Anatomic Study of the Blood Supply of Perioral Region

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The use of flaps to reconstruct lip defects requires detailed knowledge of the local vasculature. New flaps for surgery around the mouth can be devised if the surgeon knows the distribution of the perioral arterial branches. Examination of the anatomy of perioral branches of the facial artery (FA) confirmed the consistent presence of septal and alar branches in the upper lip and a labiomental branch in the lower lip. Mucosal flaps from the upper lip based on the deep septal branch or the alar branch of the FA can be used to restore lower lip defects. A composite flap from the lower lip supplied by the labiomental branch of the FA can be used to restore combined defects of the upper lip and nose or partial defects of the lower lip. We studied the vascular anatomy of the perioral region in 25 cadaver dissections. Fixation was by 10% formaldehyde solution. Red latex was injected into the common carotid arteries before dissection. In the 50 specimens, the primary supplying vessels were identified and the size and distribution of the vessels were investigated. The FA was symmetrical in 17 (68%) of 25 heads. It terminated as an angular facial vessel in 11 (22%), as a nasal facial vessel in 30 (60%), as an alar vessel in six (12%), and as a superior labial vessel in two (4%) facial halves. It terminated as a hypoplastic type of FA in one (2%) facial half. The average external diameter of the superior labial artery (SLA) was 1.6 mm (min–max: 0.6–2.8 mm) at its origin. The origin of the SLA was superior to the angle of the mouth in 34 of 47 specimens (72.3%), and at the angle of the mouth in 13 of 47 specimens (27.7%). In two of the remaining three specimens, the SLA was the continuation of the FA and the other was of the hypoplastic type. The SLA supplied the columellar branches in all specimens except for the hypoplastic type (49 specimens). Columellar branches were classified according to their number and their type. In five specimens (10%) the inferior labial artery (ILA) was not found. In the other specimens, the site of origin of the ILA varied between the lower margin of the mandible and the corner of the mouth. Its external diameter measured min–max: 0.5–1.5 mm. The ILA arose from the FA above the angle of mouth in 4 specimens (8%), inferior to the angle of mouth in 11 specimens (22%), and at angle of mouth in 30 specimens (60%). We observed that the labiomental arteries, which formed anastomoses between the FA, ILA, and submental artery, showed variations in their course in the labiomental region. We suggest that knowledge of the location of arteries with respect to easily identifiable landmarks will help to avoid complications at surgery. Clin. Anat. 18:330–339, 2005.

Key words: arterial supply; perioral region; facial artery; lips; reconstructive surgery

INTRODUCTION

Reconstruction of the upper and lower lip is important, both aesthetically and functionally, after resection of a malignant tumor at this region. Reconstruction of the vermillion must also ensure that postoperative acquisition of sensation occurs as early as possible, a requirement that often makes it difficult to select a satisfactory operative procedure (Kolhe and Leonard, 1988; Pribaz et al., 1992, 2000; Ono et al., 1997).

When a lip is injured or involved in malignant disease, the facial artery musculomucosal (FAMM) flap can be used for reconstruction. The FAMM flap

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MATERIALS AND METHODS

The arterial supply of the perioral region was dissected in 25 adult male Turkish cadavers (50 half heads) that were fixed with 10% formaldehyde solution. The carotid triangle was dissected, and red latex solution was injected into the common carotid artery just below its bifurcation. To investigate the distribution of the facial vessels at various levels, the skin, subcutaneous fat, and muscle layers were progressively removed.

The dissection of the superficial layers was made from the midline of the face laterally so as not to damage the FA. The FA was first exposed to the lower border of the mandible and then carefully dissected from the angle of the mouth toward the medial palpebral commissure. The branches of the transverse facial, infraorbital, and ophthalmic arteries, which anastomosed with branches of the FA, were also dissected.

The mode of termination of the FA was categorized in five classes as described previously by Mitz et al. (1973) and Niranjan (1988). Variations of the lateral nasal artery (LNA), superior labial artery (SLA), and inferior labial artery (ILA) were defined according to their symmetry, course, anastomoses with other branches, and termination. Detailed notes and sketches of the typical findings and photographs of the more significant anatomic dissections were taken. The type, distribution, and caliber of the vessels were assessed. The diameters of FA branches were measured at their branching points from the FA. The labiomental arteries, the septal and alar arteries were described on their courses. The branches of the FA and the ILA situated between the lower lip and submental region were classed as labiomental arteries. The evaluation of the labiomental arteries was aided by reference to the studies of Park et al. (1994) and Schulte et al. (2001). The branch of the FA that runs to the lower lip was defined as the ILA. The branches of the FA that go to the chin and anastomose with arteries from the opposite side, or with the ILA and submental arteries, were defined as labiomental arteries (Park et al., 1994; Williams, 1995; Schulte et al., 2001). All measurements were made with a micrometer.

