On the A. malaris of the Common Squirrel Monkey
(Saimiri sciureus)

By

Etsuo ISHIDOH

Department of Anatomy, Osaka Dental University,
5-31, Otemae 1-chome, Chuo-ku, Osaka 540, Japan
(Director: Prof. Yoshikuni Ohta)

Key words: Arteria malaris, Infraorbital artery, Blood supply, Plastic injection, Common squirrel monkey

Summary: Detailed observations were made of the a. malaris in 11 adult common squirrel monkeys (Saimiri sciureus) utilizing the plastic injection method. The malar artery was well-developed in all 21 examples observed and arose medially from the infraorbital artery proximal to the entrance of the infraorbital canal and lateral to the obliquus inferior muscle. The a. malaris passed superomedially outside the periorbita on the orbital surface of the maxilla and curved medially in front of the muscle, where it gave rise to the infraorbital nerve, the periosteal, the inferior oblique muscular and the infraorbital marginal branches. However, these branches arose directly from the infraorbital artery in many cases. The malar artery ascended in the lower eyelid up to the bottom of the lacrimal sac, where it gave rise to the third palpebral branch and the medial inferior palpebral artery. This artery did not anastomose with peripheral branches of the supraorbital artery. The malar artery continued to pass superomedially behind the lacrimal sac and gave off the nasolacrimal canal and the lacrimal sac branches. However, the former arose in common with the latter in many cases. The malar artery finally ascended behind the medial palpebral ligament after giving off the dorsal nasal branch and the medial superior palpebral artery at the superior end of the lacrimal sac. Its main stream formed a strong communication with the dorsal nasal artery of the supraorbital artery. This communication in an arc was characteristic in the common squirrel monkey. The medial inferior and superior palpebral arteries were well-developed in all examples and formed distinct, inferior and superior palpebral arterial arches by anastomosing with the lateral fellows of the lacrimal, respectively. A large arterial ring surrounding the upper tarsus was constructed from the superior palpebral arterial arch, branches of the lateral superior palpebral artery and the palpebral branch of the supraorbital artery.

Some descriptions of the a. malaris have been given in textbooks of mammalian anatomy. The term, a. malaris, is found in the Nomina anatomica veterinaria (1973). Recently, detailed findings for this artery have been reported in the dog by Arai (1978), the cat by Inazuka (1986) and the rabbit by Miyake (1987). However, this term is not encountered in human anatomy and the Nomina anatomica japonica (1987), in textbooks of primate anatomy (Lineback 1961, Bast 1961 and Hill 1974) or archives on the angiology

This work was presented at the 93rd Annual Meeting of the Japanese Association of Anatomists in Nagoya on 2 April 1988 and also at the 374th Meeting of the Osaka Odontological Society in Osaka on 15 October 1988.
(Castelli et al. 1965 and Dyrud 1944) of primates. Otsuka (1988) found an artery corresponding to the a. malaris in the Japanese monkey and identified this vessel as the a. malaris based on his detailed findings and the discussions given for the above other mammals. He stated that the main stream of the malar artery in the Japanese monkey was one of component vessels of the nasolacrimal artery, and also made the reasonable suggestion that such an artery may exist in the crab-eating monkey in view of previous research work (Matsukawa 1969) on the blood supply of the maxillary sinus.

The present paper reports detailed observations of the malar artery in the common squirrel monkey (Saimiri sciureus), discussing the results in relation to the descriptions given by previous workers.

Materials and Methods

Eleven adult common squirrel monkeys (Saimiri sciureus) were used. Acryl plastic was injected via the ascending aorta utilizing the plastic injection method (Taniguchi, Ohta et al. 1952, 1955). Ten of the injected heads were prepared to give vascular casts of the carotid system after digesting only the soft structures by treatment with 20% sodium hydroxide solution. Observations and measurements were performed on these 10 heads under a stereoscopic binocular microscope. The other injected head was dissected through the median surface. Its left half was used as a dissection specimen preserved in formalin solution. The right half was fixed and embedded in celloidin after decalcification with 5% nitric acid, sagittally sectioned serially at a thickness of 100 μm, and stained with hematoxylin. These halves were employed to survey the relations between the a. malaris, its ramifications and the surrounding structures. One dry skull of the squirrel monkey was also subjected to examination.

