Cubical Anatomy of Several Ducts and Vessels by Injection Method of Acrylic Resin

XII. Blood Supply of the Cleft Lip, Alveolus and Palate in a Human Fetus

By

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(With 10 figures in 3 plates)

This work was announced at 15th Annual Session of the
Japanese Stomatological Association, 1961, Gifu.

Preface

Deformity arouses embryological and surgical interests from of old. Majority of the deformed patients who consult the oral surgeon have complained the cleft lip and palate. Plastic operation of them has been performed mostly by surgical correction. Vasculature and even skeleton composing the deformed region of the cleft lip and palate, however, have been scarcely observed hitherto. The authors fortunately obtained an eight-month-old fetus with an unilateral cleft lip, alveolus and palate. On the arterial vasculature of the deformed region of the fetus, observations are made by means of the acrylic resin injection, and the authors try to offer a criticism upon the oral surgical technique of the cleft jaw from the results obtained.

Material and Method

An eight-month-old fetus; left complete unilateral cleft of lip, alveolus, hard and soft palates. Before the injection, an impression

of the lip, palate and face is taken with alginate paste to make a plaster model. The injection is carried by means of Taniguchi, Ohta and Tajiri ('52) method and its supplement ('55), into the left common carotid with the blue coloured and the right one with the red coloured. The soft tissues of the injected head are corroded to make a corrosion specimen, except hard bones as much as possible. As controls, 10 acrylic resin corrosion specimens (of the carotid arterial system) of 10-month-old normal fetuses are used.

Observations

A. External appearance

The cleft lies a little to the left (Fig. 4).

B. Bones composing the hard palate (Figs. 1, 2 and 3)

Skeletal structure of the hard palate is observed after the soft tissue is removed. The right (normal) hard palate consists of 4 bones; the palatine process of the maxilla, incisive bone, horizontal plate of the palatine bone and the vomer developed abnormally (Figs. 1, 2 and 3). The vomer is not one plate, but shows double, parting right and left, keeping a space of about 7 mm in their posterior ends. The right plate falls almost horizontally medialward, and the left one bends to the right immediately after a slight protrusion to the left, and extends almost horizontally to connect with the right palatine process of the maxilla. Accordingly, on the right hard palate, the following bones are seen; from the left side, the left abnormally developed vomer, the right vomer, the palatine process of the right maxilla and the horizontal plate of the right palatine bone. While, the left hard palate consists of the palatine process of the left maxilla and the horizontal plate of the left palatine bone.

C. Blood supply

1) Arteries supplying the soft palate

(i) Right (normal) side

a) A. pharyngea ascendens (Figs. 1 and 6)

Arriving at the base of the cranium, the artery (c. 0.49 mm) bends antero-inferiorly and continues to run about 2 mm to the lateral wall of the pharynx. Then, it reaches the posterior margin of the soft palate running infranteriorly within the submucous

layer, and at last bends anteromedially to supply the soft palate, giving a twig (c. 0.19 mm) to the uvula of the right side.

b) *A. palatina ascendens* (Figs. 1 and 6)

The artery (c. 0.37 mm) arises from the medial wall of the facial artery, about 3 mm distal to its origin, and immediately divides into two (c. 0.5 and 0.4 mm), which run supranteriorly to supply the lateral one third of the posterior part of the soft palate.

c) A branch of *A. maxillaris* (Figs. 1 and 2)

The branch (c. 0.49 mm) arises from the medial wall of the maxillary, about 0.5 mm distal to the origin of the medial meningeal artery. It ascends to the base of the cranium, giving two twigs for its supply, and bends first downward at about a right angle, next forward to proceed anteromedially between the medial pterygoid muscle and the ascending pharyngeal artery. At the medial side of the muscle, it divides into the lateral and medial branches within the submucous layer of the soft palate. The lateral runs forward in the medial side of the medial pterygoid and anastomoses (c. 48 μ) with branches of the minor palatine, and the medial proceeds anteromedially between a branch of the ascending pharyngeal and the lateral branch, to the posterior margin of the hard palate and anastomoses (c. 48 μ) with branches of the minor palatine.

d) *A. palatina minor* (Figs. 1, 2 and 6)

Details on this artery (c. 0.12 mm) are described under. One of the branches of it, the lateral (c. 0.12 mm) arrives at the palatoglossal arch.

