On the Nutrient Arterial Branches of the Mandibular Ramus in the Dog by the Plastic Injection Method

By

Ichiro Yamamoto, Tetsuo Yanagawa and Akira Arai

Department of Anatomy, Osaka Dental University, Osaka
(Director: Prof. Y. Ohta)
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The arterial distribution within the mandible and maxillae, which are the only structures having teeth, is more complicated than that of other bones. The whole mandible, including the teeth, is nourished chiefly by the inferior alveolar artery. The mandibular ramus receives small vessels not only from the inferior alveolar artery, but also from the mandibular branch of the maxillary, the posterior deep temporal, the masseteric, and the transverse facial arteries.

To date, the arterial supply of the mandible, particularly the mandibular ramus, has not been described adequately; therefore, little information about the arterial supply has been available in the literature. The present observations will deal with the nutrient arterial branches of the mandibular ramus in the dog using the plastic injection method.

Materials and Methods

Twenty-five adult dogs were used in this study.

After they were sacrificed by depletion, the colloidal plastic was immediately injected through cannulae into the common carotid arteries, employing the plastic injection method of Taniguchi, Ohta and Tajiri (1952 and 1955).

After the hardening of the injected plastic, soft structures were dissolved away with a sodium hydroxide solution in order to prepare the plastic corrosion specimens.

To demonstrate the fine arterial vasculature in the mandibular bone, the specimens, which were soaked in alkali, were dissected
carefully under the binocular magnifier. However, it has been difficult to obtain a perfect specimen of the fine vasculature within the bone in all the injected cases.

**Observations**

1. The mandibular branch (Miller 1964)
   Of the 32 halves observed, the branches (0.06-0.43, M. 0.23 mm in diameter) (Figs. 1, 3) are seen two in number in 17 cases, one in 12 cases and three in 3 cases.
   In the 17 cases, the two branches leave the lateral and medial walls of the maxillary artery, 1-8 mm distal to the origin of the maxillary artery.
   In 9 of the 12 cases in which only one mandibular branch is observed, it arises from the medial wall of the maxillary artery 1-5 mm distal to the origin of the maxillary artery. In the other 3 cases, the branches originate from the superior wall of the external carotid artery about 5 mm proximal to the bifurcation exhibited by the superficial temporal and the maxillary arteries.
   In the 3 cases with three branches, two arise from the medial wall of the maxillary artery and the other one from the lateral wall.
   The mandibular branch, arising from the medial wall, arborizes into two or three vessels, each of them supplying the caudal part of the temporomandibular joint capsule, the external acoustic meatus (Fig. 1), and occasionally the condylar process (Figs. 3, 4).
   The mandibular branch, arising from the lateral wall, courses antero-inferiorly and subdivides into many small twigs at the caudal or medial side of the angular process, then they enter the angular process through small foramina to supply it and occasionally also supplying the inferior part of the inferior mandibular notch (Figs. 4, 14). These twigs sometimes anastomose in the angular process with the angular branch arising from the inferior alveolar artery (Fig. 2).

2. The inferior alveolar artery
   The artery arises from the inferior wall of the mandibular part of the maxillary artery singularly or in common with the posterior deep temporal artery. The inferior alveolar artery enters the mandibular canal running about 10 mm, and gives off the following branches either in the canal or just prior to entering the foramen:
   (1) The angular branch.
   In 36 cases of 40 halves, this branch (0.18-0.49, M. 0.27 mm) (Fig. 7) arises singularly (29 cases) or in common with the coronoid branch (7 cases) from the inferior wall of the inferior alveolar artery 4-40 mm distal to its origin, and in 34 of these cases the branch is 1-30
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mm distal to the foramen and 3-6 mm proximal to the foramen in 2 cases.

At first, the branch runs antero-inferiorly adjacent to the parent artery in the mandibular canal for 2-15 mm (Fig. 7), but in 7 cases the branch first turns posterosuperiorly and then antero-inferiorly following the same course. Then the branch leaves the canal making a posterior curvature in the bone marrow to continue backward horizontally (Fig. 5). The branch is distributed to the angular process mainly and the inferior part of the inferior mandibular notch, sometimes up to the condylar process, without branching (Fig. 8) or bifurcating in 16 cases (Figs. 10, 11 and 12), or trifurcating in 4 cases (Fig. 7). The posterior curvature mentioned above shows a steep bending or a coiling appearance occasionally (Fig. 6) and gives rise to small twigs anteriorly into the marrow. In 6 cases, it gives off a branch to the molar or the periodontium (Fig. 5).

In the 7 cases, the angular branch arises in 5 cases from the inferior or in 2 cases from the superior wall of the inferior alveolar artery in common with the coronoid branch (Fig. 6). In these cases, the angular branch is distributed to the angular process and the inferior part of the inferior mandibular notch after turning posteriorly at the lateral side of the inferior alveolar artery following a V-shaped course (Fig. 5).

