Anatomical Map of the Facial Artery for Facial Reconstruction and Aesthetic Procedures

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Abstract

Background: The facial artery (FA) is the main blood vessel supplying the anterior face and an understanding of its anatomy is crucial in facial reconstruction and aesthetic procedures.

Objectives: The aim of this study was to assess the many anatomical features of the FA utilizing a multidimensional approach.

Methods: Head and neck computed tomographic angiographies of 131 patients (255 FAs) with good image quality were evaluated. The FA was classified according to its termination pattern, course, and location with reference to soft tissue/bone surrounding structures.

Results: In total, each branch was present as follows: the submental artery (44.8%), the inferior labial artery (60%), the superior labial artery (82.2%), the lateral nasal artery (25.1%), and the angular artery (42.5%). The most common FA course was the classic course, situated medially to the nasolabial fold (27.1%). In total 65.5% of the arteries were located medially to the nasolabial fold, and only 12.3% of them were totally situated lateral to the nasolabial fold. The median distance (with quartiles) from the inferior orbital rim reached the FA after the superior labial artery branched off in 50.2% of cases and was 36.6 mm (33.4; 43.3). The angle between the FA and the inferior border of the mandible was 49.8° (31.9; 72.4). The horizontal distances between the oral commissure and naris to the FA were 8.5 ± 4.0 mm and 12.1 ± 6.7 mm, respectively.

Conclusions: An anatomical map summarizing the major measurements and geometry of the FA was generated. The detailed anatomy and relative positioning of the FA should be considered to avoid any unexpected complications in plastic surgery.

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The facial artery (FA) is a branch of the external carotid artery that supplies multiple muscles and skin of the face. It is divided into several branches including the submental artery, the inferior and superior labial arteries, and the lateral nasal artery. If the artery continues its course beyond the branching of these 4 arteries, the latter part is referred to as the angular artery.[1] Understanding the anatomy of the FA is crucial in plastic and aesthetic surgery for the

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best treatment outcomes and highest safety procedures. In the field of aesthetic surgery, dermal fillers are increasingly popular, and the nose, nasolabial fold (NLF), cheek, nasojugal groove, and glabella are the most common facial injection sites.[2] The most serious complications arising from the use of these fillers are associated with arterial blood supply, which may be unintentionally affected by procedures.[3] Moreover, intratissue filler movement could occur, even to regions distant from the original injection area, via blood vessels. The adverse effects of inappropriate filler placement include tissue loss, blindness, stroke, and even death.[2,4] Recent studies have highlighted facial danger zones, which are strongly associated with the course of the main vessels supplying the face, especially the FA and its branches. An increased knowledge of these zones can minimize the complications of filler use.[5,6]

The FA also plays a key role in face allotransplantation, which has recently gained importance for patients who cannot be managed by conventional reconstructive procedures. This therapeutic option is used to help patients after trauma or burns or with congenital defects, and in each case the donor flap needs to be connected to the recipient's FA to assure a blood supply.[7,8] Facial reconstruction presents unique challenges to the plastic surgeon, because it includes both static and dynamic structures and is one of the most highly vascularized regions in the body. Computed tomographic angiography (CTA) is recommended as the first-choice option for preoperative imaging in facial reconstructive surgery, because the visualization of small vessels is superior to that of magnetic resonance angiography.[9]

A literature search reveals many anatomical and imaging studies that evaluate the anatomy of the FA and are therefore potentially useful in facial plastic surgery.[10-16] However, each previous study only evaluates a certain section of the FA tree, without a multidimensional measurement approach. Therefore, the aim of this study was to present a complete anatomical map of the FA and its branches together with their multi-point measurements and to reference the course of the FA to simple anatomical landmarks.

METHODS

The research was approved by the Bioethical Committee of the Jagiellonian University, Krakow, Poland (no. 1072.6120.213.2017). The methods and protocols were carried out in accordance with the approved guidelines. The need for consent was waived by the ethics committee.

Study Group

An FA evaluation in this retrospective cross-sectional study was conducted on patients who underwent a head CTA at the Department of Diagnostic Imaging, Injury Center of Emergency Medicine and Disaster, Jagiellonian University Medical College in Kraków, Poland between January 2016 and September 2017. Exclusion criteria were as follows: head trauma affecting the course of the artery, significant artifacts (dental artifacts, low-quality and illegible images, etc.), significant atherosclerotic changes in the carotid bulb, lack of filling of the whole vascular system (assessed by lack of contrast in the veins), and incomplete cross sections. Of the initial 489 CTA patients available, a total of 358 were excluded due to severe dental metallic artifact (n = 320), insufficient field of view (n = 20), weak enhancement of the carotid artery (n = 8), repeated studies of one patient (n = 5), and missing data (n = 5). The remaining 131 patients (42.0% females) were included in this study. A total 124 patients had their FA visualized bilaterally and 7 unilaterally, which gave in total 255 FA in the final analysis.

Computed Tomographic Angiography Method and Image Evaluation

CTA was performed using a multi-row computed tomography scanner (GE Optima CT 660; GE Healthcare, Chicago, IL). A volume of 70 mL of a nonionic contrast agent, iopromide (Ultravist 370; 370 mg iodine/mL; Bayer HealthCare Pharmaceutical Inc., Leverkusen, Germany), was injected into the patient. After the bolus reached the common carotid artery at a level of C3-C4, the scanning procedure was started automatically. The imaged region ranged from the aortopulmonary window to the cranial vertex. The scanner setting was 120 kV, 320 mA, 64- × 0.625-mm slice collimation. Axial 0.625-mm slices at an increment of 1.25 mm were reconstructed with a matrix of 512 × 512, applying a standard kernel.

The data were analyzed on a dedicated workstation (Advantage Workstation AW4.5; GE Healthcare, Chicago, IL) equipped with software for 3-dimensional (3D) volume-rendering postprocessing of images. All scans were reconstructed employing a setting of volume-rendering opacity of 45 to 300 HU and then investigated visually. The FA and its branches were included in the analysis, with data for both sides recorded separately. The features of the FA were evaluated in 125 bilateral and 6 unilateral cases by 4 radiologists experienced in head and neck evaluation.

Measurements

In every patient the FA and its branches were identified. FA diameter was measured when its course reached the inferior margin of the mandible. Branch diameters were measured at the point where arteries branch off from the FA. The branching distance of all arteries was measured

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from the inferior border of the mandible body to the lowest contour of the branching point.