(ii) Left (cleft) side

a) A branch of *A. maxillaris* (Figs. 1 and 7)

The branch (c. 0.5 mm) arises from the medial wall of the maxillary (c. 1.2 mm), about 2 mm distal to the origin of the medial meningeal, and runs anteromedially for a distance of about 1 mm, next downward tortuously to the lateral wall of the pharynx, then again anteromedially to the posterior margin of the soft palate. Within its submucous layer, it divides into four or five branches (0.15-0.25 mm), one of them reaching the uvula of the left side, and the others are distributed to the soft palate passing anteromedially or forward.

b) A. palatina minor (Figs. 1 and 7)

Details on this artery are described under. One of the branches of it, the posterior (c. 0.25 mm) divides into four which are distributed to the anterolateral part of the soft palate.

2) Arteries supplying the hard palate

(i) Right (normal) side

In this example, the maxillary divides into the following terminal branches at the same point; the descending palatine, sphenopalatine and infraorbital arteries. The first and the second run medialward abreast one behind another.

a) A. palatina minor (Figs. 1, 2 and 6)

The artery (c. 0.24 mm), one in number, arises from the infra-posterior wall of the sphenopalatine (c. 0.89 mm) about 2.5 mm distal to its origin, runs inferiorly to come out onto the palate passing through the minor palatine foramen, then divides into the medial and the lateral. The medial (c. 0.14 mm) supplies the posterior vicinity of the palatine bone. Besides, many small twigs (55–128 μ) out of the branch are seen posteriorly and anteriorly to an area surrounded by the major palatine, the ascending pharyngeal and maxillary arteries.

b) A. palatina major (Figs. 1, 2 and 3)

The artery (c. 0.5 mm) divides into the medial (c. 0.25 mm) and the lateral (c. 0.3 mm) in the palatine canal. The former, running along the posterior side of the latter, comes out onto the palate passing through the major palatine foramen. It gives off a twig (c. 0.25 mm) to the nasal cavity, right before leaving the foramen, and the remain onto the palate, where it furthermore divides into the medial, spreading to the posterior margin of the palatine process of the maxilla, and lateral (both c. 0.18 mm) to the posterior region of the alveolar process of it. The latter runs forward along about 2 mm medial to the alveolar margin, and bends anteromedially at the deciduous canine along the alveolar margin, then supraposteriorly at the anterior side of the incisive foramen, and finally gets into the nasal cavity through it. In this way, seven branches are given off (0.1–0.2 mm) to the lateral; four arising at proximal to the deciduous canine, one at posterior to it and two near the incisive foramen. Every branch starts for the lateral or the anterolateral from the lateral wall of the mother branch, and passes

onto the alveolar ridge to supply the periosteum and mucous membrane in a part between the major palatine and the alveolar ridge. Two other branches (0.2-0.25 mm) to the medial are observed; one arising in contact with the major palatine foramen and the other posterior to the first deciduous molar. Both proceed anteromedially and divide into 2 or 3 fine branches, which run medialward to the original median margin of the palatine process of the maxilla, where they are situated face to face with the sphenopalatine artery of the left side that supplies the inferior surface of the vomer.

c) A. sphenopalatina (Figs. 1, 2, 3 and 7)

In this example, the sphenopalatine of the left (cleft) side shows an abnormal feature. The vomer, which adheres to the palate of the right (normal) side, is supplied with the left sphenopalatine. About 0.45 mm proximal to the origin of the descending palatine artery, the maxillary (c. 0.75 mm) sends off the supreme pharyngeal artery (c. 0.46 mm) posteromedially, then bifurcates into the sphenopalatine and the descending palatine (Fig. 7). The sphenopalatine (c. 0.69 mm) divides into the lateral posterior nasal (c. 0.56 mm) and the septal posterior nasal (c. 0.48 mm). The septal posterior nasal artery takes part in supply of an area bordering upon the cleft. It proceeds infra-antero-medially along the infralateral surface of the left vomer, turns forward onto the inferior surface of the middle of the left vomer, and supplies twigs to the inferior surface of the vomers of both sides and the vertical surface of the left vomer. On the inferior surface of the left vomer, ends of the septal posterior nasal spread anteromedially, and anastomose (c. 24 μ) with branches of the major palatine of the right side. A branch (c. 84 μ) of them passing along the cleft margin, connects (c. 95 μ) with end of the nasopalatine of the right side on the incisive bone of the left side.

