On the Facial Artery of the Raccoon Dog (*Nyctereutes Procyonoides Viverrinus* Temminck)

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Summary: Detailed observations were made of the facial artery in 20 raccoon dogs (*Nyctereutes procyonoides viverrinus* Temminck) utilizing the plastic injection method. The findings obtained were discussed in comparison with the facial artery of carnivorae. The facial artery diverged anterolaterally from the external carotid artery independently at a position between the origins of the lingual and the posterior auricular arteries when the external carotid bent laterally in front of the tympanic bulla. This artery, immediately after giving off the styloglossal branch, passed forwards superomedial to the digastricus muscle and medial to the insertion of the pterygoideus medialis muscle up to the posterolateral end of the mylohyoideus muscle, where the submental artery was derived. The submental ran forwards, giving off the digastric, the mylohyoid, the sublingual and the cutaneous branches, down to the posterolateral end of the intermandibular symphysis, where it anastomosed with the opposite fellow. The facial artery bent inferolaterally and passed laterally giving off the pterygoid and the inferior masseteric branches, and then emerged out onto the face through the facial vascular notch located inferoanterior to the angular process, which was extremely well developed in this species. The main stream of the artery ran anterosuperiorly at about 40° to the horizontal plane along the anterior margin of the masster muscle, since the notch was located on a projected level posterior to the middle of the zygomatic arch, giving rise en route to the anterior massteric, the mandibular marginal, the buccal and the cutaneous branches. The artery finally divided into the inferior and superior labial arteries at the inferior margin of the mandibular origin of the buccalis muscle in the angle of the mouth. The facial artery of the raccoon dog was thus similar in its origin to that in the dog, cat and lion, but notably different in the short course of its submandibular region, and the nearly horizontal passage of the main route in the face, without the mandibular glandular branch. Additionally an extremely well developed angular process, a submandibular lobe and fairly posterior position of the vascular notch were found.

No precise descriptions have been given of the angiology of the raccoon dog, although there have been a few concerning its tooth and bone morphology. The facial artery represents the main artery of principal vessels supplying the face in man, as reported by Adachi (1928). This artery in man is always developed and distributed not only to the face but also to the submandibular and submental regions with rich ramifications. Differences exist between species in the development of this artery. The present report describes detailed observations of the facial artery including the extremely developed angular process with its vicinity in the raccoon dog, and discusses the findings in comparison with those for other carnivorae.

Materials and Methods

Twenty adult raccoon dogs (*Nyctereutes pro-
eter) arose anterolaterally from the anterior wall of the external carotid artery (2.3–3.0, M. 2.59 mm in diameter) at a position between the origins of the lingual and the posterior auricular arteries as well as between the styloglossus and the mylohyoideus muscles in 38 out of the total of 40 examples (Figs. 1 and 2). No common trunks with the lingual artery were observed. In the other 2 cases, the submental artery arose directly from the external carotid at the position where the facial artery arose in usual cases, in one case anterolaterally distal to the origin of the posterior auricular artery (Fig. 4) and in the other case at the same level as its origin (Fig. 5).

The facial artery, except in the above 2 cases, immediately gave rise to the styloglossal branch and passed forwards between the styloglossus and digastricus muscles and medial to the insertion of the pterygoideus medialis muscle, and then anterolaterally across and above the sublingual gland and the mandibular glandular duct obliquely up to the posterolateral end of the mylohyoideus, where it gave off the submental artery forwards (Figs. 7 and 8). The main stream of the facial artery emerged onto the face via the facial vascular notch (Figs. 2 and 3), which was located inferoanterior to the angular process on a plane projecting posterior to the middle of the zygomatic arch (Fig. 3). However, in the above-mentioned 2 cases, in which the origin of the facial artery was located distal to the origin of the posterior auricular artery, the facial artery was directed to the vascular notch inferolaterally between the masseter and the digastricus muscles (Figs. 4 and 5).

The facial artery in all examples passed anterosuperiorly at a small angle to the horizontal in front of the masseter, giving off the anterior masseteric, the mandibular marginal, the buccal and the cutaneous branches, up to the inferior margin of the buccalis muscle, where it terminated in the inferior and superior labial arteries (Figs. 1, 2 and 15). Both termini in all examples failed to extend up to the median line (Fig. 14), although the facial artery in the above-mentioned 2 cases divided at the vascular notch (Figs. 4 and 5).