In different 4 cases, the branch arises from the inferior wall of the posterior deep temporal artery or the medial pterygoid muscular branch, and enters the mandibular foramen along with the inferior alveolar artery. Details of these cases will be mentioned later.

(2) The coronoid branch.

This branch (0.12-0.49, M. 0.24 mm in diameter) arises from the superior wall (Fig. 12) in 28 cases of the 32 halves and from the inferior wall in 4 cases (Fig. 9). The origin of the branch is 5-20 mm distal to the origin of the inferior alveolar artery; in the mandibular canal 1-10 mm distal to the foramen in 24 cases, and proximal to the foramen in 8 cases. The branch, however, arises in common with the angular branch in 9 cases (Fig. 5) and in common with the retromolar branch in 3 cases (Fig. 12).

The coronoid branch at first runs anteriorly and slightly superiorly, then makes a posterosuperior curvature along the anterior margin of the coronoid process sending off twigs posteriorly to supply the coronoid process (Figs. 5, 11, 14).

In 10 cases, the coronoid branch exhibits an S-shaped course. In different 10 cases, the branch divides into two at the above-mentioned curvature. One branch runs posterosuperiorly supplying the coronoid process and the other runs posteriorly supplying the inferior part of the superior mandibular notch and the condylar process (Figs. 5, 11).
3. The posterior deep temporal artery

(1) This artery gives off a branch (0.07-0.43, M. 0.28 mm in diameter) (Fig. 9) from its anterior wall toward the mandibular foramen about 2 mm distal to the origin of the artery and about 3 mm proximal to the origin of the medial pterygoid muscular branch in 34 cases of the 43 halves. In 9 cases, the branch originates from the medial pterygoid muscular branch (Fig. 13).

The branch runs antero-inferiorly about 10 mm superior to the inferior alveolar artery and enters the mandibular canal through the mandibular foramen or a small foramen close to it, and runs for about 8 mm in this canal. In most cases, the branch anastomoses with either the inferior alveolar artery, the coronoid, or the angular branch, but in cases in which the inferior alveolar artery does not give off the coronoid or the angular branch, the posterior deep temporal artery gives off the corresponding branch (Figs. 13, 14). This branch shows the same distribution at the coronoid and the angular branches arising from the inferior alveolar artery.

![Text-figure. The arterial distributing territories of the mandibular ramus in the dog. Posterior view (left) and lateral view (right).](image-url)

In 29 cases, this branch, which does not supply the bone marrow, anastomoses with the following branches in the canal; in 10 cases with the angular branch of the inferior alveolar artery (Fig. 9), in 8 cases with the coronoid branch of the inferior alveolar artery, in 6 cases with the inferior alveolar artery near the origin of the angular or the coronoid branch, in 5 cases with the common trunk between the angular and the coronoid branches or with both of them.

In 12 cases, the branch leaves the canal anterosuperiorly to supply the coronoid process (Fig. 13).
In 3 cases, the branch divides into two in the mandibular canal. One supplies the coronoid process, and the other supplies the angular process running posteriorly crossing over the inferior alveolar artery (Fig. 14).

In 2 cases, the branch supplies the angular process without branching.

(2) The posterior deep temporal artery gives off one branch (0.12–0.31, M. 0.27 mm in diameter) (Fig. 15) in 17 cases of the 20 halves or two branches in 3 cases to the condylar process. The branch or branches arise from the medial wall of the artery 2–3 mm distal to the origin of the parent artery before the origin of the medial pterygoid muscular branch or at the same level. The branch runs posterosuperiorly at the medial side of the condylar process where it arborizes into small twigs which spread in the medial side of the process. A few of them perforate the bone to supply the marrow.

4. The masseteric artery

In 14 cases of the 32 halves, the masseteric artery gives off a branch (0.12–0.25, M. 0.19 mm in diameter) (Fig. 16), two in two cases, at the point where the artery passes through the superior mandibular notch. The branch runs to the lateral side of the condylar process and perforates the bone to supply it (Figs. 17, 18).

5. The transverse facial artery

In 15 cases of 32 halves, a branch (0.12–0.25, M. 0.19 mm in diameter) (Figs. 19, 20) arises from the medial wall of the transverse facial artery, 3–5 mm distal to its origin and runs medially perforating the condylar process from the caudal part and supplies the process.

**Discussion**

Uwarow (1935), Yoshimura (1959), Ichikawa (1961) and Castelli (1963) have studied the arterial distribution of the mandible in the human fetus and adult, and Ellenberger et al. (1891), Sawaguchi (1929), Perint (1949), Sato (1949), Miller (1964), Huelke et al. (1966) and Boyd et al. (1967) in the dog, guinea pig, rat, goat and rabbit. As these observations were made mostly about the arterial distribution of the teeth, the periodontal membrane and space, there have been few studies on the blood supply in the mandibular ramus. The arterial distributing territories of the nutrient branches observed in the present paper were illustrated by the schema.