RESULTS

Variations of the Course of the Facial Artery

Cadaveric dissections demonstrated that the FA arose from the external carotid artery. As the FA curved around the surface of the mandible, it gave off small muscular branches to the masseter and the depressor anguli oris muscles. The vessel, after passing the mandible, approached the corner of the mouth. The mean external diameter of the FA was 2.6 mm (min–max: 1.7–3.6 mm) as it crossed the mandible. The artery passed deep to the risorius and zygomaticus major muscles but superficial to the buccinator muscle. Near the corner of the mouth, it gave off three to five branches to the anterior part of the buccinator muscle. It also gave off a superficial branch, the ‘zygomatic branch,’ to the zygomaticus major muscle (Fig. 1). These findings were seen in all dissections. The ILA and the labiomental artery came off at the level of the inferior border of the buccinator muscle and ran anteriorly, passing deep to the depressor anguli oris. Dissection of the FA in its muscular bed with preservation of small perforating vessels demonstrated the distribution of this musculocutaneous perforating system. The FA passed on average 15.5 mm (min–max: 9.0–20.2 mm) lateral to the angle of the mouth, and gave one of its major branches, the SLA. The FA ascended from the angle of mouth toward the medial palpebral commissure (Fig. 1).

The FA was symmetrical in 17 (68%) of 25 heads. We observed five different course types. The termination as an angular type of FA (AA) was present in 11 facial halves (22%) (Figs. 2, 3). In these, after the FA gave off the LNA in the nasolabial sulcus toward the dorsum of the nose, it terminated as the AA at the medial palpebral commissure. The termination as a nasal type of FA was present in 30 (60%) of the 50 half heads. This type was characterized by alar branches that came directly from the lateral nasal artery (LNA) (Figs. 1, 2, 4). An AA was not identified in the nasal type of FA (Fig. 2). The alar type of FA was present in 6 (12%) of 50 half heads. The terminal branches of alar type of FA ascended and then
descended on the nasal ala (Figs. 2, 5). The termination as a superior labial type of FA was present in two (4%) facial halves. In this type the FA ended at the upper lip and the alar branches came off as ascending branches. In the alar and labial types, the dorsal nasal artery (from the ophthalmic artery) was dominant and the LNA was absent (Fig. 2). A termination as a hypoplastic type of FA was present in one (2%) facial half. The FA ended at the lower lip and gave no branches to the nose (Fig. 2).

Branches of the Superior Labial Artery

The average external diameter of the superior labial artery was 1.6 mm (min–max: 0.6–2.8 mm) at its origin (data from the right and left sides were grouped together). The start of the SLA was above the angle of mouth in 34 of 47 specimens (72.3%), and at angle of mouth in 13 of 47 specimens (27.7%). Three of the specimens were not included in this evaluation because in two of these the SLA was the continuation of the FA and the other was of the hypoplastic type. A vertical reference line was considered through the angle of the mouth. The SLA arose medial to this in 21 of 34 specimens, lateral to it in nine specimens and at the line in four specimens (Fig. 4).

The SLA ran tortuously and anastomosed with the opposite artery in the middle of the upper lip. The arterial anastomosis formed by the SLA was observed in the vermillion in all heads. In half of the heads, the anastomosis of the SLA ran between the mucosa and the orbicularis oris muscle. In the others it ran through the muscle. No part of the anastomosis lay between the muscle and the skin. The branches of the uniting right and left SLA that went to the skin and the mucosa were 9–10 in number and were short and thin. The branches of the right and left SLA in the lip that ascended to the base of the nose were long and thick. These branches were studied in two groups: those running between the skin and the muscle were called superficial ascending branches, and the ones running through the muscle or between the muscle and the mucosa were called deep ascending branches. When the two half heads were considered together, one or two superficial ascending branches were found in total. Their external diameters measured min-max: 0.3–1.1 mm. Similarly, two or three deep ascending branches were found and their external diameters were min-max: 0.4–1.5 mm. The superficial and deep ascending branches in the philtrum were relatively large (Figs. 3, 5, 6).