Findings

I. General aspect of the a. malaris (malar artery) (Fig. 1)

The infraorbital artery (240-480, M. 389.6 μm in diameter) passed forwards lateral to the infraorbital nerve and gave rise to the malar artery lateral to the origin of the obliquus inferior muscle after giving off the anterior superior alveolar artery (228 μm in average diameter) anteroinferiorly posterolateral to the origin of this muscle (Figs. 1, 5).

Key to abbreviations in Fig. 1

am: A. malaris
al: Inferior palpebral arterial arch
au: Superior palpebral arterial arch
ia: Infraorbital artery
im: Infraorbital marginal artery
in: infraorbital nerve branch
io: Inferior oblique muscular branch
ll: Lateral inferior palpebral artery
Is: Lacrimal sac branch
lu: Lateral superior palpebral artery
ml: Medial inferior palpebral artery
mu: Medial superior palpebral artery
nc: Nasolacrimal duct branch
nd: Dorsal nasal artery
*: Facial artery.
nr: Nasal radical artery
pb: Periosteal branch
sa: Supraorbital artery
sp: Palpebral branch of the supraorbital artery
te: Third palpebral branch
zb: A branch of the zygomatic artery
i: Obliquus inferior muscle
l: Lower eyelid
n: Infraorbital nerve
o: Infraorbital canal
s: Lacrimal sac
t: Third eyelid
u: Upper eyelid
In about half of the 20 examples observed, the malar artery was so thick that it formed the course continuation of the infraorbital artery (Fig. 4).

The malar artery (240-480, M. 302.7 μm in diameter) (Figs. 1, 4) passed superomedially on the orbital surface of the maxilla outside the periorbita and curved laterally in front of the obliquus inferior muscle (Fig. 5). En route, this artery gave rise to the infraorbital nerve branch (Fig. 6), the periosteal and the inferior oblique branches (Figs. 7, 8, 9). It continued to run superomedially along and above the infraorbital margin, giving off the infraorbital marginal and the third palpebral branches (Figs. 10, 11) up to the inferior end of the lacrimal sac, where it gave rise to the medial inferior palpebral artery (Figs. 10, 13). The
Fig. 2. Schematic drawing of a sagittal section of the lower eyelid (cf. Fig. 17).

Fig. 3. Schematic drawing of a sagittal section of the upper eyelid (cf. Fig. 22).

G : Tarsal gland
M : Orbicularis oculi muscle
☆ : Peripheral conjunctiva
← : A twig to the superior arising from the inferior palpebral arterial arch
□ : A twig of the angular artery
⊙ : Secondary inferior palpebral arterial arch
× : Palpebral marginal branches arising from the secondary arch
* : Peripheral branches of the infraorbital marginal branch
× × : Conjunctive branch
△ : Arterial ring surrounding the superior tarsus
⊗ : Peripheral twigs of the temporal branch of the superficial temporal artery
** : Palpebral marginal branch

malar artery passed superomedially posterior to the lacrimal sac, giving off the lacrimal sac and the nasolacrimal canal branches (Figs. 12, 13), up to the superior end of the sac, where it gave rise to the medial superior palpebral artery and the nasal radical branch (Figs. 12, 13). The main stream of the malar artery ascended along the medial margin of the orbit posterior to the medial palpebral ligament, without decreasing in diameter, and finally arched by making a strong communication with the dorsal nasal artery, which descended
along the medial margin of the orbit, of the supraorbital artery (Figs. 1, 2).

II. Branches of the a. malaris

1. Infraorbital nerve branch

This branch (10-80, M. 24.5 μm in diameter) was observed in all 20 examples. In only 6 cases of them did it arise directly from the malar artery (Figs. 6, 8). In 2 of these 6 cases, it arose via a common trunk (39 μm in average diameter) with the periosteal branch. From this common trunk, the infraorbital branch was given off medially and the periosteal branch anteromedially (Fig. 8). In the other 14 cases, the nerve branch arose directly from the infraorbital artery distal to the origin of the anterior superior alveolar artery (Figs. 5, 7, 13), in 12 of these 14 cases being medial to the origin of the malar artery (Fig. 5) and in the other 2, distal to the origin. In 5 of the above 12 cases and the latter 2 cases, the nerve branch arose in common with the periosteal branch (Fig. 13). The infraorbital nerve branch arising from the malar artery was usually not strong, but stronger than the direct one arising from the infraorbital artery.

