Microvascular Architecture of the Hard Palatine Mucosa in the Rabbit

By

Hiromi IKE

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

—Received for Publication, September 27, 1989—

Key words: Transverse palatine plica, Hard palate, SEM, Plastic injection, Rabbit

Summary: SEM studies on the microvascular architecture of the hard palatine mucosa, especially the transverse palatine plicae, and the morphological relations between the microvasculature and layers of the hard palate mucosa of the rabbit, were carried out by the acryl plastic injection method. The findings were compared with those obtained previously in the cat and Japanese monkey. Morphological differences and similarities between the papillae in the lamina propria and the capillary loops in the papillae were elucidated by SEM.

A boneless area was found in the hard palate since the palatine fissures occupied a large area between the diastemata. The transverse palatine plicae numbered 14-16 symmetrically in the hard palate, and were more developed than those in the cat and Japanese monkey. In sagittal sections of the hard palate, the transverse palatine plicae were observed to be serrated, since they were located close to each other with small narrow interplical regions. The plical branches were usually derived from the major and minor hard palate arteries, and formed the primary arterial network in the submucous layer of the hard palate. Twigs diverging from this network formed the second arterial plexus in the lamina propria, and furthermore, a subepithelial capillary network was formed immediately beneath the epithelium. From this network, capillary loops sprouted into papillae. Similarities were found between the papillae and capillary loops with locational differences. The descending crus of the capillary loop drained into the venous site of the subepithelial capillary network which flowed into the primary venous plexus in the lamina propria, which finally poured into the second venous plexus in the submucous layer. This plexus was termed the palatine venous plexus, and was especially well-developed in the area covering the palatine fissures. The capillary loops in the plica displayed characteristic features according to the portions within it and the interplical regions.

The morphological features of the transverse palatine plicae in mammals present different characteristics related to their food habits. Accordingly, the form and arrangement of the plicae have been studied by many investigators on a comparative basis. On the other hand, the correlation between each plica and the microvasculature within it has been described in the cat by Toda (1986) and the Japanese monkey by Kajiwara (1989) based on scanning electron microscopy. The capillary loop in the plica of the human adult and fetus was studied by Suzuki (1964) employing the india ink injection method.

In the hard palate of the rabbit, there is a defect of the osseous structure covering a large area but well-developed transverse palatine plicae are located close to one another, although the rabbit belongs to the Rodentia and is a herbivore.

The present author examined the detailed morphology of the hard palatine mucosa, the transverse palatine plicae and the microvascular architecture in each of them in the rabbit by scanning electron microscopy. In particular, the blood capillary pattern in the plica was observed from plastic microcasts. Morphological similarities and differences between the plica and the capillary architecture were elucidated three-dimensionally.

Materials and Methods

Twenty adult rabbits were employed for this study. They were bled to death after injecting heparin intravenously. The following specimens were prepared for observation.

1) Microvascular casts

Acryl plastic was injected into the common carotid arteries of the rabbit utilizing the plastic injection method (Taniguchi, Ohta et al., 1952, 1955 and Ohta et al., 1989). The injected palate was dissected after taking an alginate impression of the palate in order to
prepare a plaster model of its mucous surface. Soft structures of the palate region were treated with 10% sodium hydroxide to prepare microvascular casts of the palate and its vicinity. This material, coated with gold, was observed under a scanning electron microscope (SEM) (JSM-T300, JEOL).

2) Histological slides

The palate injected with acryl plastic was fixed in 10% formalin solution, embedded in cellloidin and sectioned serially at a thickness of 150 μm in the sagittal and frontal directions. Also, uninjected materials fixed in 10% formalin solution were embedded in cellloidin and sectioned serially at a thickness of 20 μm. All these sections were stained with hematoxylin-eosin.

3) Specimens of epithelium-separating materials

The palatine mucosa after being dissected out was subjected to separation of its epithelial layer from the lamina propria by treatment with 2 N sodium bromide. This material was fixed with 2% glutaraldehyde, postfixed with 1% osmium tetroxide and freezing-dried in t-butyl alcohol (Inoue et al., 1988). Samples were coated with gold and observed under the SEM in order to examine the morphology of the papilla of the lamina propria and the relations between it and the microvasculature.