About the arterial distribution of the angular process, Boyd, Castelli and Huelke stated that it came from the medial and lateral pterygoid muscular branches in the guinea pig. Mori (1970), in his
work about the revascularization after the experimental mandibular fracture of the dog, stated that the mandibular angle, the coronoid and condylar processes of the normal materials were supplied with branches arising from the inferior alveolar artery singularly or in common with the posteriormost molar branch. Castelli in the human adult and Sawaguchi in the puppy stated that the angular process was nourished with the inferior alveolar artery. Such observations agreed roughly with those of the present authors. But the angular branch arose singularly, occasionally in common with the coronoid branch of the inferior alveolar artery, or with the posterior deep temporal or the medial pterygoid branch. Additionally, the angular process was supplied not only with such an angular branch, but also with the mandibular branch of the maxillary, which entered the bone from the caudal part of the process. Castelli and Sawaguchi failed to point out the additional mandibular branch described by the present authors. Miller stated the mandibular branch of the dog was distributed to the caudal part of the temporomandibular joint capsule, although the present authors observed that the branch supplied not only that part of the capsule, but also the angular process and the external acoustic meatus and occasionally extended up to the superior mandibular notch or the condylar process.

In this study, the present authors were especially interested in the coronoid artery named by Uwarow. There have been various surveys regarding this vessel or other arterial branches that supplied the coronoid process. Uwarow pointed out in the human fetus that the coronoid artery arose from the masseteric artery and that the inferior alveolar artery did not send a branch to the coronoid process. On the contrary, Fukuoka (1964) stated that the masseteric did not send any branch to the process and the coronoid artery named by Uwarow arose directly from the maxillary artery. This finding was similar to that in the goat by Sato. Castelli stated in the human adult that the coronoid process was nourished with the temporal muscular branches. The present authors would make no objection to his statement, but such muscular branches did not penetrate the bone structure deeply. Actually we could see the same kind of the muscular branches when those of the temporal and the masseter muscles were removed, but these branches were not extensive and reached just under the periosteum at the utmost. They could not be accepted as the nutrient arterial branch of the coronoid process. Uwarow and Fukuoka described the masseteric and the maxillary arteries as the nutrient artery of the coronoid process. Yoshimura and Sawaguchi pointed out in the human fetus and the puppy that the arterial branch to the coronoid process arose from the inferior alveolar artery. Considering the coronoid artery of the masseteric in the human fetus,
Uwarow observed that such a branch arose from the masseteric and perforated into the mandible of the dog, but this vessel was distributed to the neck of the condylar process, rather than to the coronoid process. In the dog, the coronoid artery usually arose from the inferior alveolar artery, occasionally from the posterior deep temporal artery or the medial pterygoid branch.

About the arterial branches to the condylar process, Uwarow and Yoshimura described the maxillary artery in the human fetus, Boyer et al. (1962) studied the inferior alveolar artery in the hamster; Boyd, Castelli and Huelke et al. demonstrated the lateral and medial pterygoid muscular branches and the temporomandibular joint branch in the guinea pig; Ichikawa described the superficial temporal, the transverse facial, the middle temporal, the posterior deep temporal and the middle meningeal arteries in the human fetus. In this paper, a definite nutrient branch to the condylar process was not seen, but the process was supplied by the masseteric, the transverse facial, the posterior deep temporal and the mandibular branch of the maxillary artery.

To date, the nutrient arterial branches of the mandibular ramus have been investigated by some authors in a few vertebrates as mentioned above. The results obtained showed many differences in the arterial distribution to the mandibular bone even in the same species. These differences may have been due to the techniques employed since the observations were performed on the fine nutrient branches and the arterial sources of these branches to the mandible after this bone was removed from the injected specimen. Therefore, the identification of sources of the nutrient arterial branches to the mandible would be impossible. In this paper, needless to say, the observing procedures were made in situ on the plastic-injected mandible.

Langer (1876), who studied the arterial distribution of the general long bones, stated that there was a close relationship between the course of the nutrient arterial branches within the bone and the growth of the bone. The present authors would like to agree with his statement, as they mentioned that the coronoid, the angular and the condylar branches took their directions to the supero-anterior, the posterior and the superoposterior, respectively.

Conclusions

1. The present authors have studied the arterial distribution of the mandible in the dog, employing the plastic injection method.

2. The mandibular branch was seen as one or two, perforating the mandible from the caudal or slightly medial side of the angular process.
II. The inferior alveolar artery gave off the angular and the coronoid branches in the mandibular canal or proximal to the mandibular foramen.