We used the classification method of FA distribution in CTA proposed by Furukawa et al where 4 categories are proposed: Type I, a short course of FA that terminates proximal to the superior labial artery; Type II, an intermediate course that terminates distal to the superior labial artery, near the NLF; Type III, a classic course that extends to the lateral nasal ala, beyond the NLF with an angular branch; and Type IV, duplex FA with a dominant lateral angular branch.[17] The occurrence of these classical branches of the FA as well as variations were recorded.

The relationship between the NLF and FA was analyzed based on the classification proposed by Yang et al regarding the coursing area: (1) medial to the NLF; (2) lateral to the NLF; (3) crossing the NLF from medial to lateral side; and (4) crossing the NLF from lateral to medial side.[11] In the computed tomography 3D reconstruction, the NLF is easily visible as a significant crease from the ala of the nose to the cheilion area. Moreover, such a reconstruction allows measurements in reference to soft tissues (Figure 1).

Measurements listed in Table 1 were performed in reference with FA course and other anatomical landmarks. The distance between the center of the inferior orbital rim and the FA was vertically delineated, and the part of the FA that this line crossed was noted. Manson's point is an area on the face that can be located based on surface landmarks and the FA to be located with a very high probability.[18] This point could be found by delineating 3 lengths: (1) from the mandibular angle to the menton; (2) from the lateral canthus to the mid-point of line 1; and (3) from the root of the lobule to the menton. Measurement lines were marked on the summary map of the FA (Figure 2).

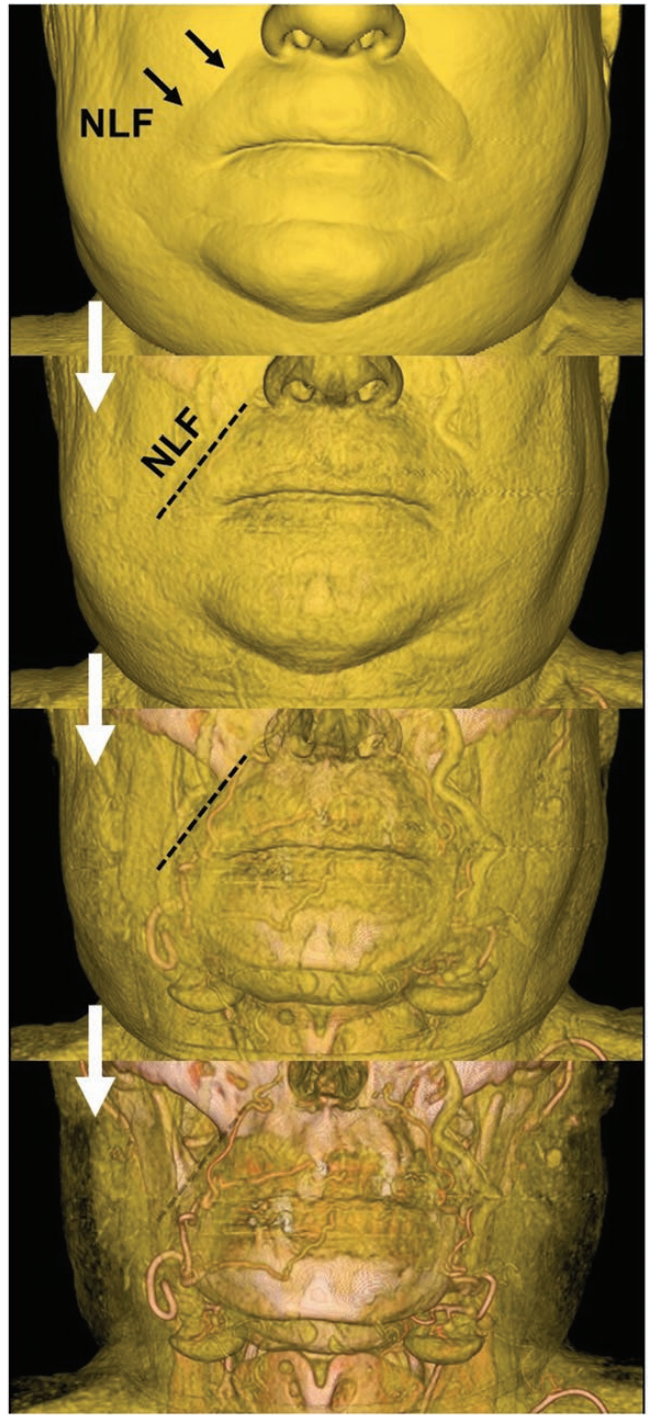

Figure 1. Three-dimensional reconstruction using computer tomography angiography, which allows the measurement of distances between the facial artery and bones as well as superficial soft tissues. This 63-year-old woman shows where the facial artery course is medial to the nasolabial fold (NLF).

Statistical Analysis

Qualitative features were presented by frequencies and percentages. Normal distribution was assessed with the Shapiro-Wilk test. Statistical significance was defined as $P < 0.05$. To verify homogeneity of variance the Levene's test was performed. Quantitative features were characterized utilizing the mean value ± standard deviation. Quantiles (Q1, Me, Q3) were applied if a nonparametric test was performed to compare quantitative features in groups. To compare FA features between left and right sides, the paired t test or Wilcoxon rank test was employed depending on whether data were normally distributed. Analysis of variance for parametric variables or Kruskall-Wallis tests for nonparametric variables were used to compare parameters between more than 2 groups. The power analysis indicated that to detect a simple correlation r ($r = 0.2$) utilizing a 2-sided test, 5% significance level test ($\alpha = 0.05$) with 80% power ($\beta = 0.2$), the required minimal sample size was approximately 193. The statistical analyses were performed with STATISTICA v13.1 (StatSoft Inc., Tulsa, OK) for Windows.