II. Branches of the facial artery
1. Styloglossal branch
This branch (0.3–0.6, M. 0.39 mm in diameter) arose from the facial artery in 38 cases of the 40 examples observed, numbering one in 30 (Fig. 6) and two in 8 cases. In the remaining 2 cases, it arose from the submental artery which diverged directly from the external carotid. It was distributed to the styloglossus, sometimes the sublingual gland, the mandibular glandular duct and the digastricus (Fig. 6). In the above 8 cases, in which it was two in number, the distal branch always supplied the above gland and duct.

2. Submental artery
This artery (1.0–1.6, M. 1.24 mm in diameter) arose from the facial artery in 38 of the 40 examples observed and directly from the external carotid in the other 2 cases (Figs. 4 and 5). It appeared as a course continuation of the parent artery and passed anteromedially on the medial surface of the mandible between the origin of the mylohyoideus and the insertion of the digastricus, in company with the mylohyoid nerve. En route, it gave rise to several twigs to the digastricus and mylohyoideus (Fig. 8), and sometimes to the pterygoid and the palatine tonsillar branches additionally (Fig. 7). Posterior to the origin of the genioglossus, it gave off the sublingual artery (1.0–0.8, M. 0.70 mm in diameter) (Figs. 7 and 8). Distal to its origin, the main stream of the facial artery, suddenly diminishing in its diameter, passed anteromedially along the mandibular basis and the inferior margin of the genioglossus up to the intermandibular symphysis, where it anastomosed with the opposite fellow (Fig. 9). A twig diverging forwards from this anastomosis ran upwards between the bilateral geniohyoidei and anastomosed with the sublingual artery inferior to the mandibular glandular duct (Fig. 8), also giving off twigs to the intermandibular symphysis and the geniohyoideus (Fig. 8).

The facial artery arising directly from the external carotid in 2 cases followed a similar course to that of the facial artery in the usual cases, giving off the mandibular glandular branch in one of the 2 cases (Fig. 5).

The sublingual artery after giving rise to cutaneous branches (Fig. 9) passed anterosuperiorly between the mylohyoideus and the genioglossus, giving off twigs to the lingual gingivae of the lower premolars (Fig. 7). It finally supplied the lingual gingivae of the lower incisors passing beneath the sublingual caruncula, anastomosing with the submental artery (Fig. 8).

3. Pterygoid branch
This branch (0.4–0.8, M. 0.43 mm in diameter) arose from the facial artery in 32 of the 40 examples observed (Fig. 10) and from the submental artery in the other 8 cases (including a direct vessel from the external carotid in one case). It passed backwards to supply the insertion of the superficial layer of the masseter, and the insertions of both the digastricus and the pterygoideus medialis. The digastricus was occasionally supplied by a direct branch from the facial artery.
4. Inferior masseteric branch

This branch (0.4–0.8, M. 0.48 mm in diameter) arose from the facial artery in 38 of the 40 examples observed (Figs. 6 and 10), in common with the mandibular marginal branch in one case, and two branches arose from the facial artery in one case (Fig. 4). It passed posterolaterally between the digastricus and the insertion of the masseter to supply them. In the last one case mentioned, the two branches did not supply the digastricus but only the insertion of the masseter (Fig. 4).

5. Anterior masseteric branch

This branch (0.4–0.9, M. 0.61 mm in diameter) arose from the facial artery in 38 of the 40 examples observed (Figs. 1 and 6), and in common with the mandibular marginal branch in 2 cases (Fig. 11). It supplied the insertion of the digastricus, the periosteum of the mandible, and the anteroinferior part of the insertion of the superficial layer of the masseter. However, it did not supply the digastricus in 11 of the above 38 cases (Fig. 13).

6. Mandibular marginal branch and cutaneous branches

Both branches supplied the platysma, the cheek skin and the masseter.

The mandibular marginal branch (0.3–0.7, M. 0.52 mm in diameter), observed in all 40 examples, arose from the facial artery in 30 (Figs. 4 and 13), in common with the cutaneous branch in 8 (Fig. 14), and with the anterior masseteric in 2 cases (Fig. 11). This branch arising at the vascular notch supplied the digastricus, the skin and periosteum of the mandibular basis after passing inferior to the molar gland and the platysma, occasionally anastomosing with peripheral branches of the mental artery (Figs. 13 and 14). This branch arising proximal to the origins of the labial arteries always arose in common with the cutaneous branch and followed the above distribution features.