At the columnellar base, anastomoses among the superficial ascending, and inferior alar arterial branches were observed. The superficial ascending branches passed into the columella, forming a vascular plexus continuous with that at the nasal tip. Ramifications of the deep ascending and inferior alar branches passed to the nasal septum, and ascended along the anterior margin of the septal cartilage. They reached the nasal tip and anastomosed with the vascular plexus at the nasal tip. As they ascended, some small vessels branched off to the septal cartilage and the medial crus of the alar cartilage. Some of the branches anastomosed with terminal branches of the sphenopalatine artery and others anastomosed with the vascular plexus of the columella (Figs. 5, 6).

The SLA bifurcated at the upper lip in 18 of 49 FA. The bifurcation point was variable in location (Fig. 1). One of the branches ran between the mucosa
and orbicularis oris muscle and divided into deep ascending branches. The other branch entered the orbicularis oris muscle and then emerged superficial to it, giving off superficial ascending branches. In the remaining 31 specimens the SLA did not bifurcate. The superficial and deep ascending branches arose directly from the left-right anastomosis of the SLA (one of our 50 specimens was of hypoplastic type with no SLA).

**Alar Branches**

The alar branches were the terminal branches of the FA in alar types and of superficial ascending branches in labial types. A relatively large branch that courses along the inferior margin of nostril on its ascent toward columellar base is called the inferior alar branch, and the artery running to the nasal tip over the ala nasi is called the superior alar branch. The inferior alar branch divided into small vessels proceeding to the alar base and anterior region of the base of the nasal cavity. It also anastomosed with ascending branches from the upper lip. The superior alar branch divided into small branches proceeding to the dorsum of the nose and to the superior margin of the nostril, thus becoming a part of the vascular plexus of the nasal dorsum and tip. The alar branches measured min–max: 1.0–1.5 mm in external diameter (Figs. 4, 7).

**Lateral Nasal Artery**

The LNA branches from the FA at the nasolabial sulcus level and runs toward the dorsum of the nose. Textbooks generally describe that, after giving off the LNA, the FA continues as the AA and proceeds
to the medial palpebral commissure. In our study, however, we found that in 60% of the specimens the terminal branch was formed by the LNA, and in 22% it was formed by the AA. The LNA arose from the FA and ran 2–3 mm superior to the alar groove. The mean external diameter of the LNA was 1.55 mm (min–max: 0.15–2.2 mm) on the right side and 1.43 mm (min–max: 0.17–1.65 mm) on the left side (Fig. 4).

Columellar Branches

Columellar arteries were defined in all types of FA except for the hypoplastic type (49 specimens). Columellar branches were the continuation of superficial ascending branches and became a part of the vascular plexus of the nasal tip. They were classified into three groups according to the number and type. We observed that the columellar artery was single and straight in 24 of 49 specimens (48.9%). There were two straight columellar arteries in 19 of 49 (38.7%) and it was of a forked type in 6 of 49 (12.2%) (Fig. 6).

Branches of the Inferior Labial Artery

The ILA was the main artery of the lower lip. This artery was found unilaterally in five specimens (10%). It was present on both sides in all the others. Its origin generally varied between the corner of the mouth and the lower margin of the mandible. The mean external diameter of ILA was 1.31 mm (min–max: 0.5–1.5 mm). The ILA arose from the FA above the angle of the mouth in four specimens (8% of all specimens), below the angle of the mouth in 11 specimens (22%), and at the angle of the mouth in 30 specimens (60%). We observed that, after separating
from the FA, the ILA immediately entered the lower lip and ran between the mucosa and the muscle. We found different arterial distributions in the lower lip such as end-to-end anastomosis between bilateral ILA and the ILA anastomosing with the submental artery.

End-to-end anastomosis between bilateral ILA was found in Group B. The ILA was observed to be predominant on one side (22%). Two to three prominent HLA arose from the FA and formed a vascular network in the subcutaneous and submucous tissues.

In Group C the ILA was found on only one side. The unilateral ILA started inferior to the angle of the mouth and immediately turned up to go to the vermilion (8%). A wide HLA originated from the FA and ran horizontally.

Small bilateral ILA were almost symmetrical and anastomosed medially (6%) in Group D. Five to eight VLA arose from the arterial anastomosis in the
lower lip and two to three of these reached to the submental area.

End-to-end anastomosis between bilateral ILA were found in Group E. A thick VLA connected the submental artery and the ILA (4%). A prominent HLA anastomosed with the ILA near the vermilion of the inferior lip.

The results of this study provide an anatomic framework to potentially facilitate or improve current reconstructive or aesthetic procedures on the lip and face.