2. Periosteal branch

This branch (20-72, M. 41.3 μm in diameter) was observed in all 20 examples. It arose from the malar artery in 8 cases (Fig. 7), in common with the infraorbital marginal branch in 4 of these 8 cases (Fig. 9), in common with the infraorbital nerve branch in 2 (Figs. 8, 14), and independently in the remaining 2 (Fig. 7). In the other 12 of the 20 examples, this branch arose from the infraorbital artery, in 10 of these 12 cases being proximal to the origin of the malar artery (Fig. 5) in 5 of them in common with the infraorbital nerve branch and in the other 5 independently; Fig. 4). In the remaining 2 of the above 12 cases, the periosteal branch arose in common with the infraorbital nerve branch distal to the origin of the malar artery (Figs. 13, 14).

The periosteal branch passed anteromedially and was distributed to a narrow area along the infraorbital margin of the maxilla (Figs. 4, 5).

3. Inferior oblique (muscular) branch

This branch (12-96, M. 48.1 μm in diameter) was observed in 13 of the 20 examples (Figs. 5, 7). In 12 of these 13, it arose from the malar artery and in one case (one of 3 cases in which the origin of the medial inferior palpebral artery was located rather proximally) directly from the infraorbital artery proximal to the origin of the malar artery (Fig. 6). This muscular branch was usually not thick and passed posteromedially to supply only the origin of the obliquus inferior muscle without anastomosing with other branches (Fig. 5). In the 7 cases in which this branch was defective, muscular branches arising from the ophthalmic artery supplied this muscle.

4. Infraorbital marginal branch

This branch (108-192, M. 121.0 μm in diameter) was usually well-developed and was observed in all 20 examples. In 9 of them, it arose from the malar artery (Fig. 11), and in common with the periosteal branch (Fig. 11) in 4 of these 9 (Fig. 9). In the remaining 11 examples, it arose directly from the infraorbital artery proximal to the origin of the malar artery (Fig. 8).

This branch passed forwards giving off fine twigs to the periosteum of the orbital surface of the maxilla. En route, in the above 4 cases, it gave rise to the periosteal branch and curved upwards posterior to the orbital septum, giving off fine twigs to the conjunctiva tunica of the lower eyelid (Fig. 2). These twigs anastomosed with inferior twigs of the third palpebral branch, twigs of the angular artery of the facial artery (Hanai et al. 1975), as well
in the palpebral margin of the lower eyelid, with twigs to the inframedial branch of the inferior palpebral arterial arch (Figs. 15, 16).

5. Third palpebral branch

This branch (72-144, M. 86.2 μm in diameter) arose from the malar artery in all 20 examples (Figs. 1, 15, 16). It passed posteromedially and divided into the inferior and superior twigs (50 μm in average diameter) in a T-shaped manner (Fig. 15) at the third palpebral margin. The former ran inferolaterally along the palpebral margin and anastomosed with the twigs to the conjunctiva of the infraorbital marginal branch mentioned above (Figs. 15, 16). The latter ascended along the palpebral margin anastomosing with a twig of the lacrimal sac branch (39 μm in average diameter) and gave rise to 4-6 fine twigs which arborized to supply the third palpebral margin (Figs. 15, 16).

6. Medial inferior palpebral artery

This artery (120-264, M. 156.8 μm in diameter) diverged from the malar artery in all 20 examples. In 17 of them, it arose laterally at the inferolateral end of the lacrimal sac (Figs. 1, 10, 15, 16). In the remaining 3, it arose immediately distal to the origin of the malar artery and passed in parallel with it until it curved laterally at the above position (Fig. 11).

This artery meandered laterally in the orbital septum located inferomedial to the lower tarsus from a position about 2.5 mm inferior to the inferior palpebral margin (Figs. 16, 17). It finally formed the inferior palpebral arterial arch (11 mm in average length; 100 μm in average diameter) (Figs. 1, 10, 15, 16) by anastomosing with the zygomatic artery at the medial one fourth of the palpebral rima (Figs. 10, 15) and laterally with the lateral inferior palpebral artery (84 μm in average diameter) of the lacrimal artery (Figs. 10, 15, 16).

