Dubai Medical Journal

Research Article

Dubai Med J 2023;6:81–96
DOI: 10.1159/000529300

Received: November 30, 2022
Accepted: January 23, 2023
Published online: March 8, 2023

Branching Patterns and Variations of Facial Artery and Clinical Importance: A Cadaveric Study

Cagatay Barut[a] Eren Ogut[b] Zeynep Askin[c] Hasan Alicikus[c]

[a]Department of Anatomy, Istanbul Medeniyet University, Faculty of Medicine, Istanbul, Turkey; [b]Department of Anatomy, Bahcesehir University, Faculty of Medicine, Istanbul, Turkey; [c]Medical Faculty Student, Bahcesehir University, Faculty of Medicine, Istanbul, Turkey

Keywords

Facial artery · Branching patterns · Anatomical variations · Types · Tributaries of the facial artery

Abstract

Introduction: The facial artery (FA) was observed with distinctive variations and anomalous, which occur during the embryological developmental process due to the ablation of neural crest cells that impact embryonic aortic arch vessels, resulting in distinctive branching patterns. Therefore, this study aimed to investigate the types, clinical importance, localization, and differences of FA in fixed cadavers according to gender and body side. ***Methods:*** The current study was conducted on 19 formalin-fixed cadavers (68.4% males, n = 13; 31.6% females, n = 6). The types, variations, prevalence, and distance to nearby surgical landmarks of FA were recorded on both sides. Measurements were taken with a surgical microscope (Zeiss Meditec, Berlin, Germany) and a digital caliper (INCA, DCLA-0605, 0.6–150 mm). ***Results:*** Angular type % 73.1 (n = 14, right; n = 19, left), labial type % 5.3 (n = 1, right), alar type % 5.3 (n = 1, right), and nasal type % 5.3 (n = 1, right) were detected. The following parameters were significant according to gender; the distance between the ala of the nose and the origin of the FA on both sides (p = 0.007 right; p = 0.018 left), the diameter of FA at the cheilion (p = 0.019 left), diameters of the superior and inferior labial arteries at their origin (p = 0.031 right; p = 0.025 right) and PO lines. ***Conclusion:*** The significant differences in gender according to the distance of the FA and its branches from the origin should be considered to reduce complications during surgery. The differences in studies according to the types and variations of FA may be due to the scale of the study, gender, or study design.

Introduction

Three main arterial trunks provide the arterial supply of the face; the transverse facial artery (FA), infraorbital artery, and FA, which is essential for surgical and nonsurgical applications [1]. The FA is one of the branches of the external carotid artery (ECA), and it is responsible for the main arterial supply of the face and has the same trunk as the lingual artery [1–5]. The FA emerges from the ECA near the level of the hyoid bone's greater horn, which is

