseter with the cutaneous branches which arise from the inferior wall of the transverse facial and of the premasseteric branch of the facial artery (fig. 9). The inferior (0.29–0.45, M. 0.35 mm) runs forward and downward in parallel to the distal masseteric branch, entering the more superficial layer of the masseter than the distal. In its course, it gives off a lot of twigs which supply the middle superficial layer of the masseter (fig. 9).

The distal branch arises from the medial or inferior wall of the transverse facial, about 6.0 mm anterior to the posterior margin of the ramus of the mandible on the lateral side. It runs forward and downward to enter the deep layer of the masseter (Yoshikawa et al., 1952). It, in the masseter, releases a lot of twigs which spread in a sectoral shape to supply the middle portion of the deep masseter, being accompanied with twigs of the masseteric artery out of the maxillary artery as well as the premasseteric branch out of the facial artery (fig. 9).

(3) The cutaneous branches (fig. 6)

At the lateral surface of the zygomatic bone, the transverse facial gives off a lot of branches from its superior and inferior walls. Branches (c. 0.14 mm) from the superior wall run upward to supply the skin above the zygomatic arch. Branches (c. 0.15 mm) from the inferior wall run downward to supply the skin on the masseter muscle.

2. The parotid branches

The branches (0.43–0.62, M. 0.52 mm), one to four in number, arise from the anterior wall of the superficial temporal artery, about 3.0 mm distal to the origin of the transverse facial or its accessory artery (fig. 10). Most branches run forward and enter the parotid gland. They meander, give off a lot of twigs to supply the gland with the parotid branch of the transverse facial, tangling with ductules in the gland (fig. 7). Especially well-developed ones run backward to supply not only the gland but the inferior margin of the external acoustic meatus.

3. The anterior auricular branch (fig. 10)

The branch (0.25–0.43, M. 0.34 mm) arises usually from the posterior or medial wall of the superficial temporal artery about 2.0 mm distal to the origin of the parotid branches, but sometimes from the posterior wall of the parietal branch (5 cases). It runs upward between the postarticular process and the external acoustic meatus of the temporal bone. On its way to the anterior portion of the auricle, it ramifies 5 or 6 twigs which are distributed to the anterior part of the auricle, the external acoustic meatus, the petrotympanic fissure and the temporomandibular joint.

4. The temporomandibular joint branch (fig. 11)

The branch (0.20–0.29, M. 0.26 mm) arises from the medial wall of the superficial temporal artery 1.0–3.0 mm distal to the origin of or in the height of the anterior auricular branch. Or, the branch arises from the medial wall of the maxillary or transverse facial artery in 3 cases. It runs upward about 3.0 mm once and descends vertically between the postarticular process and the condylar process of the mandible and enters a nutrient foramen being located at the posterior surface of the process. In its course, it ramifies a lot of fine capillaries from its any walls and they are distributed to the capsule of the joint.

Very small branch (c. 0.09 mm) which arises from the transverse facial or maxillary artery runs upward along the posterior surface

of the neck of the mandible between the postarticular process and the coronoid process, and supplies the medial part of the capsule.

5. The zygomatico-orbital artery

The artery (0.29–0.31, M. 0.30 mm) arises from the anterior or lateral wall of the superficial temporal inferior to or at the root of the zygomatic arch (fig. 12). It runs forward in the subcutis and crosses over the arch onto the temporal fascia up to the lateral angle of the orbit to supply the orbicularis oculi muscle.

The artery well-developed runs forward above the arch and enters the zygomatic temporal foramen (Hartman and Straus) to anastomose (c. 0.12 mm) with the lacrimal artery in the orbit. On its way to the foramen, many twigs arise from its any walls and are distributed to the skin above the arch (fig. 13).

6. The middle temporal artery

The artery (0.31–0.45, M. 0.39 mm) arises from the posterior wall of the superficial temporal at the posterior end of the zygomatic arch. It runs backward and penetrates the temporal fascia and divides into two, the superior and the inferior.

The superior (c. 0.29 mm) runs backward and upward to supply the temporal muscle across the posterior auricular artery under it. The muscle is supplied with twigs which arise from both the anterior and posterior walls of the branch. Twigs arising from the anterior wall run forward to supply the anterior part of the muscle with branches of the posterior deep temporal artery. Twigs arising from the posterior wall run backward to supply the posterior part of the muscle. The inferior (c. 0.31 mm) runs backward in parallel to the muscle fibers of the temporal muscle and crosses the posterior auricular artery under it to supply the origin of the temporal muscle.