The inferior palpebral arterial arch gave rise to 3-5 twigs to the superior (80 μm in average diameter) (Figs. 2, 10, 17) and 4-6 twigs to the inferomedial (72 μm in average diameter) (Figs. 15, 16, 18). The former ascended between the lower tarsus and the orbitalis oculi muscle (Figs. 17, 18) up to a position about 1.0 mm inferior to the palpebral margin and radices ciliae, where it divided into lateral and medial twigs in a T- or Y-shaped manner. These formed the secondary arterial arch (47 μm in average diameter) by anastomosing with one another (Figs. 1, 17, 18). The lateralmost of the lateral twigs arched along the lateral canthus and anastomosed (Fig. 19) with a peripheral twig (48 μm in average diameter) from the superior palpebral arterial arch (Fig. 1). The secondary arterial arch gave rise to the palpebral marginal twigs (28 μm in average diameter) at 180-310 μm intervals upwards. These supplied the ciliae, tarsal glands, conjunctiva and skin (Figs. 17, 18). The latter passed inferomedially to the palpebral conjunctiva, anastomosing with twigs of the infraorbital marginal branch (Figs. 2, 15, 16).

7. Lacrimal sac branches

These branches (72-192, M. 140.5 μm in diameter) (Fig. 1) were observed in all 20 examples. They numbered two in 13 cases (Fig. 13) and one in the other 7 cases (Fig. 12), making 33 in total. The branches in 10 of the 13 cases and 5 of the 7 cases arose in common with the nasolacrimal canal branch (Fig. 13).

This branch immediately divided into the superior and inferior branches (Fig. 12). In the above 13 cases in which 2 branches were observed, the superior branch of the proximal sac branch anastomosed with the inferior branch of the distal one (Fig. 13).

The superior branch (96 μm in average diameter) passed superomedially with the malar artery posterior to the lacrimal sac,
giving off twigs to the third palpebra (45 μm in average diameter) medially (Fig. 13), and passed forwards on the superior margin of the sac after ascending on the posterior surface of the sac. It finally terminated to form a coarse network (48-96 μm in diameter of the component vessels) on the nasal dorsum (Figs. 12, 13). A twig to the inferior composing this network formed an arterial circle surrounding the lacrimal sac by anastomosing with a fine twig of the inferior branch (85 μm in average diameter) (Figs. 12, 13). Other twigs ascended on the nasal dorsum and anastomosed with twigs of the nasal radical branch (Fig. 12).

The inferior branch (120 μm in average diameter) curved forwards after giving off the lateral and superolateral twigs (Figs. 12, 13). The former (58 μm in average diameter) passed laterally supplying the medial end of the inferior eyelid and anastomosed with the medialmost twig (90 μm in average diameter) of the inferior palpebral arterial arch (Figs. 12, 13). The latter (62 μm in average diameter) supplied the third palpebra (Figs. 12, 13). The main stream of the inferior branch passed forwards along the inferior margin of the lacrimal sac to supply the sac, although en route, in 15 of the 20 examples, it gave rise to the nasolacrimal canal branch (Fig. 13). The inferior branch divided into fine lateral and medial twigs (Figs. 12, 13). The former (85 μm in average diameter) supplied the skin from the medial canthus to the nasal dorsum (Fig. 12). The latter (85 μm in average diameter) passed superomedially supplying the nasal dorsum and formed the arterial circle surrounding the lacrimal sac mentioned above (Fig. 12) by anastomosing with twigs of the superior branch.

8. Nasolacrimal canal branch

This branch (96-168, M. 108.4 μm in diameter) was observed in all 20 examples. In 15 of them, it arose from the inferior branch of the lacrimal sac branch (Fig. 13). In the remaining 5, it arose independently from the malar artery (Fig. 12). This branch passed inferomedially to enter the orbital orifice of the nasolacrimal canal and descended in the posterolateral wall of the nasolacrimal canal, supplying it, after curving backwards (Fig. 12).

9. Medial superior palpebral artery

This artery (204-288, M. 264.5 μm in diameter) was observed in all 20 examples. It passed laterally from 1.5 mm superior to the superior palpebral margin and between the tarsus and the orbicularis oculi muscle in a meandering fashion (Fig. 22). It formed the superior palpebral arterial arch (12 mm in average length; 120-249 μm in diameter) by anastomosing with a branch to the medial of the lateral superior palpebral artery of the lacrimal artery (Figs. 3, 20, 23). This arterial arch (Fig. 3) gave off 4-7 twigs (60-192 μm in diameter downwards, which passed inferiorly or inferomedially and gave off abundant palpebral marginal twigs and conjunctive twigs (48 μm in average diameter, respectively) (Fig. 21). The conjunctive twigs supplied the margin of the upper eyelid in an arborizing fashion. The palpebral marginal twig penetrated the superior tarsus passing between the lobuli of the tarsal glands backwards (Figs. 3, 22) and ascended on the posterior surface of the tarsus, giving off numerous regular twigs to the tarsus and conjunctiva like a comb (Figs. 3, 21, 22).