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Table 1. Location and Properties of the FA With Reference to Facial Structures

Parameter	Abbreviation on the map	Median (lower and upper quartiles)	10th percentile	90th percentile
Diameter of FA at inferior border of mandible	A	1.8 mm (1.4; 2.1)[a]	1.2	2.5
Distance from medial canthus to FA vertically	B	38.0 mm (29.3; 47.0) To angular artery: 31.6 mm (20.6; 38.8) To lateral nasal artery: 36.3 mm (33.6;41.7) To superior labial artery: 49.7 mm (41.4; 55.0)	17.4 11.8 27.7 35.1	55.6 46.0 49.9 57.7
Distance from mandibular angle to FA along inferior border of mandible	C	27.2 mm (24.0; 30.7)	20.9	33.7
Angle between FA and inferior border of mandible	D	49.8° (31.9; 72.4)	20.3	104.1
Distance from oral commissure to FA horizontally	E	7.9 mm (5.7; 10.7)[a]	4.2	13.5
Distance from naris to FA horizontally	F	10.5 mm (7.2; 15.3)	5.5	22.0
Distance from center of inferior orbital rim to FA vertically	G	38.9 mm (33.0; 45.9)	21.9	52.7
Distance from oral commissure to point where FA passes over inferior border of mandible	H	51.0 mm (45.9; 56.8)	40.5	62.9
Distance from naris to inferior border of mandible	I	63.3 mm (58.4; 68.8)	52.8	75.5
Distance from center of inferior orbital rim to inferior border of mandible	J	79.5 mm (73.6; 85.1)	69.0	91.1
Manson's point distance to FA	M	1.1 mm (0.0; 2.5)	0.0	4.0

FA, facial artery. [a]Statistically significant difference between left and right side, $P < 0.05$.

RESULTS

In total 131 patients were included in this study; 55 of cases were females (42.0%) and 76 of cases were males (58.0%). The mean age of the included patients was 61.4 ± 18.4 years old (range, 18-90 years).

Visualized Branches and Types of FA

Of the 255 evaluated FAs, the total numbers of visualized branches in CTA were as follows: 5 branches, 8 (3.1%); 4 branches, 45 (17.6%); 3 branches, 88 (34.5%); 2 branches, 72 (28.2%); 1 branch, 35 (13.7%); and no visible branch except FA trunk, 7 (2.7%). Table 2 shows the percentage distribution of each FA branch, together with diameters and branching distance. The superior labial artery was the most commonly occurring branch of the FA (82.2%), followed by the inferior labial artery (60.0%), the submental artery (44.8%), the angular artery (42.5%), and then the lateral nasal artery (25.1%). The bilateral appearance of arteries was similar except for the inferior labial artery, which was present on the right side in 84.5% of patients but only in 36.9% on the left side. There were no significant differences in mean diameter or mean branching distance of the FA branches between vessels located on the right and left side ($P > 0.05$).

According to the Furukawa et al classification, we were able to assign the appropriate type of FA in 249 cases (Table 3; Figure 3). Each of the types were presented in CTA in Figure 4A-D. In the remaining 6 cases (2.4%), the FA was hypotrophic with the dominant transverse FA (TFA), and its course replaced the FA from the superior labial artery to the angular artery. We have labeled this variant as Type V (Table 3; Figures 3 and 4E). Bilateral symmetry of FA types was observed in 51.6% of cases. The most corresponding type of the same morphology was the classical course (Type III), which symmetrically occurred in 25.8% of cases (Table 2). The diameter of FA within types I to III was the highest for Type III (2.0 [1.7; 2.3]) and the lowest for Type I (1.3 [1.2; 1.6]) ($P < 0.001$).

Measurements and Configuration of FA

The anatomical map with diameters and distances of the FA and its branches is shown in Figure 2. The vertical line connecting the central point of the inferior orbital rim and FA (Figure 2; Table 4) reached the FA after superior labial artery branching in 50.2% cases. The remaining variants, together with the median lengths of their connecting lines, are presented in Table 3.

The distance from naris to the inferior border of the mandible as well as the distance from the center

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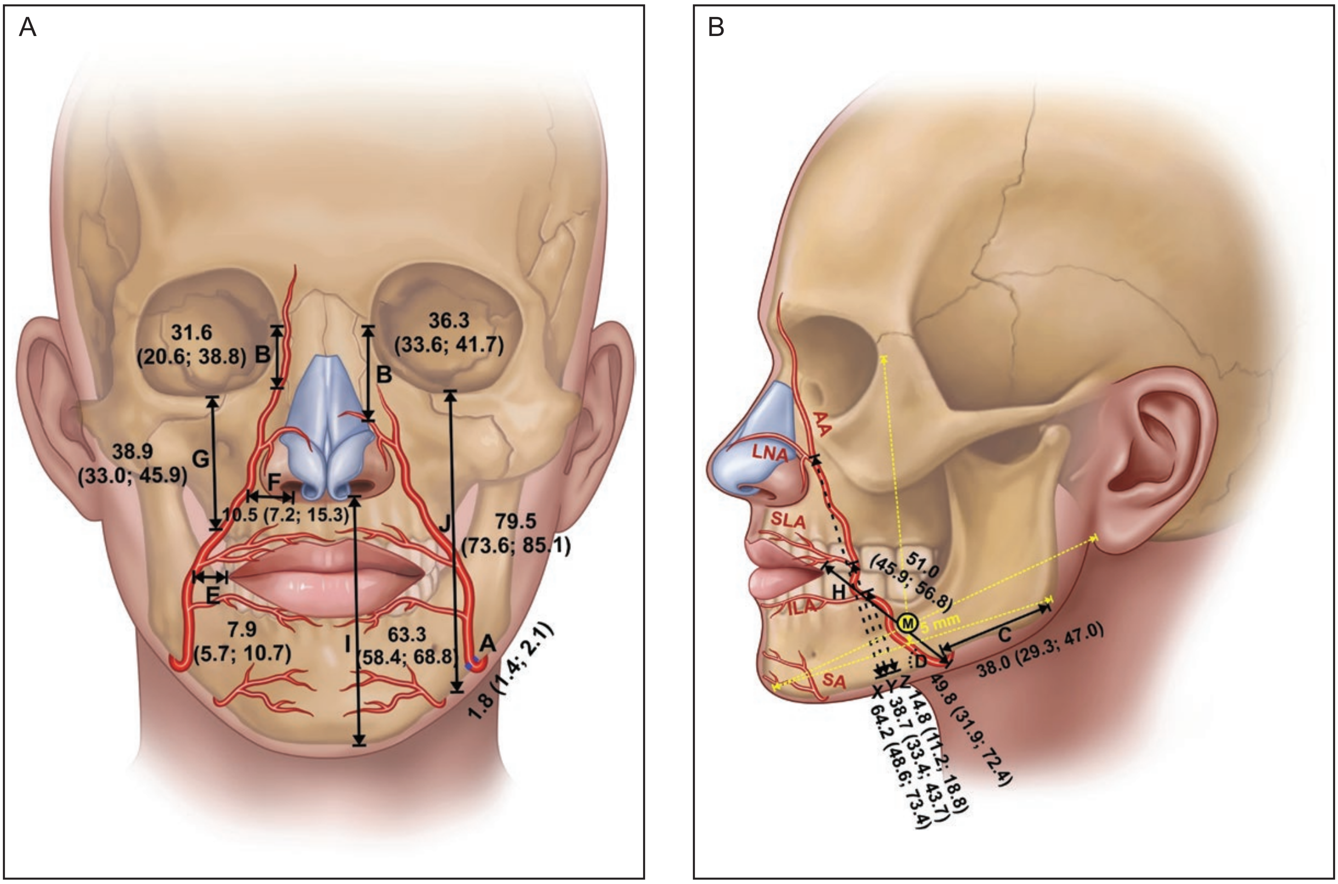