**DISCUSSION**

The FA is the main artery of the face and, if it is absent or poorly developed, the region is supplied either by a more developed contralateral FA or by the transverse facial, infraorbital, or ophthalmic artery of the ipsilateral side. Compensation is usually provided, not by one, but by several arteries (Mitz et al., 1973; Piggot et al., 1987; Niranjan, 1988; Park et al., 1994; Nakajima et al., 2002; Magden et al., 2004).

The perioral region is very important because of its functional and aesthetic roles. The main blood supply of the region originates from the SLA and ILA. The AA lies directly beneath skin to which it gives off a number of small but important unnamed branches. The perioral region is an ideal donor area for local skin flaps, full-thickness flaps, or oral mucosa flaps. Mucosa flaps of the lip use labial mucosa from the inner surface of one lip to resurface the vermilion of the other lip. In addition to local flaps, mucosal free grafts have also been described by Ahuja (1993), who used labia minora grafts for vermilion reconstruction. The buccinator myomucosal flap was introduced by Rayner and Arscott in 1987. Bozola et al. (1989) modified this flap as an axial buccinator musculomucosal flap based on the buccal and posterior superior alveolar arteries. Carstens et al. (1991) described a buccinator myomu-
cosal flap based on the facial artery. Pribaz et al. (1992) developed buccal flaps and described the FA musculomucosal (FAMM) flap. Compared to other buccal flaps, the oblique orientation of the FAMM flap is more amenable for transposition in lip, oral, nasal and orbital reconstruction (Rayner and Arscott, 1987; Bozola et al., 1989; Carstens et al., 1989; Pribaz et al., 1992, 2000; Ahuja, 1993; Üglesic and Virag, 1995; Ono et al., 1997; Dupoirieux et al., 1999; Gardetto et al., 2002).

Variation of the FA must be considered in planning flaps for individual patients (Piggot et al., 1987; Hynes and Boyd, 1988; Üglesic and Virag, 1995; Kawai et al., 2004). Mitz et al. (1973) described five types of FA distribution. In 78% of dissections, the FA terminated as the LNA (Type I: nasal), in 4% it terminated as an AA (Type II: classic); in 10% it terminated as a SLA (Type III: intermediate); in 4% the FA terminated as double type (Type IV: a narrow branch accompanied the FA during its course on the face); and in 4% the FA was rudimentary (Type V: FA ended at the lower jaw).

Niranjan (1988) found symmetrical FA in 17 (68%) specimens. He found the FA terminated as an AA in 34 specimens (68%), as a LNA in 13 specimens (26%), as a SLA in two specimens (4%) and in one specimen (2%), the facial artery terminated at the alar base. Nakajima et al. (2002) observed the AA in 72% of their dissections but they demonstrated an AA with a large diameter in only three dissections. The differences between the findings of Niranjan (1988) and Mitz et al. (1973) may result from their studying different ethnic groups or from differences between the terminology used for classifying the arteries.

With regard to the naming of the LNA, Cormack and Lamberty (1986) called the branch that supplied only the upper ala, the LNA, and Rohrich et al. (1995) called the artery proximal to the branch, the LNA. Nakajima et al. (2002) investigated the anatomical variations of the major branches of the FA to the upper lip and nose. They were classified into three types on the basis of the anatomy of the LNA that was defined as an artery running toward the alar base. In 88%, the FA bifurcated into the LNA and SLA at the angle of the mouth. In 8%, the FA became the AA after giving off the SLA and LNA sequentially. In 4%, the FA became an AA after giving off the SLA, and the LNA then branched off from the SLA.

Between the muscular and mucosal layers of the lips lies the arterial circle formed by superior and inferior labial branches of the FA. The position of ILA is close to the mucosa of the inner aspect of the lip just above the level of the lower margin of the vermillion (Kolhe and Leonard, 1988; Williams, 1995; Edizer et al., 2003). Irregularities of the vermillion attract considerable attention and can spoil the appearance of an otherwise excellently repaired cleft lip. Traditionally, vermillion reconstruction is done from buccal mucosa lining the cheek, from mucosa of the tongue or from the inner surface of the lower lip. The distance between the angle of mouth and the FA and the positions of the ILA and labiomental arteries are important in raising buccal mucosa and lower lip mucosa flaps (Ahuja, 1993; Pribaz et al., 2000; Schulte et al., 2001).

Park et al. (1994) found the upper lip to be supplied by superficial and deep ascending branches from the SLA. The external diameters of the deep ascending branches were larger than those of superficial ascending branches in their study.