(NOTE) Lateral superior palpebral artery and the palpebral branch of the supraorbital artery

The lateral superior palpebral artery (110-216, M. 155.4 μm in diameter) of the lacrimal artery trifurcated into the medial, the superomedial and the superior branches when it reached the eyelid. The former (153 μm in average diameter) formed the superior palpebral arterial arch by anastomosing with the medial superior palpebral (Figs. 1, 20, 23); the middle (173 μm in average diameter)
supplied the bulbar conjunctiva from the lateral end of the tarsus (Figs. 1, 23); the last (180 \( \mu \)m in average diameter) anastomosed with the palpebral branch of the supraorbital artery after passing superomedially along the lateral margin of the superior tarsus and medially along its superior margin (Figs. 1, 23).

The palpebral branch (168-336, M. 210.6 \( \mu \)m in diameter) of the supraorbital artery descended down to the superior tarsus posterior to the orbicularis oculi muscle and divided into branches to the inferior and to the superolateral (Fig. 23). The former (170 \( \mu \)m in average diameter) descended between the tarsus and the orbicularis oculi and anastomosed with the superior palpebral arterial arch (Figs. 1, 23); and the latter (184 \( \mu \)m in average diameter) formed a large arterial ring surrounding the superior tarsus by anastomosing with the branch to the superior of the lateral superior palpebral artery in association with the superior arch (Figs. 1, 23). This ring was constructed from the following parts (Fig. 1): the inferior half by the superior palpebral arch, the lateral and superior parts by the branch to the superior of the lateral superior palpebral artery, and the medial half by the palpebral branch of the supraorbital artery (Fig. 23). Abundant twigs diverged from this ring to the tarsus and formed an incomplete arterial network on the posterior surface of the superior tarsus in association with other adjacent branches after penetrating the tarsus (Figs. 22, 23). Many other small twigs from this ring supplied the frontalis muscle, anastomosing with the frontal branch of the superficial temporal artery (Figs. 3, 20).

10. Nasal radical branch

This branch (72-180, M. 123.8 \( \mu \)m in diameter) was observed in all 20 examples. It arose medially from the malar artery and arborized anteromedially on the nasal radix (Figs. 1, 12, 13). Its medial twigs anastomosed with the opposite fellows (75 \( \mu \)m in average diameter). A branch to the inferior (88 \( \mu \)m in average diameter) of it anastomosed with the palpebral twigs of the lacrimal sac branch, and a branch to the superior anastomosed with the dorsal nasal artery of the supraorbital artery. Through these anastomoses, a coarse arterial network was formed on the nasal radix and dorsum (Figs. 1, 12).

Discussion

No description of the a. malaris of primates is found in anatomical textbooks and archives of angiology. Otsuka (1988) stated that this artery in *Macaca fuscata* was similar in its features to that of the dog (Arai 1978), cat (Inazuka 1986) and rabbit (Miyake 1987) as regards its origin, location, principal ramifications and supply to the nasolacrimal canal as a terminal branch. He attempted to discuss the r. naso lacrimalis of the infraorbital artery described in a report by Matsukawa (1969) concerning the nutrient arteries of the maxillary sinus of the crab-eating monkey, and stated this ramus should be the a. malaris.

The present author confirmed the existence of the a. malaris in Saimiri sciureus in *Platyrhini E.*. The development of this vessel was always much better than that in the Japanese and crab-eating monkeys in *Catarrhini E.*. The origin of this artery in *S. sciureus* was located on the infraorbital artery immediately proximal to its entrance of the infraorbital canal and at a position lateral to the origin of the obliquus inferior muscle. The ramifications of this artery were not similar to those of the dog, cat and rabbit. Some branches arising near the origin of the malar artery in the common squirrel monkey arose directly from the infraorbital artery in many cases of all the examples observed. Such a branching aspect differs from that of the Japanese monkey. The ramifications of the malar artery in other
On the A. malaris of the Common Squirrel Monkey (Saimiri sciureus) 121

mammals described previously by other workers are summarized in Table I.

The origin of the infraorbital nerve branch was located on the infraorbital artery at a position proximal to the origin of the malar artery in a large number of the examples observed, while this branch arose constantly from the infraorbital artery in the dog, cat and rabbit. These different features in the squirrel monkey and other animals may be related to topographical aspects such as the length of the infraorbital artery up to the entrance of the canal and more proximal branching of the infraorbital artery itself as seen in the Japanese monkey.