Findings

1. Macroscopic aspects

A. Bony palate

The bony palate of the rabbit was composed of the bilateral bodies (Bensley, 1948) (lateral portion of the palatine lamina of the intermaxillary bone as designated by Tsusaki, 1954) and the palatine processes (medial portion of the palatine lamina of Tsusaki) of the incisive bone, the palatine processes of the maxillae and the horizontal plates of the palatine bone. The bony palate of the rabbit was distinguished by long diastemata occupying about 80% of the sagittal length of the whole palate. Additionally, the incisive foramen was so large that it has been termed the fissura palatina (NAV, 1973) (Fig. 2). The anterior half of this fissure with a round margin was surrounded by the body and the palatine process of the incisive bone. The posterior half with a sharp margin was surrounded by the posterior half of the diastema and the palatine processes of the maxillae. The fissures of both sides were located close to each other in the median line appearing as an elongated heart shape (Fig. 2), so that the osseous structure was widely defective in the fissures. The width of the palatine process of the maxillae was narrow in both the sagittal and frontal directions. Its length was equal to that of the premolar and molar arch, and the posterior margin of the processes was connected with the horizontal plates of the palatine bone in the transverse palatine suture. At its posterolateral end, a pair of palatine foramina was observed. The posterior margin of the palate protruded backwards along the median palatine suture.

B. Hard palate

The shape of the hard palate appeared as a long equilateral triangle surrounded by the incisors and diastemata and posteriorly a rectangle attached to the triangle between the bilateral premolars and molars (Fig. 2). The anteriormost portion immediately posterior to the incisors gradually widened backwards, being widest at the posterior end of the diastemata (at the level of the 9th or 10th transverse palatine plica), and again narrowed between the bilateral posterior teeth (Fig. 2). The posterior end was located at the level of the first molars or posteriormost transverse palatine plicae (Fig. 2).

The hard palate curved upwards in sagittal sections (Fig. 4). This curvature was more slight between the molars. In frontal sections, the palate was slightly swollen before the molars but appeared as a V-shaped concave line along the median palatine suture between the molars.

The transverse palatine plicae were observed to number 14 to 16 symmetrically (Fig. 2). The anteriormost of them was located bilateral to the incisive papilla (Fig. 2). Among all plicae, the typical form belonged to type I (Iwaku, 1976). The plica located in the posterior half of the palate were not regular in form. A short unilateral plica which did not adhere to the opposite one in the median line and belonged to type II (Iwaku), and sometimes a small dividing plica (Papillargruppen of Gegenbauer, 1878) of the modification type (Iwaku), were observed. Each plica was covered with a smooth mucosa without any undulations (Figs. 2 and 5). The intervals between the plicae were generally not long but resembled the notches of a saw or serrations (Fig. 4).

The author attempted to group the hard palate into three portions as shown in Fig. 2, since locational differences were found among the plicae in terms of their morphology. An area around the incisive papillae was termed the incisive portion, another area on the palatine fissure the palatine fissure portion, and another area between the bilateral posterior teeth the molar portion, respectively (Fig. 2).