7. The parietal branch (figs. 12 and 14)

The branch (0.25–0.31, M. 0.28 mm) is the continuation of the superficial temporal artery and runs backward and upward on the temporal muscle like an arch. It crosses the posterior auricular artery under it and is distributed to the origin of the temporal muscle. In most cases the branch becomes slender and does not reach the parietal region.

Summary and Discussion

Lineback (1933) and Dyrud (1944) have never observed in detail on the superficial temporal artery of the rhesus monkey except that they showed the artery. Castelli and Huelke (1965) stated in the Macaque that the superficial temporal artery was represented by a very small vessel with limited distribution or was completely absent. But, in the *Macacus cynomolgus*, the present authors observed the superficial temporal artery in all cases.

In the human, the artery ran upward in the direction of the extension of the external carotid artery (fig. 15). In the *Macacus cynomolgus*, however, the artery ran upward after arising from the superior or lateral wall of the external carotid artery behind the ramus of the mandible.

Castelli et al. stated in the rhesus monkey that a masseteric, transverse facial and zygomaticoorbital arteries were corresponding to the parotid gland branches divided out of a parotid trunk arising from the maxillary artery, that is, very near the point of origin of the maxillary artery, the first branch arose; it was a short parotid trunk which soon divided into six or seven secondary branches, the parotid gland branches. It was found in this thesis that a short parotid trunk by them were corresponding to the superficial temporal artery and also that both the transverse facial and the zygomaticoorbital arteries arose regularly from the superficial temporal artery. The masseteric artery they stated was the branch of the transverse facial artery, so the present authors called it the masseteric branch.

As to the transverse facial artery in the human, Adachi (1928) stated that it arose from the external carotid artery in 5 and from the maxillary artery in one of 72 cases observed except that the artery commonly arose from the superficial temporal artery. In the *Macacus cynomolgus*, the present authors observed the artery arose from the maxillary artery in 8 of 20 cases.

In the human, the transverse facial artery sometimes took place of the facial artery which disappeared at the mandibular angle. In the monkey, however, the facial artery was developed so well that the premasseteric branch, Ramus premassetericus of *A. maxillaris externa* (Adachi, in the human), arose from the artery, therefore the transverse facial did not take place of the facial as in the human. The present observations were that the accessory transverse facial artery arose from the superficial temporal artery in 7 of 20 cases besides the transverse facial artery. Both the transverse facial and

its accessory arteries went forward between the zygomatic arch and the parotid duct.

Castelli et al. stated that a large masseteric artery passed forward along the lateral side of the subcondylar portion of the ramus of the mandible to enter the deep head of the masseter muscle. It supplied most of this muscle and anastomosed with other branches from the maxillary artery along the front edge of the ramus. The authors in this thesis observed three masseteric branches arising from the transverse facial artery—the proximal, the middle and the distal ones. The first and the second branches were distributed to the superficial layer of the masseter muscle and the last to its deep layer. The distal branch, thickest of all, corresponded to a large masseteric artery by Castelli et al.

Castelli et al. stated that several small temporomandibular capsular branches arose from the maxillary artery as the vessel passed adjacent to the medial side of the condylar neck. These ascending branches had a very short course, and passed into the medial aspect of the temporomandibular capsule and adjacent tissues. Additionally, articular branches arose from the posterior deep temporal artery near its origin, and from the parotid branches. It was observed in the present paper that as being showed in figure 11, the temporomandibular joint branch arising from the medial wall of the superficial temporal artery was distributed to the lateral side of the temporomandibular capsule and the articular disc. The branches arising from the medial wall of the maxillary and the transverse facial arteries were distributed to the adjacent structures around the medial part of the condyle.

As to the zygomatico-orbital artery in the human, Adachi stated that it arose from the superficial temporal artery in two thirds and from the anterior branch in one third of 52 cases. This is clearly observed in figures 15 and 17. It was described in the textbook of Gray's Anatomy that the zygomatico-orbital artery was sometimes a branch of the middle temporal artery. It supplied branches to the Orbicularis oculi, and anastomosed with the lacrimal and the palpebral branches of the ophthalmic artery. In the *Macacus cynomolgus*, the anterior branch was not observed as in the human, so the zygomatico-orbital artery did not arise from the anterior branch as Adachi described in the human. It arose from the anterior or lateral wall of the superficial temporal artery on the posterior end of the zygomatic arch. A well-developed zygomatico-orbital artery entered the zygomatic temporal foramen (Hartman and Straus, 1933)

peculiar to the monkey, and anastomosed with the lacrimal artery in the orbit as Gray stated in the human.