The periosteal and infraorbital marginal branches also arose directly from the infraorbital artery in many cases. The former was not strong, similar to that of the Japanese monkey and often arose in common with the latter. The supply territory of the latter usually extended to the conjunctiva of the lower eyelid, which was wider than that in the Japanese monkey. This difference reflected the size of the lower eyelid itself.

The inferior oblique muscular branch was commonly fine, and less than that of the Japanese monkey. The third palpebral branch was sufficiently developed.

The medial inferior and superior palpebral arteries were well-developed, although the supply territory of these vessels never reaches the eyelid in the Japanese and crab-eating monkeys. Both arteries communicated strongly with the lateral fellows of the lacrimal artery and constructed arterial arches in the respective eyelids, as seen in the rabbit. However, the a. malaris of the cat was described by Inazuka (1986) to give rise to the medial superior and inferior palpebral arteries which anastomosed with the lateral fellows of the superficial temporal arteries, but never constructed any arterial arches as mentioned above. Arai (1978) reported in the dog that the inferior palpebral artery arch was observed in spite of the lacking of the lateral inferior palpebral artery.

Both the lacrimal sac and the nasolacrimal canal branches provided a rather rich supply to the sac and its vicinity, as seen in the dog, cat and rabbit, since the passage of the malar artery itself was located just close to and

| Table 1. Comparative aspects of the a. malaris in some mammals. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| 1. Parent artery | Dog | Cat | Rabbit | Japanese monkey | Common Squirrel monkey |
| 2. Portion of origin | Intraorbital artery |
| 3. Branches | Infraorbital canal |
| 1) Infraorbital nerve b. | + |
| 2) Nasolacrimal canal b. | + |
| 3) Periosteal b. | + |
| 4) Inferior oblique m. b. | + |
| 5) Third palpebral b. | --- |
| 6) Infraorbital marginal b. | + * |
| 7) Lacrimal sac b. | + |
| 8) Nasal radical b. | + |
| 9) Med. inf. palpebral b. | + |
| 10) Med. sup. palpebral b. | + |

+: Present, —: defective, *: arising from 10).

NOTE: The present findings are added to Otsuka's table (1988).
behind these structures. The nasolacrimal canal branch arose in common with the lacrimal sac branch in many cases. In the squirrel monkey, the latter was usually not developed in contrast to that of the rabbit and naturally extended to the nasolacrimal canal which is an extension of the lacrimal sac. Inazuka (1986) reported that the medial superior and inferior palpebral arteries in some cases of the cat arose close to the origin of the lacrimal sac branch. Otsuka (1987) found that either palpebral arteries in restricted cases of the Japanese monkey arose from the lacrimal sac branch. Accordingly, it may be taken as the usual aspect that the sac branch directly leaves the malar artery, as seen in the squirrel monkey. Finally, the present author agrees with the above suggestion that the malar artery in the squirrel monkey gives rise to the medial inferior and superior palpebral arteries and the lacrimal sac branch, and makes a strong communication with the dorsal nasal artery of the supraorbital artery.

The locational differences found between the superior and inferior palpebral arterial arches may be due to the differences in size of the upper and lower tarsi, especially the longitudinal length of the tarsal glands as shown in Figs. 2 and 3.

At the termini of the malar artery, the diameter of this artery where the nasal radical branch diverged did not decrease in spite of the last ramification. It is difficult to identify either vessel as a terminus of the parent artery because the main stream of the artery formed a strong communication with the dorsal nasal artery of the supraorbital artery. In the dog and rabbit, the dorsal nasal branch was a terminal branch of the malar artery. In the cat, it was a branch diverging from the medial or lateral inferior palpebral artery. The present author concluded provisionally that this branch was not one of the termini but one of the ramifications because the distribution features of this branch appeared similar to those in the other species. However, special mention should be made of the fact that the terminal continuation of the malar artery in the squirrel monkey always made an obvious strong communication with the dorsal nasal artery, maintaining a still rather large diameter. In addition to these characteristics, a large, distinct arterial ring surrounding the upper tarsus was constructed by the superior palpebral arterial arch, branches of the lateral superior palpebral arterial arch and the palpebral branch of the supraorbital artery.