Pribaz et al. (1992) reported their clinical experiences with the FAMM flap in reconstruction of the oral cavity. The flap is centered over the facial artery, and its orientation is oblique, extending from retromolar trigone to the ipsilateral gingival-labial sulcus at the level of the alar margin. The FAMM flap can be based superiorly (retrograde flow) or inferiorly (anterograde flow). Flap design is based on two factors: the site defect and the presence or absence of arterial flow. Inferiorly-based FAMM flaps may be used to reconstruct defects of the hard and soft palate, tonsillar fossa, alveolus, floor of mouth, and lower lip. When based superiorly, the FAMM flap can be used to close mucosal defects in the anterior hard palate, alveolus, maxillary antrum, nasal floor and septum, upper lip and orbit (Pribaz et al., 2000). For a superiorly based flap, the dissection begins anteroinferiorly by cutting through the mucosa, submucosa and the buccinator muscle to expose the FA (retrograde flow). For flaps that are inferiorly based, a similar procedure is followed. The surgeon begins
anterosuperiorly to identify the artery at the upper lip (antegrade flow). The arc of rotation has its pivot point inferiorly at the retromolar trigone, superiorly at the gingival labial sulcus, or anywhere in between depending on reconstructive needs. The importance of the distance of the FA to the angle of mouth, the branching points of the SLA and the ILA from the FA and their courses have been emphasized by Pribaz et al. (1992). Further, mobilization of the FAMM flap is deep to the main muscles of facial expression and should not endanger the branches of the facial nerve (Pribaz et al., 2000). In our dissection series, we have shown clearly that the FA courses deep to facial mimetic muscles thus, when preparing a facial muscular flap, the relationship between the FA and facial mimetic muscles must be considered.

Schulte et al. (2001) recommended the use of landmarks that would increase confidence during flap harvest for lip reconstruction. At the midpoint of the lip, they found the upper arterial circle in the muscle in 19% of the samples and between the mucosa and the muscle in 81% of the samples. The lower arterial circle was found in the muscle in 13% of the samples and between the mucosa and the muscle in 87% of the samples. In this investigation, we demonstrated different forms of SLA and ILA. We observed a vascular network in the upper lip mucosa, which is formed by anastomosis between the deep ascending branch of the superior labial artery and the lateral nasal artery. In our samples, the ascending branches were relatively large in the philtrum (medial subunits). We hope that these anatomical findings will be useful to surgeons when elevating an upper-lip flap, including the mucosal component, to repair a full-thickness defect of the perioral region.

Park et al. (1994) defined the vertical branches of the ILA as labiomental arteries and observed them in all cadavers. They defined the horizontal branches of the FA, going to the chin, as mental arteries and observed them in four of their nine cadavers. They illustrated these arteries in six groups. The detailed arrangement of these arteries, however, was not given in their article. Schulte et al. (2001) observed a single horizontal mental branch of the ILA in 27% of their dissections and did not observe horizontal branches of the FA. In addition to this, they did not mention the vertical branches of the ILA that were defined by Park et al. (1994). These two groups also mentioned the importance of these arteries in flap design, but did not give information about their course in the labiomental region. Thus, when we made our observations about the ILA and the arteries of the labiomental region, we devised our own classification system based on the findings of Park et al. (1994) and Schulte et al. (2001). In this study, the inferior labial artery was not as dominant as expected. The vascular territory of the inferior labial artery reached the submental region via the labiomental arteries. Although, the labiomental arteries were found in all our dissections, their locations and distribution patterns were variable. The labiomental arteries were larger and tended to have an orderly course when the ILA was narrow. To elevate a labiomental arterial flap safely, we recommend routine use of a Doppler probe preoperatively and intraoperatively. Doppler ultrasound helps to localize the facial vessels, and provides information on backflow and the potential for inverted flow in the facial artery (Park et al., 1994; Pribaz et al., 2000).

In conclusion, dissection and localization of the FA is important in reconstructive surgery, particularly in the vermilion and nasolabial region. The results of our study support previous work but this study has recorded more details about vascular structures suitable for designing flaps. Knowledge of the location and frequency of the perioral arteries is essential in designing appropriate mucosal flaps, skin flaps or musculomucosal flaps. The length of the pedicles, their location and diameter, and the courses of the perioral arteries by which they are sustained are important to the reconstructive surgeon operating in the face and around the mouth.

We provide an anatomic description of the superior and inferior labial arteries, and their relationship to landmarks that the facial reconstructive surgeon can use. The diameters of the arteries and the distance to certain landmarks influence the flap design. We suggest that knowing the location of the perioral arteries with respect to easily identifiable and easily used landmarks will help avoid complications. We hope that our findings provide anatomic information useful for the design of reliable flaps.

REFERENCES