Figure 2. Mapping of the facial artery and its relationship to anatomical landmarks: frontal view (A) and lateral view (B). Results presented as median and quartiles. Yellow lines indicate the Manson's point (M), which is an area on the face that can be located based on surface landmarks and the facial artery to be located with a very high probability. AA, angular artery; ILA, inferior labial artery; SA, submental artery; SLA, superior labial artery. X,Y,Z - from the inferior border of the mandible body to the lowest contour of the branching point for ILA, SLA and LNA.

Table 2. Main Branches of the FA

Branch of FA	Right			Left			Total					
	n (%)	Diameter (mm)	Branching distance[a]	n (%)	Diameter (mm)	Branching distance[a]	n (%)	Diameter	Branching distance[a]	Symmetry n (%)	*P* value diameter between left and right side	*P* value distance between left and right side
Submental	59 (45.7)	0.89 ± 0.35	N/A	57 (43.8)	0.93 ± 0.40	n/a	116 (44.8)	0.91 ± 0.38	—	38 (30.6)	0.651	
Inferior labial	109 (84.5)	1.00 ± 0.35	14.7 ± 6.7	48 (36.9)	0.99 ± 0.30	15.8 ± 8.6	158 (61.0)	1.00 ± 0.33	15.0 ± 7.3	31 (25.0)	0.953	0.398
Superior labial	110 (85.3)	1.10 ± 0.73	37.8 ± 11.6	103 (79.2)	1.05 ± 0.28	38.5 ± 8.68	213 (82.2)	1.07 ± 0.56	37.8 ± 9.4	82 (66.1)	0.867	0.566
Lateral nasal	38 (29.5)	0.84 ± 0.45	63.4 ± 17.1	27 (20.8)	0.84 ± 0.21	58.7 ± 17.6	65 (25.1)	0.84 ± 0.21	60.8 ± 16.7	14 (11.3)	0.840	0.438
Angular	54 (41.9)	0.97 ± 0.31	51.9 ± 17.8	56 (43.1)	0.96 ± 0.27	48.5 ± 15.1	110 (42.5)	0.97 ± 0.26	49.7 ± 15.8	35 (28.2)	0.700	0.286

FA, facial artery. [a]Branching distance: measured perpendicularly from the inferior border of the mandible to beginning point of the artery.

of the inferior orbital rim to the inferior border of the mandible were associated with the higher diameter of FA (R = 0.18; *P* < 0.001 and R = 0.24; *P* < 0.001, respectively).

The FA position in relation to the NLF is presented in Table 5. The most frequent variant was the FA located medially to the NLF (group 1) (65.5%). The other 3 groups occurred at a similar frequency: group 2, lateral to the NLF (12.3%);

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Table 3. Classification of the FA Depending on the Termination Branch

Side	FA type					Sum
	I	II	III	IV	V (TFA)	
Right, n (%)	35 (27.1)	35 (27.1)	52 (40.3)	3 (2.3)	4 (3.1)	129
Left, n (%)	28 (22.2)	45 (35.7)	50 (39.7)	1 (0.8)	2 (1.6)	126
Total, n (%)	63 (24.7)	80 (31.4)	102 (40.0)	4 (1.6)	6 (2.4)	255
Co-occurrence	I	II	III	IV	V (TFA)	Symmetry
I	7.3%					51.6%
II	16.1%	16.1%				
III	17.7%	11.3%	25.8%			
IV	0.0%	0.8%	0.8%	0.8%		
V	0.0%	1.6%	0.0%	0.0%	1.6%	
Dimension	I	II	III	IV	V (TFA)	*P* value
Diameter of FA (mm)	1.3 (1.2; 1.6)	1.6 (1.4; 1.9)	2.0 (1.7; 2.3)	—	—	<0.001[a]
Oral commissure to FA distance (mm)	7.5 (5.7; 11.0)	9.0 (6.5; 11.4)	7.4 (5.2; 10.4)	—	—	0.074[b]

Modified Furukawa classification: I, terminates proximal to the superior labial artery; II, terminates distal to the superior labial artery, close to the nasolabial fold; III, textbook course, lateral nasal or angular artery as the final branch; IV, duplex with a dominant lateral angular branch; V, short course with a dominant TFA. FA, facial artery; TFA, transverse facial artery. [a]Statistically significant differences between all types. [b]$P = 0.064$ between II and III type.