The transverse palatine plicae in the incisive portion were observed to number one or two, which passed posterolaterally from the posterolateral end of the incisive papilla (Fig. 2). Each of them was short and appeared as an inverted V-shape since the unilateral plica adhered to the opposite one in the median line (Fig. 2). In sagittal sections of the plica, its anterior slope was long and inclined slowly posteroinferiorly, the ridge or top of it was sharp, and its posterior slope was short and notched anterosuperiorly (Fig. 4). In
general view, the plica resembled a thick board (Fig. 5), being impressed with its posterior slope overlapped by the anterior slope (Fig. 4). The flat zone between the plicae was extremely narrow because the bottom of the posterior slope suddenly became the anterior slope of the next posterior plica (Fig. 4). In the palate fissure portion, the plicae numbered eight or nine which usually adhered bilaterally (Fig. 2). They were represented by the typical form in the rabbit. A plica in the posterior half of the fissure portion was directed to the anterolateral from its median end, immediately arched laterally approximately in parallel with the frontal plane and bent anteriorly or anterolaterally at the lateral margin of the diastema (Fig. 2). The plica was adherent to the opposite one with a longitudinal recess (Fig. 5) at the median line and revealed a \(-/-\)-shape, but plicae in the anterior half of the fissure portion became obscure and revealed a \(-/-\)-shape (Fig. 2). In sagittal sections, the anterior slope was rather steep with a round ridge and the posterior slope was shorter and descended perpendicularly to the interpalatine bottom. The plica thus appeared as a tall rectangle with small flat interpalatine regions (Figs. 4 and 8). In the molar portion, the transverse palatine plicae numbered four or five (Figs. 2 and 4). Most of them passed mediolaterally in a straight course (Fig. 2). No plica was ever connected with the opposite one since it was cut by the V-shaped concavity in the median line (Fig. 2). In sagittal sections, the anterior slope of the plica in this portion was similar to the posterior slope in length (Fig. 4). The plicae were lower than those in the palate fissure portion appearing as round triangles with small flat interpalatine regions (Fig. 4).

2. Histological features

The stratified squamous epithelium covering the hard palate was similar to all averages in thickness. The lamina propria was generally thin. However, it was relatively thickened around the incisive papilla, and was swollen in itself to form the transverse palatine plicae which were composed of dense fine collagen fibers (Fig. 4). The border between the bases of the plicae and the submucous layer was observed to be flat (Fig. 4). Locational differences were found in the number and form of the papillae in the lamina. In general, the papillae were tall on the anterior and posterior slopes and the ridge or top of the plica, but low in the interpalatine area (Fig. 8). The height of the papillae in the interpalatine region in the incisive portion was rather distinct.

The submucous layer covering the palate fissure was particularly thick since the osseous element was defective (Figs. 4 and 5). Conversely, since this layer was defective in the median area of the molar portion, the lamina propria was directly in contact with the periosteum in the manner of the mucoperiosteum. In the submucous layer, a well-developed palatine venous plexus was observed and was composed of thick venous vessels mainly passing sagittally (Figs. 4 and 5), being particularly well-developed on the palate fissure (Fig. 5). This layer was separated from the similar layer or venous plexus of the nasal mucosa by a connective tissue membrane extending from the surrounding periosteum in order to cover and close the fissure (Figs. 4 and 5). The separation was not complete, however, and a few communications were seen between venous vessels on both the nasal and palate sides. The membrane closing the fissure crossed a continuation of a similar membranous element of the nasal septum rectangularly (Fig. 5). Since this continuation reached the submucous layer of the hard palate, the palatine venous plexus was also incompletely separated (Fig. 5). Bilateral to the incisive papilla, the nasopalatine canals opened in the shape of a semilunar hiatus. No palatine glands were found in the hard palate.

3. Vascular architecture

A. Arterial system

i) Arterial supply of the hard palate

The hard palate was supplied by the major and minor hard palate arteries (Sawa, 1961), both of which reached the palate via the palatine foramen (Fig. 6). The main stream of the latter passed backwards to supply the soft palate, and its ramifications spread radially in a deep layer of the submucous tissue of the hard palate between the molars. Branches to the posterolateral of them were distributed to the lateral one third of the 14th to the 16th plicae as the plical branches, and branches to the posteromedial were distributed to the medial two thirds of these plicae. All plical branches of the minor hard palate artery were usually not thicker than the plical branches of the major hard palate artery, and passed in the palate venous plexus close to the periosteum.