As to the middle temporal artery in the human, Adachi described that it arose from the superficial temporal artery in 8 and from the maxillary artery in 2 of 10 cases. The present authors observed in the human as being showed in figure 16, not reported yet, that the artery arising from the superficial temporal artery soon divided into the anterior and the posterior branches. The former ran forward within the temporal muscle and anastomosed with a branch, entering the zygomatic temporal foramen and appearing from the temporal facial foramen, which arose from the anterior deep temporal artery. The latter ran backward and upward within the muscle along the middle temporal sulcus and supplied the muscle. In the monkey, the middle temporal artery arising from the posterior wall of the superficial temporal artery ran backward supplying the temporal muscle. The middle temporal sulcus was not observed in the monkey.

The parietal branch was a direct continuation of the superficial temporal artery. It was not developed so well as in the human and disappeared without anastomosing with the opposite fellow.

Conclusions

1. Three-dimensional studies by means of the injection method of acrylic resin were accomplished on origins, ramifications and supplying territories of the superficial temporal artery in the *Macacus cynomolgus*.
2. The superficial temporal artery arose from the superior or lateral wall of the external carotid artery, almost attached to the posterior margin of the ramus of the mandible.
3. Branches of the artery were as follows; the transverse facial and its accessory arteries, the parotid, the anterior auricular and the temporomandibular joint branches, the zygomatico-orbital and the middle temporal arteries, the parietal branches.

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Explanation of Figures

Key to Abbreviations

a	Anterior auricular branch
at	Accessory transverse facial artery
C	Condylar process
cb	Cutaneous branch
Cp	Coronoid process
e	External carotid artery
Em	External acoustic meatus
m	Maxillary artery
M	Masseter muscle
ma	Masseteric artery
md	Masseteric branch, distal
mm	Masseteric branch, middle

mp	Masseteric branch, proximal
mt	Middle temporal artery
pb	Parietal branch
Po	Postarticular process
ps	Parotid branches of superficial temporal artery
pt	Parotid branch of transverse facial artery
R	Ramus of mandible
s	Superficial temporal artery
t	Transverse facial artery
z	Zygomatico-orbital artery
Za	Zygomatic arch
←	Direction of snout

Plate I

- Fig. 1. Lateral view. General course of the superficial temporal artery. Bulb of eye (×). C. ×1.0
- Fig. 2. Lateral view of the transverse facial artery. Origin of the transverse facial artery (×). C. ×2.5
- Fig. 3. Posterior view of the ramus of the mandible. Origin of the transverse facial artery (×). C. ×2.5
- Fig. 4. Lateral view of the accessory transverse facial artery. C. ×2.0
- Fig. 5. Lateral view of the transverse facial and its accessory transverse facial arteries. C. ×2.0
- Fig. 6. Lateral view of the transverse facial and its accessory transverse facial arteries. The latter supplies the skin around the coronoid process of the mandible (×). C. ×1.0
- Fig. 7. Lateral view of the parotid duct (×) and the transverse facial artery. C. ×2.0
- Fig. 8. Lateral view of the masseteric branches. C. ×2.0

Plate II

- Fig. 9. Lateral view of the masseteric branches. Premasseteric branch of the facial artery (×). The middle masseteric branch divides into the superior (s') and the inferior (i') branches. Facial artery (○). C. ×1.5
- Fig. 10. Lateral view of the parotid and the anterior auricular branches of the superficial temporal artery. C. ×2.0
- Fig. 11. Lateral view of the temporomandibular joint branch (×). C. ×2.5
- Fig. 12. Lateral view of the zygomatico-orbital artery and the parietal branch. Lateral angle of the orbit (×). C. ×1.2
- Fig. 13. Lateral view of the well-developed zygomatico-orbital artery. Zygomatic temporal foramen (✓). Orbit (○). C. ×1.2
- Fig. 14. Lateral view of the middle temporal artery and the parietal branch. The latter divides into the superior (s') and the inferior (i') branches. The posterior auricular artery (×). C. ×1.2
- Fig. 15. Lateral view of the superficial temporal artery (in the human). The artery runs vertically at the direction of the external carotid artery. Frontal branch (×). C. ×0.3
- Fig. 16. Lateral view of the middle temporal artery (in the human). The artery divides into the anterior (×) and the posterior (○) branches. C. ×2.0
- Fig. 17. Lateral view of the superficial temporal artery (in the human). Frontal branch (×). C. ×0.3

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