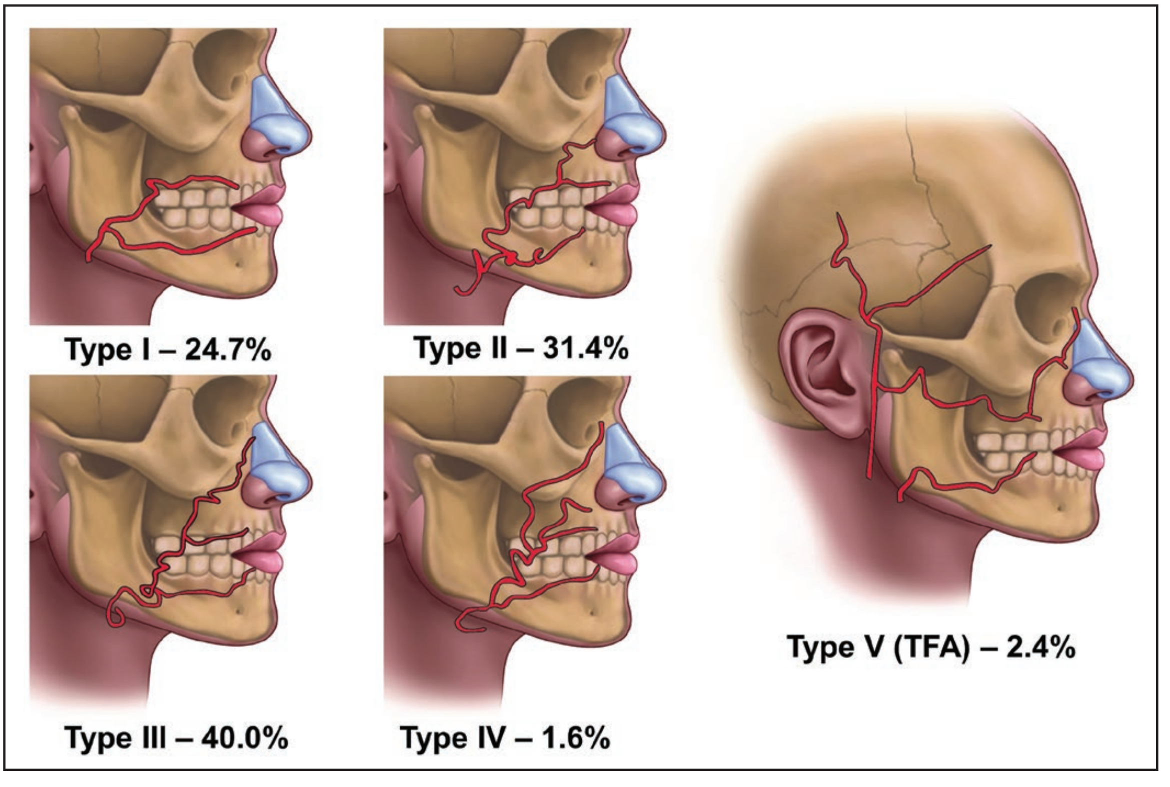

Figure 3. Facial artery classification in types and their occurrence. Modified Furukawa classification: Type I terminates proximal to the superior labial artery; Type II terminates distal to the superior labial artery, close to the nasolabial fold; Type III textbook course, lateral nasal or angular artery as the final branch; Type IV duplex with a dominant lateral angular branch. The additional type of facial artery course (Type V), where the vessel is hypoplastic and the remaining course is supplied by the dominant transverse facial artery (TFA).

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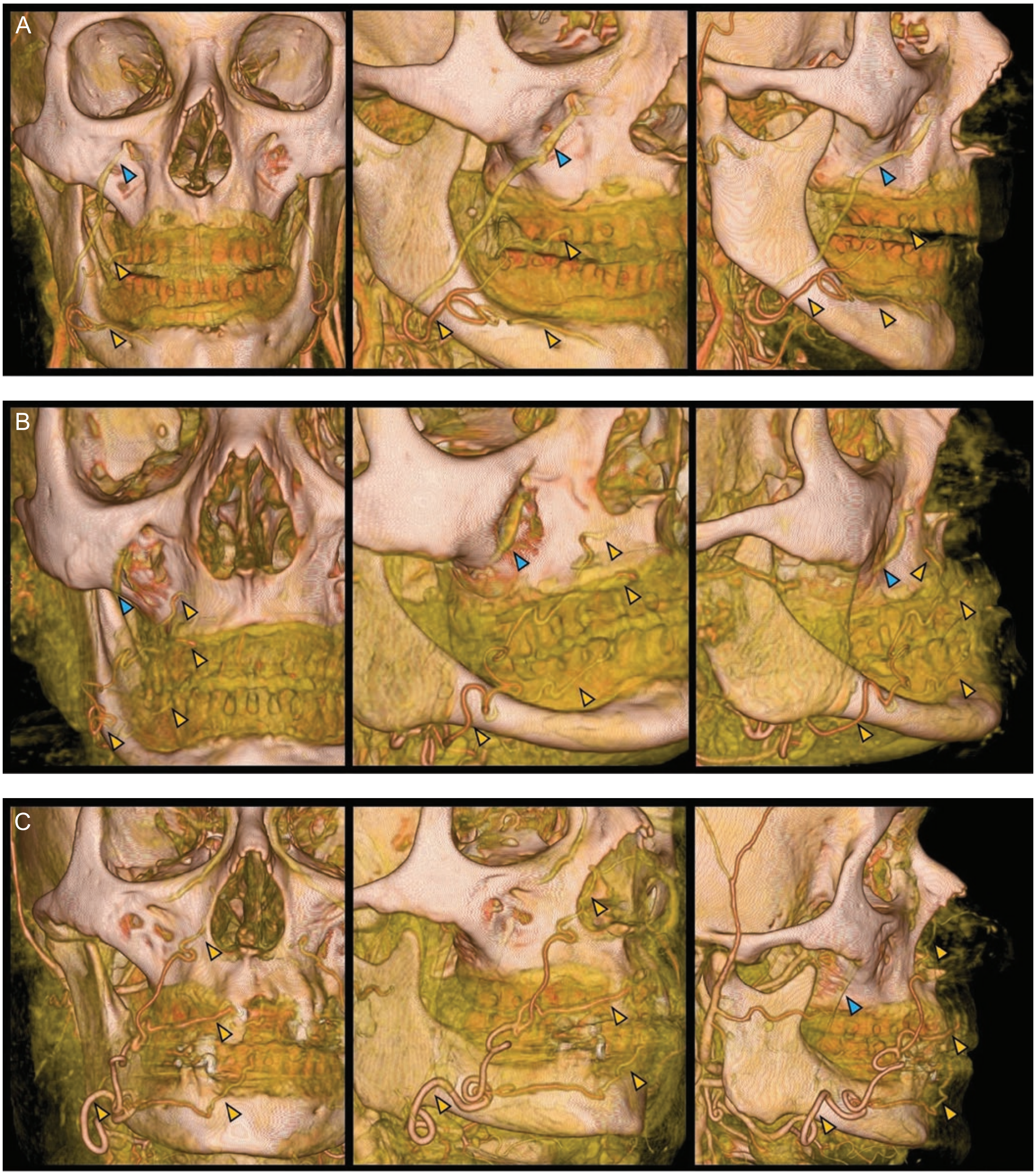