The major hard palate artery passed forwards lateral to the middle line between the posterior teeth and median line. This artery subsequently ran gradually in a shallow layer separated from the periosteum (Fig. 6) and superficial to the venous plexus at the level of the posterior end of the palate fissure, and then continued on the lateral margin of the fissure. The end of the artery bent rectangularly immediately behind the minor incisor medianwards and anastomosed with its opposite fellow to form a unilateral vessel in a position anterior to the opening of the nasopalatine canal. The major hard palate artery gave off the medial and lateral branches as the plical branches (Fig. 6), independently or in common with each other. These branches passed in the palate venous plexus in the molar portion (Fig. 6), but superficial to it in the incisive and the palate fissure portions. In the 3rd to the 5th plicae, the bilateral medial branches anastomosed with
each other. However, some of them in the palatine fissure portion did not anastomose but bent to enter the fissure onto the nasal mucosa. All plical branches formed a primary arterial network (submucous arterial network), being located in the venous plexus in the molar portion of the hard palate and superficial to the plexus in both the incisive and palatine fissure portions (Figs. 1 and 7). In the molar portion, other branches of the major hard palatine artery spread radially and formed an arterial network on the periosteum (Fig. 6).

ii) Microvascular architecture in the transverse palatine plica and interplical region

Small twigs diverging from the primary or submucous arterial network were directed to the plica and interplical region (Figs. 1 and 7). Those directed into the plica were generally thick and large in number, but those to the interplical region were thin and small.

In the incisive and palatine fissure portions, these twigs immediately arborized in the lamina propria where they formed a second arterial network (Figs. 1 and 7) because the primary arterial network was located superficial to the venous plexus. In the molar portion, these twigs penetrated the venous plexus to the lamina propria where they arborized and formed the second arterial network (Fig. 6) because the primary arterial network was located just in the venous plexus. The second arterial network appeared as a complicated and thick plexus; that is, it was more dense in the plicae of the incisive portion but coarse in the palatine fissure and molar portions and usually coarse and obscure in the interplical region (Figs. 1 and 7).

The second arterial network gave rise to smaller twigs towards the epithelium and formed a subepithelial capillary network (Fig. 3) both in the plica and interplical region (Figs. 1 and 7). This network was flat on the anterior and posterior slopes of the plica and interplical region, and complicated dense meshes were present on the ridge or top of the plica (Figs. 1 and 7). The meshes of the network, being fine and dense, were elongated sagittally (Fig. 3). The meshes in the interplical region were coarse and elongated sagittally.

B. Morphological relations between the capillary loop and the papilla of the lamina propria

Morphological resemblances were always found
between the capillary loop and papilla, although loca-
tional differences were found among them.

In general, an ascending crus arose from the arterial
side of the subepithelial capillary network into the
papilla of the lamina propria, where it formed a
capillary loop, from which a descending crus drained
down into the venous side of the capillary network (Fig.
1). The papillae were lined in the sagittal direction, that
is, crossing the ridges or tops of the plicae rectangu-
larly. The capillary loops in the dividing small plica
(Gegenbauer, 1878) radiated, and each loop appeared
as a tall hair-pin.

Detailed morphological aspects of the papilla, the
capillary loop and the interplical region will now be
described.

i) Incisive portion (Figs. 9-14)

The anterior slope of the plica: The papillae were
dense and apparently lined in the sagittal direction (Fig.
9). Each papilla resembled a slender and tall cone with
a sharp tip (Fig. 9). The capillary loop appeared as a
typical, single and tall hair-pin with a narrow interval
between the ascending and descending crura (Fig. 10).

The ridge of the plica: The papillae were dense but
lined obscurely. Each papilla resembled a low cylinder
of irregular size with a round tip but lower than that
in the anterior slope. The capillary loop was lower than
that in the anterior slope and appeared as a hair-pin
with a wide interval between the crura.

The posterior slope of the plica: The papillae were
coarse and lined obscurely (Fig. 11). Each papilla
resembled a thick and tall cylinder with a round tip. Both crura passed in parallel and separated from
Fig. 12. The top of the loop was often twisted (Fig.
12).

The interplical region: The papillae were coarse and
lined obscurely. Each papilla resembled a slender and
tall needle with a sharp tip (Fig. 13). The capillary loop
appeared as a hair-pin with a slightly wide interval bet-
ween the crura and was lower than that in the anterior slope (Fig. 12). The top of the loop was often twisted (Fig. 12).

ii) Palatine fissure portion (Figs. 15-22)

The anterior slope of the plica: The papillae were
dense and lined sagittally (Fig. 15). Each papilla resembled a tall cone with a sharp tip inclined
pharyngeally and a wide basis (Fig. 15) which was
larger than that in the incisive portion. The capillary
loop appeared as a slender and tall hair-pin with a
slightly wider interval between the crura (Fig. 16) than
that in the same slope in the incisive portion.