III. The posterior deep temporal artery gave off two branches from its anterior and medial walls, respectively.

IV. The masseteric artery gave off one or two branches at the point where it passed through the superior mandibular notch.

V. The transverse facial artery gave off a branch from the medial wall during crossing over the condylar process.

3. The blood supply of each process of the mandibular ramus and its vicinity was shown, also illustrated in the schema, as follows:

   The angular process was nourished chiefly by the angular branch, but also by the mandibular branch. However, when the angular branch was lacking, a branch was supplemented from the posterior deep temporal artery or the medial pterygoid muscular branch.

   The coronoid process was nourished chiefly by the coronoid branch, similar to the angular branch in its distributing feature.

   The area extending from the condylar process to the superior part of the inferior mandibular notch was nourished chiefly by a branch from the transverse facial, and occasionally by the mandibular and the angular branches. The area extending from the process to the inferior part of the superior mandibular notch was supplied chiefly by a branch of the masseteric and additionally by the coronoid branch. The medial side of the process was nourished with a branch from the medial wall of the posterior deep temporal artery.

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Literature cited


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Explanation of Figures

Abbreviations

a Angular branch
Ap Angular process
Cop Condylar process
c Coronoid branch
Cp Coronoid process
ec External carotid artery
Ea External acoustic meatus
f Facial artery
i Inferior alveolar artery
Im Inferior mandibular notch
M₂ Lower second molar
M₃ Lower third molar
m Mandibular branch
ma Masseteric artery
mx Maxillary artery
mp Medial pterygoid muscular branch
p Posterior deep temporal artery
r Retromolar branch
Sm Superior mandibular notch
s Superficial temporal artery
t Transverse facial artery
Tmj Temporomandibular joint
— Direction of the snout
Plate I

Fig. 1. Lateral view of the mandibular branch. The mandibular branch (upper) arising from the medial wall of the maxillary artery is distributed to the external acoustic meatus (ıdır) and the temporomandibular joint capsule (ดา). The other one (below) arising from the lateral wall of the maxillary artery runs antero-inferiorly to the angular process. C. ×5

Fig. 2. Lateral view of the mandibular and angular branches. The mandibular branch arising from the lateral wall of the maxillary artery is distributed to the angular process and anastomoses (ดา) with the angular branch. The masseteric artery gives off the branch (†) to the condylar process. C. ×2.5

Fig. 3. Superolateral view of two mandibular branches. One supplies the condylar process and the other the angular process. C. ×3.5

Fig. 4. Lateral view of the mandibular branch. The branch gives off the branches to the condylar process, to the angular process and to the inferior part of the inferior mandibular notch (ดา), respectively. C. ×3.5

Plate II

Fig. 5. Lateral view of the mandibular ramus. The coronoid branch gives off the branch (ि) to the condylar process. C. ×2.6

Fig. 6. Lateral view of the angular and the coronoid branches, close-up of Fig. 5. The angular and the coronoid branches arise through a common trunk (榇) from the inferior alveolar artery. The angular branch shows a steep curve (ि) with a coiling (ि). C. ×4.5

Fig. 7. Lateral view. The angular branch trifurcates. C. ×2

Fig. 8. Lateral view of the mandibular ramus. The angular branch runs backward horizontally without branching. C. ×1.5

Fig. 9. Lateral view. The posterior deep temporal artery gives off the branch (ि) to the mandibular ramus, and anastomoses (榇) with the angular branch arising from the inferior alveolar artery. C. ×3.3
Plate III

Figs. 10 & 11. Lateral view of the mandibular ramus. The angular branch bifurcates. One (↑) supplies the condylar process and the other (→) the angular process. The coronoid branch also bifurcates. One (\) supplies the coronoid process, and the other (\) the inferior part of the superior mandibular notch and the condylar process. C. ×2.6, 1.6

Fig. 12. Close-up of Fig. 11. The angular branch bifurcates. One (\) supplies the condylar process, and the other (\) the angular process. The coronoid branch arises in common with the retromolar branch (→). C. ×3.5

Fig. 13. Lateral view of the coronoid branch. The medial pterygoid muscular branch gives off the branch (\) to the coronoid process. C. ×2.8

Fig. 14. Lateral view. The mandibular branch supplies the angular process and the inferior part of the inferior mandibular notch (\). The posterior deep temporal artery gives off the branch (→) to the coronoid and angular processes. C. ×2

Fig. 15. Medial view of the condylar process. The posterior deep temporal artery gives off the branch (→) to the condylar process from the medial side. C. ×3.5

Plate IV

Figs. 16, 17 and 18. Lateral and slightly anterior view of the condylar process. The masseteric artery gives off the branch (\) to the condylar process. C. ×5, 3.8, 11

Fig. 19 & 20. Lateral and slightly posterior view of the condylar process. The transverse facial artery gives off the branch (↑) to the condylar process. C. ×2.8, 4.2
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Plate II

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