The cutaneous branches (0.2–0.8, M. 0.48 mm in diameter), observed in all 40 examples, numbered one in 32 (Figs. 12 and 15) and two in 8 cases (Fig. 14). They passed superoposteriorly to supply the skin on the masseter, the parotid duct (Fig. 14), the mandibular lymph nodes (Fig. 16) and the facial nerve (Fig. 17) by formation of a subcutaneous arterial network with vessels of the superficial
temporal and the branch to the superior of the superior labial artery (Fig. 14).

7. Buccal branch

This branch (0.3–0.6, M. 0.46 mm in diameter), observed in all 40 examples, arose from the facial artery proximal to the origins of the labial arteries in 18 (Fig. 11), from the superior labial artery in 16 (Fig. 15), and from the inferior labial in 6 cases (Fig. 14). It arose medially to supply the molar gland, the buccalis muscle and buccal mucosa, anastomosing with twigs of the buccal artery.

8. Inferior labial artery

This artery (0.5–0.9, 0.73 mm in diameter) passed forwards tortuously as a terminus of the facial artery lateral to the upper margin of the molar gland and gave off several molar glandular branches (Fig. 15), 2 or 3 of which diverged directly from the facial (Fig. 14). It passed along the inferior labial margin between the orbicularis oris muscle and the molar gland, anastomosing with peripheral branches of the mental artery (Fig. 14) and en route gave rise to several inferior labial marginal branches upwards (Fig. 14), a mucous branch medially, one or two cutaneous branches laterally and one or two molar glandular branches downwards (Fig. 14).

9. Superior labial artery

This artery (0.8–0.9, M. 0.83 mm in diameter) passed superoanteriorly as the other terminus of the facial artery and bent forwards at the upper margin of the molar gland and gave off several molar glandular branches (Fig. 15), 2 or 3 of which diverged directly from the facial (Fig. 14). It passed along the inferior labial margin between the orbicularis oris muscle and the molar gland, anastomosing with peripheral branches of the mental artery (Fig. 14) and en route gave rise to several inferior labial marginal branches upwards (Fig. 14), a mucous branch medially, one or two cutaneous branches laterally and one or two molar glandular branches downwards (Fig. 14).

Discussion

1. Mandible

Huxley (1880) described the general morphology of the raccoon dog, and Okano (1974) reported the form and measurements of its mandible. Variations of the dentition of this species were investigated by Harada et al. (1989). However, no precise descriptions have been given of the angiology of the raccoon dog. Okano noticed a deep notch located in front of the posterior end of the mandibular angle which was characteristic of this species. The notch was formed between the angular process and the sub-angular lobe (Huxley 1880), as observed in some other mammals such as the fox and C. littoralis. The present authors termed it the facial vascular notch, since the facial artery and vein passed through it as seen in other mammals, although the process and notch are peculiar in their position and form. The digastricus has its insertion on the subangular lobe which, however, corresponds to the mandibular angle in man. The facial vascular notch is usually positioned on the projected plane of the middle or anterior one-third of the zygomatic arch in carnivores, but moves fairly posteriorly towards the basis of the arch in the raccoon dog. The vertical dimension of this species is notably lower than that in the dog and cat, so that the passage of the facial artery takes a forward inclination.

2. Origin of the facial artery

The facial artery always arose independently from the external carotid between the origins of the lingual and the posterior auricular arteries, except in 2 cases. Common trunks between other arteries were not found as in the dog (M. Irifune 1980), cat (Nakamura 1987, Hikida et al. 1989) and lion (Lin et al. 1990) among the carnivores. In the above 2 cases, the facial artery also arose independently, but its origin was distal to the origin of the posterior auricular, while the origin of the submental was situated just at the usual origin of the facial. A similar variation has been reported in the dog (4 of 80 cases by M. Irifune 1980), the cat (2 of 100 cases by Nakamura 1987, one of 100 cases by Hikida et al. 1989) and the lion (one of 6 cases by Lin et al. 1990). The origin of the facial artery of the raccoon dog in both usual and variational cases is thus comparable to that of other carnivores.

3. Ramifications

The first branch is always a fine, styloglossal branch of the submandibular region of the facial artery, as reported in the dog (M. Irifune 1980) and the cat (Nakamura et al. 1987). However, Hürlimann (1913) described that the first branch in the cat was the mandibular glandular branch, rarely arising from the external carotid. Lin et al. (1990) reported that the first branch was the mandibular glandular branch in the lion.