Karger@karger.com
www.karger.com/dmj

Karger
OPEN ACCESS

Correspondence to:
Cagatay Barut, cagbarut@yahoo.com

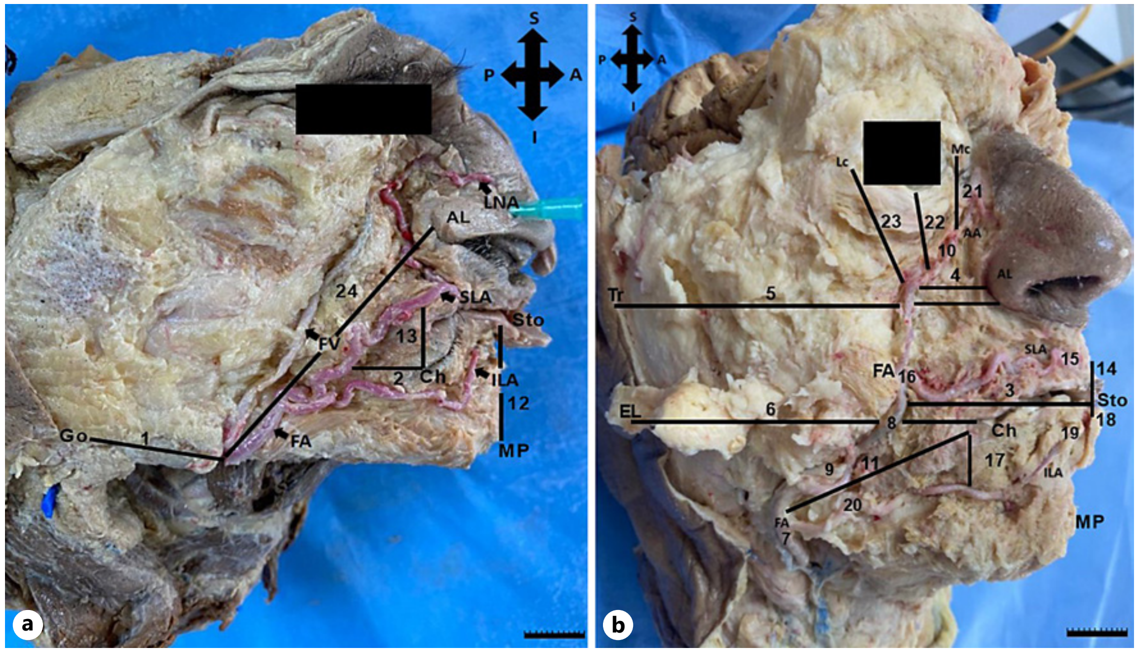

Fig. 1. The measurements (1–24) were taken as follows. **a** 1. The distance between gonion and facial artery (Go-FA), 2. The distance between cheilion and the facial artery (Ch-FA), 12. The distance between stomion and mental prominence (Sto-MP), 13. The distance between the superior labial artery and cheilion (SLA-Ch), 24. The distance between the ala of the nose and the origin of the facial artery (PO line). **b** 3. The distance between stomion and facial artery (Sto-FA), 4. The distance between the ala of the nose and facial artery (AL-FA), 5. The distance between ala of nose and tragus (AL-Tr), 6. The distance between cheilion and the ear lobe (Ch-EL), 7. The diameter of the facial artery at its origin (r FA [O]), 8. The diameter of the facial artery at the cheilion (r FA [Ch]), 9. The diameter of the facial artery between its origin and cheilion (r FA [O-Ch]), 10. The diameter of the angular artery (r AA), 11. The distance between cheilion and the origin of the facial artery (Ch-O), 14. The distance between the superior labial artery and stomion (SLA-Sto), 15. The diameter of the superior labial artery at the stomion (r SLA [Sto]), 16. The diameter of the superior labial artery at its origin (r SLA [O]), 17. The distance between the inferior labial artery and cheilion (ILA-Ch), 18. The distance between the inferior labial artery and stomion (ILA-Sto), 19. The diameter of the inferior labial artery at the stomion (r ILA [Sto]), 20. The diameter of the inferior labial artery at its origin (r ILA [O]), 21. The distance between medial canthus and angular artery (Mc-AA), 22. The distance between the midpoint of the eye and angular artery (Mid-AA), 23. The distance between lateral canthus and angular artery (Lc-AA). A, anterior; AA, angular artery; AL, ala of the nose; Ch, Cheilion; EL, ear lobe; FA, facial artery; FV, facial vein; Go, gonion; I, inferior; ILA, inferior labial artery; Lc, lateral canthus; LNA, lateral nasal arter; Mc, medial canthus; Mid, median plane of the eye; MP: mental prominence; O, origin; P, posterior; PO line, the distance between the ala of the nose and the origin of the facial artery; r, diameter; S: superior; SLA, superior labial artery; Sto, Stomion; Tr: tragus.

protected by the mandibular ramus [2–4]. Then, it travels obliquely just under the digastric and stylohyoid muscles, runs below the mandible, and ascends across the buccal region to the angle of the mouth and nose [4]. It continues as the angular artery and provides three distinct branches: the inferior labial artery (ILA), the superior labial artery (SLA), and the lateral nasal artery (LNA) [5]. The transverse FA and following arteries that run alongside the cutaneous nerves also supply the face [5]. The development of the FA consists of three stages which cause several discrepancies such as enlargement, agenesis of the FA, hypoplasia, or different branching patterns [4]. During the 4–5th weeks of the embryological development process, the aortic sac effectuates the aortic arches; the third aortic arch gives rise to the ECA, where the origin of FA [6]. The variations of the FA eventuate due to the ablation of neural crest cells that impact embryonic aortic arch vessels [4].