The ridge of the plica: The papillae were considerably
dense and lined obscurely (Fig. 17). The papilla re-
sembled a thick and tall cylinder with a round tip (Fig.
17). Each descending crus of the capillary loop did not
drain directly into the venous side of the subepithelial
capillary network, but a continuation of two or three
loops drained into it (Fig. 18) since secondary papillae
were often developed. Such loops did not appear as
a regular and single hair-pin. On the continuous loops,
communicating routes were found between the
ascending and descending crura (Fig. 18).

The posterior slope of the plica: The papillae were
dense and lined sagittally (Fig. 19). Each papilla
resembled a thick and tall cylinder with a round tip (Fig.
19). The capillary loop appeared as a tall hair-pin,
similar to that of the posterior slope in the incisive
portion, with a wide interval between the crura (Fig. 20).

The interplical region: The papillae were coarse and
lined obscurely (Fig. 21). Each papilla resembled a half
globe or low cylinder with a round tip (Fig. 21). The
size and height of the papillae were not regular (Fig.
21). The capillary loop appeared as a low arcade (Fig.
22). Both crura passed in parallel and separated from
each other (Fig. 22). The top of the loop protruded
from the subepithelial capillary network into the
epithelium due to its curvature (Fig. 22). In many cases,
a complicated loop was found in the shape of a basket
(Fig. 22).

iii) Molar portion (Figs. 23 and 24)

The anterior slope of the plica: The papillae were
dense and lined sagittally. Each papilla resembled a
thick and tall cylinder with a round tip, similar to that
of the posterior slope of the plica in the palatine fissure
portion. The capillary loop appeared as a hair-pin with
a slightly wide interval between the crura.

The ridge of the plica: The papillae were dense and
lined obscurely (Fig. 23). Each papilla resembled a
slender and tall cylinder with a round tip (Fig. 23),
similar to that of the ridge of the plica in the incisive
portion. The capillary loop appeared as a slender, tall
and simple hair-pin (Fig. 24), being similar to that of
the ridge of the plica in the incisive portion.

The posterior slope of the plica: The papillae and
capillary loops were similar to those of the anterior
slope of the molar portion in both their size and form.

The interplical region: The papillae were coarse and
lined obscurely. Each papilla resembled a tall cone or
cylinder, taller than that in the palatine fissure portion,
with a round tip. Both crura passed in parallel and
separated from each other. The loop often protruded
towards the epithelium in the shape of an arcade.

C. Venous system

The descending crus of the loop drained into a
thicker capillary in the venous side of the subepithelial
capillary network, which was observed as the thick,
primary venous plexus in the lamina propria, similar
to the second arterial plexus (Figs. 1 and 7). The com-
ponent venous vessels were not accompanied by arterial
vessels (Figs. 1 and 7). This plexus in the interplical
region was considerably thin, coarse and obscure (Figs. 1 and 7). The blood of the primary venous plexus drained deeply to the second venous plexus, that is, the palatine venous plexus in the submucous tissue (Figs. 1 and 7. This plexus, which covered the entire hard palate, was composed of numerous vessels mostly running in a sagittal direction, being especially more developed in the superficial and deep layers which filled out the palatine fissures (Fig. 5). In the superficial layer, the component vessels were thick along the median line but thin in the deep layer (Fig. 5). Part of the venous plexus beneath the 4th to the 8th plicae of the palatine fissure portion extended laterally beyond the lateral margin of the diastemata (Fig. 5). The venous plexus was thin in the incisive and molar portions, although it was not observed along the median line of the molar portion. Bilateral communications were few in number in the plexus.

**Discussion**

The microvascular architecture of the hard palate has been studied by Sayo (1985) in the dog, by Toda (1986) in the cat, and by Kajiwara (1989) in the Japanese monkey. Sawa (1961) described the gross angiology of the palate in some mammals, while the arterial supply to the bone structure of the palate in the rabbit has been studied by Sayo (1985) in the dog, by Toda (1986) in the Japanese monkey. Rather, coarse meshes which alter gradually to the subepithelial capillary network are found since the lamina propria itself is thinner in the rabbit.