The second branch of the facial artery in carnivores is the glandular branch, although it is not observed in the raccoon dog. Usually, this branch originates from the facial in the dog (Takashima 1967, M. Irifune 1980, Nakamichi 1989), the cat (Takashima 1967, Matsumoto 1983, Nakamura et al. 1987) and the lion (Lin et al. 1990), although it rarely arises from the external carotid, the posterior auricular or the lingual artery, from the submental artery in the human fetus (Takashima 1967) and the
cat (Nakamura et al. 1987). In the raccoon dog, it arose from the submental which is a direct vessel of the external carotid in 2 cases. Thus, the mandibular glandular branch is not included in the ramifications of the facial artery of the raccoon dog, although it is always observed in the dog, cat and lion.

The ramifications in the submandibular region of the facial in carnivores are rich such as the styloglossal, the mandibular glandular, the sublingual glandular, the pterygoid, the masseteric, etc. However, the ramifications in this region of the facial artery comprise only the styloglossal branch and the submental artery in the raccoon dog. The origins of the above branches are located proximal to the origin of the submental artery in the dog, cat and lion, but markedly distal in the raccoon dog. The masseteric branch in the lion may correspond to both the inferior and anterior masseteric branches in the dog, cat and raccoon dog. The origin of the submental artery in the raccoon dog is located proximal to the pterygoid branch of the dog and cat, as well as that of the masseteric branch of the lion.

There may be a tendency for the origin of the submental to be moved fairly proximal in the raccoon dog as compared to other species. The supply territory of the submental artery as well as the anastomosing features immediately behind the intermandibular symphysis in the raccoon dog are similar to those in the dog, cat and lion, although the sublingual artery arising from the lingual does not anastomose with the submental artery in the lion. The sublingual artery supplying the sublingual mucosa and lingual gingivae of the lower incisors in the dog and cat diverges from the submental (M. Irifune 1980, Hikida et al. 1989). The present authors could find a vessel which was identifiable as the sublingual artery, judging from its origin and distribution territory similar to that in the raccoon dog.

The ramifications in the facial region of the facial artery in the raccoon dog are very similar to those in the dog, cat and lion (Takashima, T.: Stereological studies on several ducts and vessels by injection method of acrylic resin. XIII. Arterial distribution of the upper lip in some mammals. Okajimas Folia Anat. Jpn., 40: 81–128, 1964). The ramifications in this region of the facial artery of the raccoon dog is always observed in the dog, cat and lion. That is, the inferior labial artery (Hanai 1964) of the infraorbital is always the territory similar to that in the raccoon dog.

The superior labial artery is also the mandibular marginal branch of the facial and the median line; instead, the lower lip is supplied by the terminal of the dog and cat. That is, the inferior labial artery (Nyctereutes procyonoides viverrinus T.) — Anomalies in number of the teeth. Jpn. J. Oral Biol., 31: 257–264, 1989. (in Japanese)


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Literature cited

Abbreviations for Figures

am : Anterior masseteric branch
an : Oral angular branch
bb : Buccal branch
bs : Branch to the superior
cu : Cutaneous branch
di : Digastric branch
ec : External carotid artery
fa : Facial artery
il : Inferior labial artery
im : Inferior masseteric branch
in : Infraorbital artery
la : Lingual artery
me : Mental artery
mm : Mandibular marginal branch
mx : Maxillary artery
my : Mylohyoid branch
pa : Posterior auricular artery
pt : Pterygoid branch
sb : Sublingual artery
sg : Styloglossal branch
sl : Superior labial artery
sm : Submental artery
st : Superficial temporal artery
A : Angular process
D : Digastricus muscle
H : Mylohyoideus muscle
L : Mandibular lymph node
M : Masseter muscle
MG : Mandibular glandular duct
MO : Molar gland
P : Parotid duct
S : Subangular lobe
ST : Styloglossus muscle
T : Tympanic bulla
→ : Direction of snout

Explanation of Figures

Plate I

Fig. 2. Inferolateral view of the facial artery. Right side. × 0.9.

The superficial layer of the masseter muscle has been removed. The facial artery arises from the external carotid. The origin (O) and insertion (×) of the digastricus muscle are shown.

Fig. 3. Lateral view of the skull of a raccoon dog. Right side. × 1.1.