The FA demonstrates disparities in its origin, termination, and branching patterns, leading to classification according to its' termination point [7]. The FA and its tributaries are topographically connected to the cheilion (Ch), stomion (Sto), gonion (Go), nasolabial groove, vermilion border, and facial muscles that control facial expressions [8]. Therefore, variations and branching patterns of FA and distance to various reference points were analyzed to clarify the localization and tributaries of FA in detail.

Table 1. Precision estimates of measurements

Parameters	*N*	TEM, mm	rTEM (%)	*R*
Right Go-FA: gonion-facial artery	17	0.45	2.07	0.99
Left Go-FA: gonion-facial artery	19	0.42	2.01	0.99
Right Ch-FA: cheilion-facial artery	17	0.57	4.02	0.98
Left Ch-FA: cheilion-facial artery	18	0.54	4.06	0.99
Right Sto-FA: stomion-facial artery	17	0.83	1.91	0.98
Left Sto-FA: stomion-facial artery	19	0.69	1.63	0.99
Right AL-FA: ala of nose-facial artery	14	0.38	3.29	0.99
Left AL-FA: ala of nose-facial artery	17	0.39	2.99	0.98
Right AL-Tr: ala of nose-tragus	15	0.73	0.69	0.98
Left AL-Tr: ala of nose-tragus	17	0.48	0.45	0.99
Right Ch-EL: cheilion-ear lobe	17	0.77	0.82	0.99
Left Ch-EL: cheilion-ear lobe	18	0.78	0.81	0.98
Right r FA (origin): diameter of facial artery at the origin	17	0.15	4.16	0.98
Left r FA (origin): diameter of facial artery at the origin	19	0.19	5.93	0.92
Right r FA (ch): diameter of facial artery at chelion	17	0.13	5.33	0.92
Left r FA (ch): diameter of facial artery at chelion	18	0.15	6.32	0.86
Right r FA (O-Ch): diameter of facial artery between the origin and chelion	17	0.14	5.09	0.92
Left r FA (O-Ch): diameter of facial artery between the origin and chelion	18	0.15	5.67	0.90
Right r AA: diameter of angular artery	16	0.22	14.85	0.79
Left r AA: diameter of angular artery	18	0.17	13.10	0.69
Right Ch-O: cheilion-origin of facial artery	17	0.83	1.80	0.98
Left Ch-O: cheilion-origin of facial artery	18	0.70	1.50	0.99
Right Sto-MP: stomion-mental prominence	17	0.38	0.93	0.99
Left Sto-MP: stomion-mental prominence	19	0.41	1.00	0.99
Right SLA-Ch: superior labial artery-cheilion	14	0.40	4.41	0.97
Left SLA-Ch: superior labial artery-cheilion	16	0.48	5.04	0.97
Right SLA-Sto: superior labial artery-stomion	13	0.26	4.08	0.97
Left SLA-Sto: superior labial artery-stomion	16	0.30	4.89	0.99
Right r SLA (Sto): diameter of superior labial artery at stomion	13	0.16	10.64	0.89
Left r SLA (Sto): diameter of superior labial artery at stomion	16	0.20	12.69	0.76
Right r SLA (O): diameter of superior labial artery at the origin	14	0.15	7.14	0.95
Left r SLA (O): diameter s of superior labial artery at the origin	17	0.21	10.40	0.81
Right r ILA (Sto): diameter of inferior labial artery at stomion	13	0.12	7.89	0.90
Left r ILA (Sto): diameter of inferior labial artery at stomion	19	0.16	10.73	0.82
Right r ILA (O): diameter of inferior labial artery at the origin	14	0.24	11.48	0.88
Left r ILA (O): diameter of inferior labial artery at the origin	19	0.15	7.97	0.90
Right ILA-Ch: inferior labial artery-cheilion	14	0.49	4.10	0.98
Left ILA-Ch: inferior labial artery-cheilion	18	0.60	4.26	0.99
Right ILA-Sto: inferior labial artery-stomion	13	0.32	4.55	0.99
Left ILA-Sto: inferior labial artery-stomion	18	0.35	3.61	0.99
Right Mc-AA: medial canthus-angular artery	14	0.56	4.34	0.98
Left Mc-AA: medial canthus-angular artery	18	0.31	3.03	0.99
Right Mid-AA: middle of eye-angular artery	13	0.35	1.34	0.99
Left Mid-AA: middle of eye-angular artery	17	0.59	2.05	0.99
Right Lc-AA: lateral canthus-angular artery	12	0.52	1.16	0.99
Left Lc-AA: lateral canthus-angular artery	17	0.72	1.61	0.96