Acknowledgments

The author wishes to express his sincere gratitude to Professor Yoshikuni Ohta for critically reading this manuscript, and to Professor Takao Tokioka, Department of Anatomy, Meikai University Dental School, Assistant Akimichi Takemura, D.D.S. and all staff members of the Department of Anatomy for their invaluable assistance.

References


Key to abbreviations in figures

- am: A. malaris
- al: Inferior palpebral arterial arch
- au: Superior palpebral arterial arch
- ia: Infraorbital artery
- im: Infraorbital marginal artery
- in: Infraorbital nerve branch
- io: Inferior oblique muscular branch
- il: Lateral inferior palpebral artery
- ls: Lacrimal sac branch
  - ls1: Br. to the proximal
  - ls2: Br. to the distal
  - ls3: Br. to the superior
  - ls4: Br. to the inferior
- lu: Lateral superior palpebral artery
  - lu1: Br. to the proximal
  - lu2: Br. to the superomedial
  - lu3: Br. to the superior
- ml: Medial inferior palpebral artery
- mu: Medial superior palpebral artery
- nc: Nasolacrimal duct branch
- nd: Dorsal nasal artery
- nr: Nasal radical artery
- pb: Periosteal branch
- sa: Supraorbital artery
- sp: Palpebral branch of supraorbital artery
  - sp1: Br. to the inferior
  - sp2: Br. to the superolateral
- te: Third palpebral branch
- zb: A branch of the zygomatic artery
- G: Tarsal gland
- I: Obliquus inferior muscle
- L: Lower eyelid
- M: Orbicularis oculi muscle
- N: Infraorbital nerve
- O: Infraorbital canal
- S: Lacrimal sac
- T: Third eyelid
- U: Upper eyelid
- ←: Direction of snout
Explanation of Figures

Plate I

Fig. 4. Superolateral view of the infraorbital artery and a. malaris. Left side, × 5.
The superior and lateral walls of the orbit were removed and the eyeball was raised. B: lacrimal bone.

Fig. 5. Superior view of the inferior wall of the orbit. Dissection specimen, left side. × 7.5.
The a. malaris arises from the infraorbital artery lateral to the origin of the obliquus inferior muscle.
In this case, the malar artery appears as a direct continuation of the infraorbital artery, since it is thicker
than that of the infraorbital (ia2) after giving off this artery. The malar artery gives rise to the inferior
oblique muscular branch anterior to its origin. The periosteal and the infraorbital nerve branches arise
directly from the infraorbital artery (ial) proximal to the origin of the malar artery.

Figs. 6, 7 and 8. Anterolateral views of the origin of the a. malaris. The infraorbital canal was opened.
Fig. 6. Right side, × 24. The inferior oblique branch arises from the infraorbital artery distal to the
origin of the malar artery and passes backwards medial to it (dotted line). The infraorbital nerve branch
arises from the malar artery.
Fig. 7. Left side, × 13. The malar artery gives rise to the inferior oblique, the infraorbital marginal
and the periosteal branches. The infraorbital nerve branch arises directly from the infraorbital artery
proximal to the origin of the malar artery.
Fig. 8. Left side, × 15.2. A common trunk (↓) between the infraorbital nerve and the periosteal branches
arises from the malar artery. The infraorbital marginal branch arises directly from the infraorbital artery.
Plate II

Fig. 9. Anterolateral view of the origin of the malar artery. Left side, ×24.
The infraorbital canal was opened. ➔: A common trunk between the infraorbital and the periosteal (2 in number) branches.

Fig. 10. Anterior view of the lower eyelid and the infraorbital margin. Left side, ×14.
The malar artery passes superomedially along the infraorbital margin, giving off the infraorbital marginal branch, and gives rise to the medial inferior palpebral artery, which forms the inferior palpebral arterial arch by anastomosing with a twig of the zygomatic artery (*) and the lateral inferior palpebral artery. Twigs to the superior (←) diverge from this arch.

Fig. 11. Anterior view of the lower eyelid and the infraorbital margin. Left side, ×5.2.
The medial inferior palpebral artery arising from the malar artery passes in parallel with the parent artery and curves laterally at the inferolateral end of the lacrimal sac.