Figure 4. Facial artery classification in computed tomographic angiography. (A) Terminates proximal to the superior labial artery. (B) Terminates distal to the superior labial artery, close to the nasolabial fold. (C) Textbook course, lateral nasal or angular artery as the final branch. (D) Duplex with a dominant lateral angular branch. (E) The additional type of facial artery course where the vessel is hypoplastic and the remaining course is supplied by the dominant transverse facial artery. On the other side, the classical course of the facial artery is present. Yellow arrows indicate the facial artery and branches; red arrows indicate the transverse facial artery; blue arrows indicate the facial vein.

group 3, crossing the NLF from medial to lateral side (9.5%); and group 4, crossing the NLF from lateral to medial side (12.7%). There were no differences in FA diameters between the FA groups in relation to the NLF ($P > 0.05$). The distances between the oral commissure and the FA were naturally the largest for the FA that runs laterally to the NLF and the smallest for the artery that runs medially (10.6 mm [8.2; 14.4] vs 7.3 mm [5.3; 9.2], respectively). The measurement of the distances from the naris to the FA revealed longer distances when the FA crossed the NLF from medial to lateral side and shorter distances when the FA ran medially to the NLF (21.7 mm [16.0; 26.5] vs 9.0 mm [6.8; 11.8]). Using

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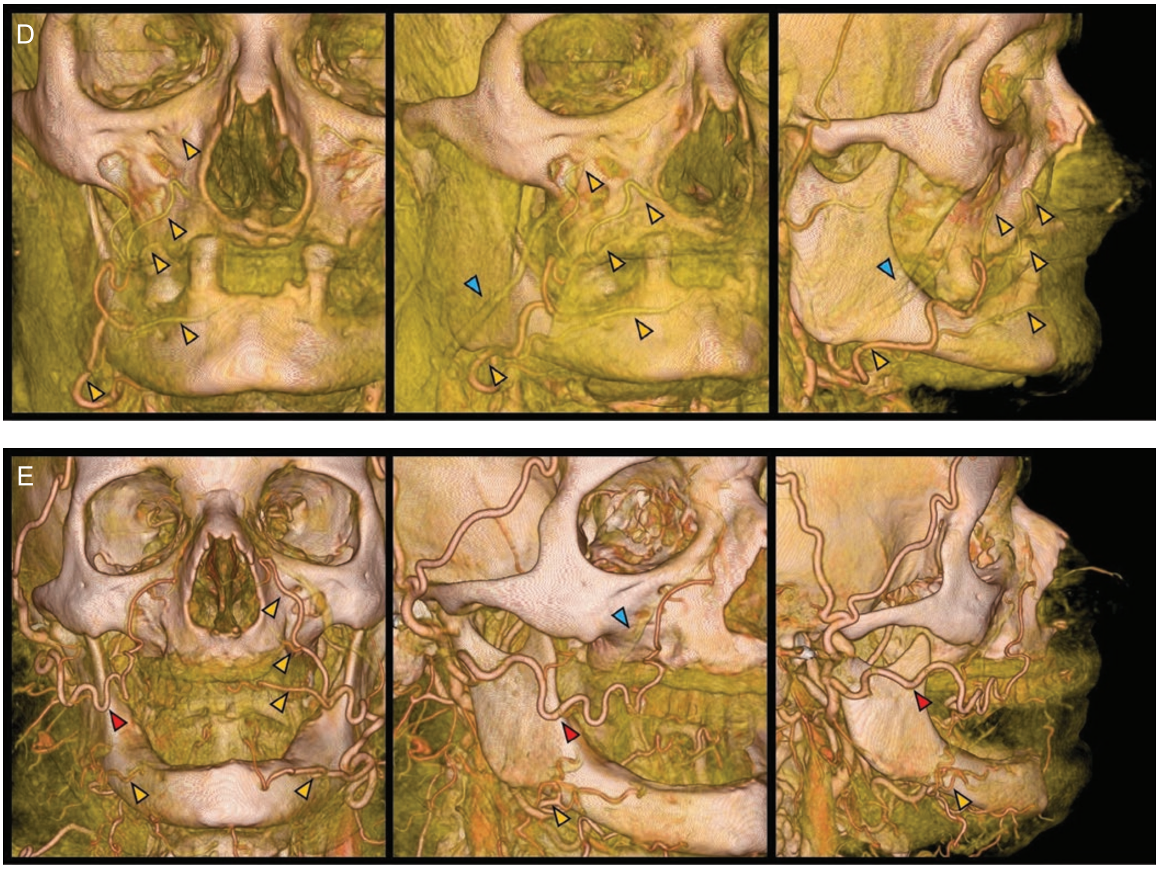

Figure 4. Continued

multidimensional measured data, the relationships between the 3 most frequent types of FA according to Furukawa et al and the course of the FA in relation to the NLF were assessed and are presented in Table 6. The most frequent configuration was the FA classic course (Type III) with an FA that runs medially to the NLF (27.1%). The Manson's point was calculated to be 1.1 mm (0.0; 2.5) from the FA. The calculated 90th percentile for this parameter was 4.0 mm, which allowed the FA to be located within a 8-mm-circular diameter from the center of Manson's point.

DISCUSSION

In this study, we compared many of the anatomical features of the FA utilizing a multidimensional approach, which could be significant in facial reconstruction and aesthetic procedures. Many previous publications have shown varying configurations of the FA and its branches, so there has not been a widely used and accepted classification.[8,14-17,19-21] The estimated prevalence of the FA branches based on cadaveric studies is from 57.5% to 100% for the inferior labial artery, 77.5% to 98.0% for superior labial artery, 32.5% to 98.0% for the lateral nasal artery, and 32.5% to 73.5% for the angular artery.[8,14-17,19-21] To illustrate commonalities and differences between major studies in this field, the results were presented in Table 7.[10,13-17,19,21-27] Due to many terminologies used, the compilation is the subjective opinion of the author.