Characteristic bone marks are indicated as follows; the subangular lobe, on which the digastricus muscle has its insertion (dotted line); the facial vascular notch (✓) located posterosuperior to the lobe on a plane projecting posterior to the middle of the zygomatic arch (+).

Figs. 4 and 5. Inferolateral view of the origin of the facial artery. Left side. × 1.4, × 1.3, respectively.

The facial artery arises from the external carotid distal to the origin of the posterior auricular in Fig. 4, and at the same level as the posterior auricular in Fig. 5. The submental artery arises at the usual position of the origin of the facial in these figures. In Fig. 5, the submental artery gives rise to the mandibular glandular branch (←).
Fig. 6. Inferolateral view of the origin of the facial artery. Right side. × 3.1.

The styloglossal branch arises from the facial and is distributed to the styloglossus, the sublingual gland (•), and the mandibular glandular duct.

Fig. 7. Medial view of the submental artery. Right side of a dissection specimen. × 1.1.

The submental artery gives rise to the palatine tonsillar branch (↓) on the medial surface of the mandible. The sublingual artery passes anterosuperiorly between the mylohyoideus and the genioglossus (G), giving off twigs (→) to the lingual gingivae of the lower premolars. *: Palatine tonsil, o: intermandibular symphysis.

Fig. 8. Medial view of the submental artery. Left side. × 1.1.

The submental artery gives rise to the digastric (←), and mylohyoid (↓) branches and the sublingual artery. A twig (→) diverging forwards from the anastomosis with the opposite submental, gives off twigs (↑) to the intermandibular symphysis (o). The sublingual artery supplies the lingual gingivae of the lower incisors (△). G: Genioglossus muscle.

Fig. 9. Inferior view of the floor of the mouth. × 1.3.

The platysma has been removed. The cutaneous branches (→) arise from the submental artery which passes up to the postero-inferior end of the symphysis, where the artery anastomoses with the opposite fellow (←).
Plate III

Fig. 10. Inferomedial view of the mandibular basis. Left side. × 3.1.
   The facial artery gives off the pterygoid and the inferior masseteric branches. *: Pterygoideus medialis muscle.

Fig. 11. Lateral view of the facial artery. Left side. × 1.6.
   The anterior masseteric and the mandibular marginal branches diverge from the facial artery via a common trunk. The superior labial artery anastomoses (→) with a branch of the infraorbital artery, and the inferior labial with a branch (↘) of the mental artery. ↑: Superior labial marginal branch, ↓: inferior labial marginal branch.

Fig. 12. Inferolateral view of the mandibular basis. Left side. × 2.6.
   The anterior masseteric and the mandibular marginal branches diverge from the facial artery via a common trunk (↘). The former is distributed to the insertion (dotted line) of the digastricus, the periosteum of the mandible (→) and anteroinferior part of the insertion of the superficial layer of the masseter (↓).

Fig. 13. Lateral view of the facial region of the facial artery. Left side. × 1.2.
   The facial artery gives rise to the mandibular marginal branch which anastomoses (↑) with branches of the mental artery. The superior labial artery anastomoses (→) with branches of the infraorbital artery.
Plate IV

Fig. 14. Lateral view of the facial region of the facial artery. Right side. × 1.1.

A cutaneous branch diverges in common with the mandibular marginal branch and the other directly from the facial. The former anastomoses (†) with peripheral branches of the inferior labial and the mental arteries. The latter forms a subepithelial arterial network with similar branches (↗) of the superficial temporal and the branch to the superior (↗). ↓: Inferior labial marginal branch.

Fig. 15. Lateral view of the angle of the mouth. Right side. × 2.1.

The facial artery terminates in the inferior and superior labial arteries in the inferior margin (→) of the mandibular origin of the buccalis muscle (*). The buccal branch arising from the superior labial penetrates the buccalis muscle. The inferior labial gives rise to the oral angular branch. ↗: Molar glandular branch of the facial artery, †: the similar glandular branch of the inferior labial artery, ↓: inferior labial marginal branch.

Fig. 16. Blood supply to the mandibular lymph nodes. Right side. × 1.4.

The nodes are supplied by the cutaneous branches. The buccal branch diverges from the inferior labial artery.

Fig. 17. Lateral view of the angle of the mouth. Left side of a dissection specimen. × 1.3.

A cutaneous branch supplies the parotid duct and the facial nerve (†). *: Parotid gland.