(ii) Left (cleft) side

a) A. palatina minor (Figs. 1 and 7)

The artery (c. 0.3 mm), one in number, arising from the posterior wall of the descending palatine artery, about 0.5 mm distal to its origin, descends perpendicularly to the palate through the minor palatine foramen, where it divides into posterior (s. 194 pages) and anteromedial branches. The anteromedial branch (c.

0.2 mm) is distributed to the posterior quarter of the inferior nasal concha.

b) A. palatina major (Figs. 1 and 7)

The artery (c. 0.49 mm) bifurcates into the medial and lateral within the palatine canal.

The medial branch (c. 0.3 mm) divides into two small twigs (both c. 0.2 mm) in the canal, and finally runs anteromedially to the cleft margin to supply the horizontal plate of the palatine bone. One of the twigs runs anteromedially between the horizontal plate of the palatine bone and the palatine process of the maxilla for their supply, and the other appears on the palate via the major palatine foramen, and then again branches into the lateral and the medial (both c. 0.15 mm). The former runs to the medial gingiva of the most posterior deciduous molar anterolaterally, and the latter proceeds posteromedially near the posterior branch of the minor palatine, superficial to the anteromedial branch described above.

The lateral branch (c. 0.41 mm) runs anterolaterally between the above two small twigs of the medial branch to the alveolar margin of the 1st and 2nd deciduous molars, where it turns anteromedially at about a right angle after running for about 1.5 mm long, and bends forward to run archwise to the tip of the palate anteromedially along the alveolar margin. It gives off five branches (0.12-0.24 mm) to the lateral and two (0.12-0.24 mm) to the medial. They are distributed to the mucosa of the hard palate.

3) Arteries supplying the upper lip

(i) Right (normal) side (Figs. 8, 9 and 10)

After diverging a branch supra-antero-medially at the angle of the mouth, the facial artery (c. 0.75 mm) runs anteromedially for a distance of about 3 mm and branches off the superior labial passing medialward along the superior labial margin, then turns to the angular artery ascending along the nasolabial groove.

The branch to the supra-antero-medial (c. 0.43 mm) at first runs supramedially across the mother artery, superficial to it, in the shallow part of the upper lip, and near the median line gets into the deep part, then at last is distributed to the inferior end of the septum and of the right vestibulum. A twig (c. 0.22 mm) out of this supplies the cheek, and six twigs (0.07-0.1 mm) arising in the upper lip run upward or forward to supply it.

When the facial runs in the infralateral of the nasal ala, it gives off a branch (c. 0.37 mm) which divides into two, the superior and inferior (both c. 0.25 mm): both run supramedially, the former to the nasal dorsum and the latter to the vicinity of the naris.

The superior labial artery (c. 0.68 mm) at first passes medially along the inferior margin of the upper lip, next bends upward near the median part, getting into deep. The artery reaches the septum and runs upward along the anterior margin of it to the apex of the nose, then upward on the median part of the nasal dorsum, where it sends off 3 or 4 fine twigs (c. 0.19 mm) to the opposite side, which anastomose (45–75 μ) with branches of the nasal dorsal artery of the opposite side (Rr. ascendentes profundi, Hanaï, '61). The superior labial derives a branch to the infra-antero-medial (c. 0.43 mm) from its inferior wall, about 1 mm distal to its beginning, and a branch to the supranterior (c. 0.37 mm) and another to the postero-inferior (c. 0.18 mm) in the median part and two other branches to the lateral (0.09 and 0.19 mm) of both sides in the septum. The first runs medially along the superior labial margin and bends upward at the lateral one third of the lip, then divides into three (0.19–0.3 mm) (Rr. ascendentes superficiales, Hanaï) spreading fan-shapedly to supply the superficial part of the upper lip. The second divides into two (c. 0.25 mm): one bends superiorly and ascends along the cleft margin passing through the anterior margin of the median part and the other ascends along the cleft margin after bending left to beneath the naris. Both supply the left (cleft) medial part of the upper lip. The third immediately divides into two (0.1 and 0.15 mm), and they supply the upper labial frenulum and the labio-gingival junction of the medial part. The branches to the right of the last supply the inferior end of the septum, and those to the left pass along the upper margin of the naris of the opposite side to anastomose (c. 124 μ) with branches of the nasal dorsal of the opposite side.