The subepithelial capillary network is always observed as flat meshes in the anterior and posterior slopes of the plica and the interplical region. This network in the ridge of the plica is often found as a complicated plexus in three dimensions, since the ridges themselves are sharply serrated. The meshes of the subepithelial network are seen to be sagittally-elongated and dense in the plicae but coarse in the interplical regions. These differences may give rise to the surface area of the plica being wider and the number of the papillae being larger than those of the interplical region. The arrangement of the capillary loops diverging from the subepithelial network is also found to be in the sagittal direction. Such an arrangement may be related to the growth direction of the palate.

There is no doubt that a morphological similarity exists between the papillae and the capillary loops within them. This fact was noted by Suzuki (1964) in the human adult and fetus and by Sato (1950) in the rabbit based on India ink-injected histological slides. However, there has been no previous attempt to elucidate the morphological relations between the papillae and loops by means of epithelium-separated specimens. In order to determine the precise differences and relations between them, the present author thus attempted to divide the hard palate into three portions and to make detailed investigations of each region in each plica and the microvascular architectures in each plica by directly observing denuded papillae on epithelium-separated specimens.

The capillary loops are tallest on the anterior slope of the plica and smallest in the interplical region in the rabbit, although they are tallest in the plica and digitiform process of the cat and in the ridge of the plica.
Microvasculature of the Hard Palatine Mucosa in the Rabbit

of the Japanese monkey. The morphological characteristics of the capillary loops were seen to involve locational differences in the whole hard palate and even in one plica, and the particular form of the capillary loop in the anterior slope of the plica may reflect the mechanism of the preying motion and mastication of the rabbit. The capillary loop is generally observed to be a simple hair-pin which corresponds to type I in man as designated by Suzuki (1964). In the rabbit, two or three continuously wavy or arcade loops in the ridge of the plica of the palatine fissure portion, are observed as a variation of the simple hair-pin loop. Such a continuous loop was not included in his classification. As mentioned above, the arrangement of the loops, even the continuous loops, is mostly in the sagittal direction.

According to the sagittal arrangement of the capillary loops, the papillae of the lamina propria are also regularly arranged in the same direction as mentioned in the Japanese monkey by Kajiwara (1989). The density of the papilla is greater in the plica but lower in the interplical region. Locational differences in the density within one plica may be due to physical stimulation during mastication.

Simultaneously, the well-developed palatine venous plexus may contribute in the process of the regurgitation of food and assist in mastication with the cheek teeth. Locational differences in the capillary loops in the lamina propria may be related to the physical stimulation and swallowing of food.

Acknowledgements

The author wishes to express his sincere gratitude to Professor Y. Ohta for critically reading this manuscript, and to all staff members of the Department of Anatomy for their invaluable assistance.

This work was presented at the 30th Annual Meeting of the Japanese Association for Oral Biology in Fukuoka on 9 October 1988, and also at the 383rd Meeting of the Osaka Odontological Society in Osaka on 8 July 1989.

Literature cited

Abbreviations for Figures

- cn: Subepithelial capillary network
- fp: Palatine fissure portion of the hard palate
- ip: Incisor portion of the hard palate
- mp: Molar portion of the hard palate
- pa: Primary (submucous) arterial network
- pv: Primary venous plexus in the lamina propria
- sa: Second arterial plexus in the lamina propria
- sv: Second venous plexus (palatine venous plexus)
- AS: Anterior slope of plica
- B: Bone structure of the hard palate
- I₁: Major incisor
- I₂: Minor incisor
- LP: Lamina propria
- M: Connective tissue membrane extending from the periosteum of the palatine fissure
- N: Nasal cavity
- PS: Posterior slope of plica
- SM: Submucous layer
- T: Top of plica
- —: Direction of snout

Explanation of Figures

Plate I

Fig. 2. The whole view of the palate of the rabbit (dissection specimen). ×2.7
The openings (arrowheads) of the nasopalatine canals are located bilateral to the incisive papilla (*).
The three portions distinguished in the present paper are indicated by solid lines: the incisive, the palatine fissure (dotted line) and the molar portions.
The transverse palatine plicae are observed to number 15. The plicae located anterior to the molars are always well-developed in the typical form. The interplicical regions are small and narrow.