Figs. 12 and 13. Anterolateral views of the medial canthus. Right side, ×9.4, respectively.
The lacrimal sac branch divides into the superior and the inferior branches. The former forms a coarse network after giving off twigs (*) to the third eyelid and to the lacrimal sac, anastomosing with palpebral twigs of the dorsal nasal branch. The latter gives rise to the lateral twig (○) which anastomoses with twigs of the inferior palpebral arterial arch, and the superolateral twig (X) which supplies the third eyelid. The main stream of the latter divides into lateral twigs (□) to the skin and medial twigs (XX) which supply the nasal dorsum. It finally forms an arterial circle (△) surrounding the lacrimal sac by anastomosing with peripheral twigs of the former. The dorsal nasal branch anastomoses with the opposite fellow, the lacrimal sac branch and twigs of the dorsal nasal artery.

Fig. 12. The malar artery gives rise to the lacrimal sac and the nasolacrimal canal branches behind it, and also to the medial superior palpebral artery above it. The malar artery ascends and anastomoses with the dorsal nasal artery (nd).

Fig. 13. A common trunk (□) between the infraorbital nerve and the periosteal branches diverges from the infraorbital artery proximal to the origin of the malar artery. Two lacrimal sac branches, the dorsal nasal branches and the medial superior palpebral artery diverge from the malar artery. The superior branch of the proximal one (ls1) of the lacrimal sac branches anastomoses with the inferior branch of the distal one (ls2). The inferior twig (ls4) of the above proximal branch gives rise to the nasolacrimal branch. C: Nasolacrimal duct.
Plate III

Fig. 14. Superolateral view of the infraorbital artery. Left side, ×11.
The periosteal branch arises directly from the infraorbital artery in common (↗) with the infraorbital nerve branch proximal to the origin of the malar artery.

Figs. 15 and 16. Anterolateral views of the lower eyelid and part of the upper eyelid. Left side, ×12, and right side, ×12.2, respectively.
The infraorbital marginal branch supplies the palpebral conjunctiva and anastomoses with twigs (⊙) of the angular artery, of the zygomatic artery (zb) and twigs (×) to the conjunctiva of the medial inferior palpebral artery.
The third palpebral branch divides into the superior (△) and the inferior twigs (*). The former passes inferolaterally and anastomoses with twigs of the infraorbital marginal branch. The latter ascends and anastomoses with twigs of the infraorbital marginal branch. The latter ascends and anastomoses with the lacrimal sac branch. Both branches supply twigs to the palpebral margin.
The medial inferior palpebral artery arises from the malar artery laterally and forms the inferior palpebral arterial arch by anastomosing with peripheral branches of the zygomatic artery and the lateral inferior palpebral artery. Twigs (←) are seen to arise from this arch.
Plate IV

Figs. 17, 18 and 19.

Fig. 17. Sagittal section (cf. Fig. 2). ×25.
Fig. 18. Anterior view of the middle part of the lower eyelid. Right side, ×20.
Fig. 19. Anterior view of the lateral canthus. Right side, ×12.
The inferior palpebral arterial arch in the periorbita gives rise to a twig (←) superiorly which ascends between the tarsus and the orbicularis oculi and forms the secondary arterial arch (⊙) by anastomosing with adjacent ones after giving off muscular branches to the orbicularis oculi anteriorly (×). The inferior orbital marginal branch diverges from the secondary arch. There is an anastomosis (↑) between twigs of both the inferior and superior palpebral arterial arches.

Figs. 20, 21, 22 and 23.

Fig. 20. Anterior view of the upper eyelid. Left side, ×12.2.
Vascular casts of the skin and the orbicularis oculi were removed.
Fig. 21. Inferior view of the superior palpebral margin. Right side, ×20.
↑: Orifices of the tarsal glands.
Fig. 22. Sagittal section of the upper eyelid (cf. Fig. 3). ×25.
Fig. 23. Transparency of the vascular pattern in the upper eyelid. Right side, ×10.5.
The peripheral branch of the supraorbital artery divides into a branch to the inferior (spl) which anastomoses with the superior palpebral arterial arch and a branch to the superolateral (sp2). The lateral superior palpebral artery trifurcates into branches to the medial (lu1), to the superomedial (lu2) and to the superior (lu3). The former forms the superior palpebral arterial arch by anastomosing with the medial superior palpebral artery; the middle supplies the palpebral conjunctiva; and the latter forms an arterial ring surrounding the superior tarsus by anastomosing with branches of the supraorbital artery, a branch to the inferior (spl) and the superior palpebral arterial arch (▲). This arch gives rise to twigs to the inferior (⊙), which spreads to the inferior, infralateral and medial to give off abundant palpebral marginal twigs (★). They give off conjunctive twigs (×) backwards.