There is a lack of consensus as to which of the FA branches should be considered the final branch.[20,28] The angular artery is often defined as the final FA branch, but this artery can also branch off the ophthalmic or the infraorbital artery instead of the FA. The morphology of the angular artery located between the canthus and nasal bone was described by Kim et al, where the most frequent course was a "detouring" pattern (31.6%) in which the angular artery continuously transverses from the detouring branch of the FA and ascends vertically to the nasojugular and medial canthal areas.[29] In 26.3% of cases, the artery was absent, in 22.8% it originated from the ophthalmic artery, and in only 19.3% it had a persistent, classical pattern, originating from the FA adjacent to the ala of nose. We believe that the angular artery should be assigned to its location, not to the artery from which it branches. In the current study, a rigid definition of the FA terminal branch was not stated; instead, the terminal branch morphology was described according to 1 of 5 different types.

In the notable study conducted by Furukawa et al, the classification of FA final branches were as follows: Type

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Table 4. Vertical Distance from the Center of the Inferior Orbital Rim to Part of the FA

Reaching part of FA	No.	%	Median (Q1; Q3) (mm)
After inferior labial artery branching	66	28.1	45.9 (41.8; 50.8)
Inferior labial artery	3	1.3	—
After superior labial artery branching	118	50.2	36.6 (33.4; 43.3)
Superior labial artery	16	6.8	44.0 (41.8; 50.8)
Lateral nasal artery	6	2.6	19.6 (7.5; 32.1)
Angular artery	26	11.1	29.3 (17.1; 32.4)

Distance measured in 235 cases. FA, facial artery; Q1; Q3, quartiles.

Table 5. Course of the FA in Relation to the NLF Presented as Average/Median Values Measured in 252 Cases

	Group	No.	%	Diameter of FA at mandibular arch[a]	Oral commissure to FA horizontally[b]	Naris to FA horizontally[c]
Medial to the NLF	1	165	65.5	1.7 (1.4; 2.1)	7.3 (5.3; 9.2)	9.0 (6.8; 11.8)
Lateral to the NLF	2	31	12.3	1.5 (1.1; 2.1)	10.6 (8.2; 14.4)	12.6 (9.0; 17.7)
Crossing the NLF from medial to lateral side	3	24	9.5	2.0 (1.6; 2.4)	9.1 (6.3; 11.6)	21.7 (16.0; 26.5)
Crossing the NLF from lateral to medial side	4	32	12.7	1.7 (1.3; 2.1)	9.3 (5.6; 12.1)	10.5 (6.5; 13.7)

FA, facial artery; NLF, nasolabial fold. [a]$P = 0.155$. [b]Statistically significant difference between groups 1 and 2 ($P < 0.001$). [c]Statistically significant difference between groups 1 and 3, as well as groups 3 and 4 ($P < 0.001$).

I, 34.2%; Type II, 39.6%; Type III, 24.0%; and Type IV, 2.1%. Similarly, in the current study, types I to III were the most frequent; however, the classical course (Type III) dominated (40.0%).[17] This agrees with the observations of Pilsl et al where the FA classical type was seen in 41.7% of cases.[22] Our study also describes an additional, fifth type of FA classification. In 2.4% of cases, we observed that the dominant TFA replaces the course of, and compensates for the hypoplasia of, the FA. Typically the TFA originates from the superficial temporal artery as a Y-shaped trunk.[30,31] Special attention should be given to this variation during the dissection of the cervicofacial flap. To reduce the risk of necrosis in this type of surgery, as many facial and transverse facial perforating branches as possible should be preserved.[32,33] The distribution of perforators may not be typical in this type of TFA and FA variation.

We have also noted that the asymmetric pattern of inferior labial artery distribution, with significant right side dominance, observed in our study is similar to that seen by both Furukawa et al and Koh et al.[14,17] This could be explained by the fact that arteries less than 1 mm in diameter could be concealed in CTA.[34] Interestingly, Banks et al have described 3 types of perfusion: unilateral carotid dominance, dual perfusion, and split perfusion. In their research, they found that unilateral carotid dominance was observed in the nasal dorsum and tip; however, bilateral perfusion was seen in the maxilla evaluated on cadavers.[35] In lip reconstruction surgery, most of the flaps are based on local axial vascularization via the labial arteries. The occurrence of arterial variations in this region could cause problems during flap harvesting.[36] Moreover, our observations could be significant for partial nose and lip transplantation, where anastomoses on the right side could provide a better blood supply to the graft than those on the left side.

In reconstruction surgery, the FA musculomucosal flap is a valuable option for the reconstruction of defects and the intraoral axial pedicle flap based on the FA.[37] The possible reconstruction sites where a FA musculomucosal flap can be used are on the floor of the mouth (39.9%), the palate (20.8%), the alveolar ridge (13.2%), and the lips (10.1%).[38] Moreover, there are many local flaps that use a partial supply from FA branches, including the nasolabial flap, the submental flap, and the cervicofacial flap.[32] The location of the defect in relation to facial aesthetic subunits determines the technique and the choice of a proper flap.[39] It should be noted that the length of the FA and its branching type has a great influence on musculomucosal flap procedures. In the current study, the length of the FA varied significantly, and in 24.7% of cases it terminated proximal to the superior labial artery (Type I of FA). In 42 cases (16.5%), the FA only had one or none visible branches, and such sparingly branched FAs can influence the ability to create a flap and the length of the flap.

Injections of dermal filler into the nasolabial area for the removal of creases can lead to postprocedural tissue

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Table 6. Correspondence Between FA Types I to III and Relationship to NLF

Type of FA	Medial to the NLF	Lateral to the NLF	Crossing the NLF medial to lateral	Crossing the NLF lateral to medial
I	49 (19.8)	9 (3.7)	0 (0.0)	5 (2.0)
II	46 (18.8)	11 (4.5)	5 (2.0)	18 (7.3)
III	67 (27.1)	8 (3.2)	19 (7.7)	8 (3.3)

Total n = 245. I, terminates proximal to the superior labial artery; II, terminates distal to the superior labial artery, close to the NSF; III, textbook course, lateral nasal or angular artery as the final branch. FA, facial artery; NLF, nasolabial fold.