(ii) Left (cleft) side

Being broken, no observation has been possible.

Summary and Discussion

Toward end of the last century Dursy (1869) and His (1885, 1892) hypothesized that the etiology of the cleft palate was a dys-

rhapsia among the processes of the face. Stupka (1838), Pohlmann ('10), Canick ('54) and Stark ('54), however, were positive in denying an existence of the processes, and stated that the cleft was caused by defect of the mesodermal tissue. Though various rehabilitation methods of the cleft palate and lip have been given, no mention is given here of them separately.

In spite of the embryological and surgical researches, anatomical observations on the cleft region have not been well made. Takahashi and Iida ('52) and Th. Soemmering ('54) made observations only on the osseous construction surrounding the cleft margin.

The authors now summarize the results obtained and start a discussion about techniques of the plastic operation from viewpoints of angiology of the cleft region.

§ Skeletal construction :

Bones constructing the palate of the normal side are the palatine process of the maxilla, the incisive bone, the horizontal plate of the palatine bone and the abnormally developed vomer.

On the malformation of the nasal septum, Takahashi and Iida state that the septum presents a flexion toward the cleft side without regard to the extent of the cleft lip, but the complexity of the flexion increases proportionally to the age.

In this report, the vomer shows a peculiar feature, dividing into two parts as already mentioned. It is considered that the vomer developed from two, right and left, ossificating points are not united in one plate on account of the cleft. Left plate bends at about a right angle toward the normal side after protruding toward the cleft side. Right plate falls almost horizontally in order to fill up a crevice between the left plate and the palatine process of the right maxilla. Consequently, both plates come in contact. Another consideration may put that both ossificating points develop separately under a strong pull toward the normal side, so the plate of each side protrudes or falls.

The protrusion toward the cleft side of the nasal septum in this case is in accord with the view by Takahashi and Iida. Bifurcation of the vomer, however, is not found in literature.

§ Arterial distribution :

Works published by Sawa ('61) on the arterial distribution of the hard and soft palates and by Hanai on it of the upper lip

are used for reference.

The right (normal) side of the soft palate: The distributing arteries are four. The ascending pharyngeal supplies the posterior region of the soft palate and the uvula, the ascending palatine the lateral part of the region, the branch out of the maxillary the anterior region of the soft palate, anastomosing with peripheries of the minor palatine, which is distributed to the anterolateral part, near the palatoglossal arch, of the soft palate.

The left (cleft) side of the soft palate: The distributing arteries are the branch of the maxillary and peripheries of the minor palatine. The former is distributed to almost the whole soft palate, and the latter to the anterolateral part of it.

The right (normal) side of the hard palate: The distributing arteries are the right minor and major palatines, and the left (cleft) sphenopalatine. The first is distributed to an area limited by the horizontal plate of the palatine bone, the middle to the whole area of the palatine process and the medial part of the alveolar process of the maxilla. The last shows an interesting aspect that the septal posterior nasal artery out of the sphenopalatine, passes on the superior wall of the nasal, i. e., the ceiling of the cleft, then comes onto the right vomer, next onto the palatine surface of the right (normal) side. A reason for the passage of this artery may surely be a defect of the incisive canal of the left side and the flexion of the vomer. The strength of the artery, however, does not show any atrophic features caused by cleft.

The palate to all appearance seems to be parted right and left by the cleft, but the vasculature presents a normal appearance in principle to the utmost.

The left (cleft) side of the hard palate: The distributing arteries are the minor and major palatines. There is a shade of difference in thickness between the major palatine arteries of both sides, also in aperture between the lateral and medial branches of each side. In short, all arteries distributed to the palate do not show any conscious difference between the right and left in exception of the sphenopalatine distributed to the vomer. A reason for such difference seems to be that there also is a shade of difference in development between the palatine processes of both sides. Although the outward appearance of the right normal side shows more developed than of the left (cleft) side, but it is nothing but the vomer falls almost horizontally by a pull toward the cleft side.

May it then offer a criticism on the surgical operation, the mucoperiosteal procedures by Langenbeck (1861), Veau ('22) and Dorrance ('33), may do no injury to large arteries, the ascending pharyngeal, the ascending palatine of the right normal side and branches out of the maxillary of both sides, in the soft palate. The septal posterior nasal artery of the sphenopalatine supplying about one third of the hard palate of the cleft side, however, is sure to be cut when a flap is made along the cleft margin. Often, the occurrence of a little unadhered part on the suture line as a postoperative lesion may be caused by disturbance of the circulation. Hence, efforts should be made not to damage the major palatine arteries.