Fig. 3. The whole view of the microvascular architecture of the hard palate. ×2.7
The subepithelial capillary network covering all of the hard palate is shown.

Fig. 4. Sagittal section of the hard palate. ×2.9

Fig. 5. Frontal section in the middle of the palatine fissure portion. ×7.5
The plicae are continuously observed to be serrated. The lamina propria itself, which is composed of dense fibers, protrudes to form the plicae, and the border layer is always flat in a sagittal section (dotted line). The palatine venous plexus is located in the submucous layer, and is especially more developed in the palatine fissure portion. A connective tissue membrane (↓) extends from the periosteum of the palatine fissure and separates the submucous layer of the oral mucosa from that of the nasal mucosa. This membrane bends rectangularly at the median line and adheres to the similar membrane (←) from the nasal septum. It finally reaches the submucous layer of the palate and separates the palatine venous plexus into each side.
Plate II

Fig. 6. Microvascular architecture in the molar portion of the hard palate in a sagittal section through the major hard palatine artery of the right side. ×8.9

The major hard palatine artery (*) emerges from the palatine foramen (\(\downarrow\)), and passes in the palatine venous plexus and then superficial to the plexus at the posterior end of the palatine fissure. The medial and lateral branches (→) of this artery and the plical branches of the minor hard palatine artery constitute the primary arterial network.

Fig. 7. Microvascular architecture in a transverse palatine plica of the palatine fissure portion in a sagittal section. ×41.0

The second arterial network is thickened like a plexus. That in the interplical region is so coarse and indistinct that it becomes the subepithelial capillary network (cf. Fig. 1).

Fig. 8. Close-up of a square area of a transverse palatine plica of the palatine fissure portion in Fig. 4. ×32.2

The lamina is itself swollen to form the transverse palatine plica. In general, the papillae are tall but small in the interplical region.
Plate III

Papillae of the lamina propria on the epithelium-separated specimen and capillary loops in the papillae are shown from Fig. 9 to Fig. 16, and also continued in Figs. 17-24 of Plate IV. ×250 in all these figures, respectively.

Figs. 9 and 10. The papillae in the anterior slope of the plica in the incisive portion resemble sharp, slender and tall cones. The capillary loop appears as a typical, single and tall hair-pin with a narrow interval between the ascending and descending crura.

Figs. 11 and 12. The papillae in the posterior slope of the plica in the incisive portion resemble thick and tall cylinders. The loop is an atypical hair-pin with a wide interval between both crura.

Figs. 13 and 14. The papillae in the interplical region in the incisive portion resemble slender and tall needles with sharp tips. The loop appears as a hair-pin with a slightly wide basis between the crura, the tops of which are often sharp by being close to each other.

Figs. 15 and 16. The papillae in the anterior slope of the plica in the palatine fissure portion resemble tall cones with sagittally-elongated bases. The loop appears as a slender and tall hair-pin with a slightly wide interval between both crura (cf. Fig. 10).
Plate IV, continued from Plate III

Figs. 17 and 18. The papillae in the ridge of the plica in the palatine fissure portion resemble thick and tall cylinders with round tips. The loops are often continuous with two or three in the secondary papillae.

Fig. 19 and 20. The papillae in the posterior slope of the plica in the palatine fissure portion resemble thick and tall cylinders with round tips. The loop appears as a tall hair-pin with a wide interval between the crura.

Figs. 21 and 22. The papillae in the interplical region in the palatine fissure portion resemble half-globe or low cylinders with round tips of various sizes. The loop appears as a low arcade protruding from the subepithelial capillary network.

Figs. 23 and 24. The papillae in the ridge of the plica in the molar portion resemble slender and tall cylinders with round tips. The loop appears as a slender and tall simple hair-pin.