Table 7. Major Studies in This Field Representing Termination Types of FA

Study	Year	No.	Superior or inferior labial (Type I) n (%)	Inferior alar (Type II) n (%)	Lateral nasal or angular/ supratrochlear (Type III) n (%)	Dominant lateral branch (Type IV) n (%)	Hypoplastic FA and dominating TFA (Type V) n (%)
Koziej et al[40]	2019	255 arteries (131 CTA cases)	63 (24.7)	80 (31.4)	102 (40.0)	4 (1.6)	6 (2.3)
Pilsl et al[22]	2016	60 arteries (30 CTA of cadavers)	11 (18.3)	—	Lateral nasal: 16 (26.7); angular: 25 (41.7)	8 (13.3)	—
Lee et al[10]	2015	54 arteries (cadavers)	—	—	Lateral nasal: 28 (51.8); angular: 10 (18.6)	16 (29.6)	—
Lee et al[10]	2015	60 arteries (36 cadavers)	13 (21.7)	—	47 (78.3)	-	—
Dickson et al[21]	2014	40 arteries (21 cadavers)	17 (42.5)	3 (7.5)	20 (50.0)	—	—
Furukawa et al[17]	2013	187 arteries (94 CTA cases)	64 (34.2)	74 (39.6)	45 (24.1)	4 (2.1)	—
Lohn et al[13]	2011	201 arteries (112 cadavers)[a]	25 (12.4)	35 (17.4)	Lateral nasal: 96 (47.8); angular: 40 (19.9)	—	—
Loukas et al[16]	2006	284 (142 cadavers)	28 (9.9)	—	245 (86.2)	11 (3.9)	—
Pinar et al[15]	2005	50 arteries (25 cadavers)	3 (6.0)	6 (12.0)	41 (82.0)	—	—
Koh et al[14]	2003	91 arteries (47 cadavers)	11 (12.1)	3 (3.3)	66 (72.5)	11 (12.1)	—
Gardetto et al[24]	2002	44 arteries (cadavers)	2 (4.5)	6 (13.6)	34 (77.4)	2 (4.5)	—
Dupoirieux et al[25]	1999	20 arteries (10 cadavers)	7 (35.0)	—	Lateral nasal 9 (45); angular: 4 (20)	—	—
Niranjan[19]	1988	50 arteries (25 cadavers)	2 (4.0)	1 (2.0)	42 (84)	5 (10)	—
Kozielec and Jozwa[27]	1977	119 (110 human fetuses)	50 (42)	—	69 (58)	—	—
Mitz et al[26]	1973	50 (cadavers)	(18)	—	(82)	4% of other types	—

Because there are many terminologies used, the compilation is the subjective opinion of the author. CTA, computed tomography angiography; FA, facial artery; TFA, transverse facial artery. [a]No FA detected in 5 cases.

necrosis of the nose, with injections at this location being the second most common reason for facial necrosis to occur.[3] Our study is the first to our knowledge to evaluate the course of the FA in relation to NLF using CTA. Previous cadaveric studies indicated that the most frequent type of relationship between the FA and the NLF is that the FA is located medially to the NLF (42.9%).[11] Our current study indicated an even greater dominance of such a pattern and suggests that during the injection of filler into the NLF region, additional caution should be taken when the filler is placed medially to the NLF. Kim et al showed on cadavers that FA branches in the NLF, inferolateral area to the cheilion, and areas lateral to the ala are often located subcutaneously.[10] The danger zone region in the NLF is in its upper third where the artery course can be very superficial.[6] Moreover, our analysis

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shows that the 10th percentile for the distance between naris and FA is 5.5 mm.

The depth of the artery is an important clinical feature that could not be evaluated in the CTA. In a study conducted by Lee et al, cadavers' FA depth and its relationship to the facial musculature layer was investigated.[10] Lee et al found an inconstant, layer-changeable course of the FA either along the surface or in the deep regions of the facial muscles. It has been shown that FA branches in the area of NLF inferolateral to the mouth corner and lateral to the ala of the nose are frequently situated subcutaneously.[10] This unpredictable positioning strengthens the suggestion that aspiration before injection of the dermal filler should be performed in this area. Our study has shown that 65.5% of the FAs are located medially to the NLF, and only 12.3% of FA were totally situated lateral to the NLF.

In a previous study published by the authors regarding the anatomy of the superficial temporal artery, a detailed map of the artery was presented.[40] The current study is a consecutive investigation demonstrating the vascularity of the human face based on a large data sample. Our study revealed a detailed map of anterior face vascularization (Figure 2). One of the landmarks that allows physicians to localize the FA with high precision is the Manson point, where the FA occurs with the highest probability. Our study, which included a relatively large sample size, indicated that the median value for this parameter was 1.1 mm (0.0; 2.5). Another relevant point to predict the location of the FA is the S point described by Lee et al, which is located 12.1 ± 3.1 mm (thumbnail dimension) from the corner of the mouth and allows the estimation of the origin point of the superior labial artery.[23] In the current study, we showed that the mean horizontal distance between the oral commissure and the FA measured to the first branch of the FA or the FA trunk was 8.5 ± 4.0 mm. For this distance, physicians can expect a vessel from 4.2 mm (10th percentile), which indicates that the FA can run very close to the oral commissure and thus may pose a risk during various procedures.

This study is not without limitations. Firstly, the FA tree also consists of smaller vessels, such as the nasal septal branch, horizontal labiomental artery, and vertical labiomental artery, but these could not be visualized by means of CTA.[28] In addition, due to the low resolution of CTA the possible origins of the angular artery from the infraorbital artery as well as the ophthalmic artery were not assessed. Although CT in contrast to cadaver sections can miss some very minor vessels, they do not seem to be that significant due to the random vascularity of the face. Most complications in aesthetic procedures and most large reconstruction flaps are based on the greater vessels that are captured by CT. The dose needs to be matched adequately to the patient's safety. The depth of the FA could not be recorded employing CTA. Secondly, the course of veins, via which complications can also arise in plastic surgeries, was not evaluated. The facial vein runs posteriorly to the FA and presents a constant course between the mandible and median canthus.[41] We observed that in all cases the vein was situated behind the artery. The analyzed patients only included Caucasians; thus, no interracial differences were evaluated. Finally, the proposed anatomical map should not be used as a universal tool because anatomical variations may occur in individual patients. Specifically, patients with craniofacial deformities were not included, and the above results cannot be explicated in this group.

CONCLUSIONS

The course of the FA has been a subject of great debate in the plastic surgery field. This study presents a detailed anatomy of the FA and its relationship to anatomical landmarks. We have created a unique anatomical map that summarizes the major measurements and geometry of the FA based on a large sample size. This work will be supportive for plastic, reconstructive, and aesthetic surgeons in planning facial surgical procedures.

Disclosures

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