Any executive one of the arterial branches supplying the right part of the upper lip is not distributed to the left side of it over the median line. Only a fine branch (c. 0.37 mm) out of the upper labial of the right side is observed. Namely, the arterial distribution of a narrow part between the median line and the cleft margin is not sufficient. This fact may bear directly on that the rehabilitation of the part medial to the suture line in the postoperative stage, shows less than that of the part lateral to it in almost the cleft lip patients.

Accordingly, the incised line parallel to the cleft margin, for example by Mirault (1845), may be left out of consideration from a view point of the vascular construction, but the notches in a right angle to the above line, for example by Tennison ('22), Le Mesurier ('49), Cardoso ('52), must be objects of the utmost care.

Conclusions

1) The authors make observations on the skeleton and arterial distribution of the cleft region of an unilateral (left) cleft lip, alveolus and palate of an eight-month-old fetus by means of the acrylic resin injection.

2) The vomer in this case shows an abnormal view that it consists of two plates, the right one of which falls medialward and the left one bends to the right and extends almost horizontally to connect with the right palatine process of the maxilla, as if filling the crevice. The nasal septum bends toward the right, normal side after it presents a flexion toward the left, cleft side.

3) Supplying arteries of the soft palate: Right, normal side; the ascending pharyngeal, the ascending palatine, a branch out of the maxillary and peripheries of the minor palatine. Left, cleft side; a branch of the maxillary and the minor palatine. Any executive one of the arteries may not be cut off when surgical flaps are made.

4) Supplying arteries of the hard palate: Left side; the major and minor palatines. Right side; the major and minor palatines, and the septal posterior nasal of the sphenopalatine of the left side supplying the vomer fallen horizontally. The last may surely be cut off when an incised line is made along the cleft margin. Accordingly, care must be taken not to do injury to the major palatine when flaps are made in the plastic operation, in order to give a good postoperative nutrition of the suture region.

5) The upper labial artery which supplies the right part of the upper lip passes upward in the median part onto the nasal dorsum, where it anastomoses with the nasal dorsal of the opposite side. A narrow part between the median line and the cleft margin is supplied with a fine branch of the upper labial of the right side. The branch may play an important role in the postoperative stage.

The authors wish to express their thanks to Professor Y. Taniguchi and Professor T. Shirayama, their respected instructors, for guidance and encouragement shown to them.

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Explanation of figures

Key to abbreviations

- A: Alveolus
- C: Cleft of the palate
- I: Deciduous central incisor
- N: Naris
- T: Tongue
- U: Uvula
- ×: Palatine process of the right maxillary bone
- : Palatine process of the left maxillary bone
- △: Horizontal plate of the palatine bone
- ★: Right plate of vomer
- : Left plate of vomer
- i: Internal carotid artery
- e: External carotid artery
- m: Maxillary artery
- f: Facial artery
- ph: Ascending pharyngeal artery
- pa: Ascending palatine artery
- pn: Septal posterior nasal artery
- sp: Shenopalatine artery
- : Median line

- Fig. 1. Schematic illustration of the cleft palate and its arterial distribution.
- Fig. 2. Enlarged photo of Fig. 3.
- Fig. 3. The whole inferior view of the cleft palate. A branch out of the maxillary (↓). Supreme pharyngeal artery (↖).
- Fig. 4. Antero-inferior view of the oral cavity before digesting. Abnormally developed vomer (↙).
- Fig. 5. Arterial vasculature of normal palate of fetus (10 months) for control. Incisive foramen (↓).
- Fig. 6. Inferior view of right soft palate.
- Fig. 7. Inferior view of left soft palate. Supreme pharyngeal artery (↖).
- Fig. 8. Anterior view of right upper lip.
- Fig. 9. Inferior view of it.
- Fig. 10. Schematic illustration of right upper labial artery.
 Rr. ascendentes superficiales (↘) et profundi (↖). Branch to supra-anterior (↑) and to postero-inferior (→), out of right upper labial artery. Anastomoses (↙) between Rr. ascendentes profundi and left nasal dorsal artery. Angular artery (←).