AA, angular artery; AL, ala of the nose; Ch, cheilion; EL, ear lobe; FA, facial artery; Go, gonion; ILA, inferior labial artery; Lc, lateral canthus; Mc, medial canthus; Mid, median plane of the eye; MP, mental prominence; O, origin; PO line, the distance between the ala of the nose and the origin of the facial artery; r, diameter; rTEM, relative technical error of measurement; R, coefficient of reliability; SLA, superior labial artery; Sto, stomion; TEM, technical error of measurement; Tr, tragus.

Table 2. Distribution of types of FA in relation to gender

	Male				Female				Total			
	right		left		right		left		right		left	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Not available	2	15.4							2	10.5	–	–
Angular type	8	61.5	13	100	6	100	6	100	14	73.7	19	100
Alar type	1	7.7							1	5.3	–	–
Labial type	1	7.7							1	5.3	–	–
Nasal type	1	7.7							1	5.3	–	–
Total	13	100		100	6	100	6	100	19	100	19	100

n, number.

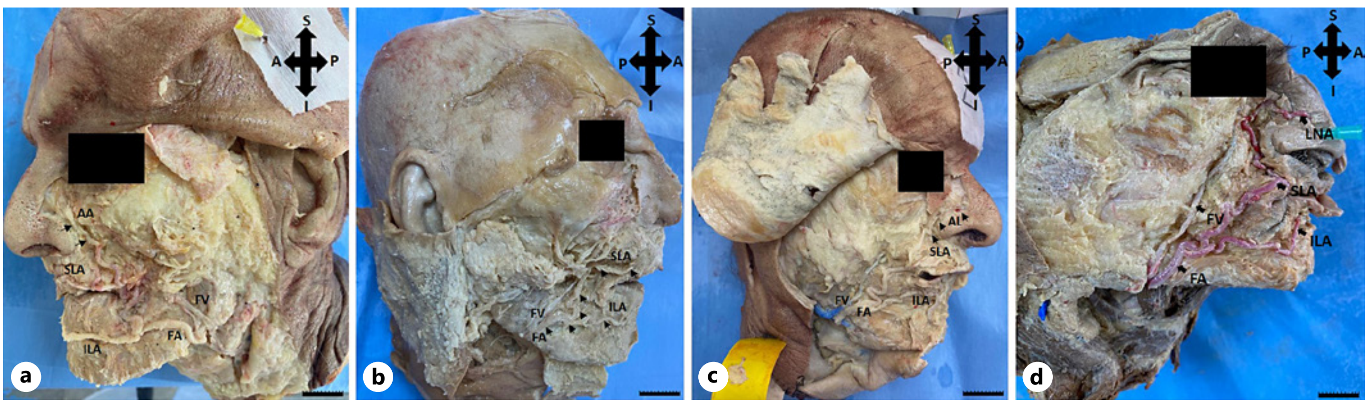

Fig. 2. The types of FA. **a** The angular type of FA (black arrows). **b** The labial type of FA (black arrows). **c** The alar type of FA (black arrows). **d** The nasal type of FA (black arrows). A, anterior; AA, angular artery; AL, ala of the nose; FA, facial artery; FV, facial vein; i, inferior; ILA, inferior labial artery; LNA, lateral nasal artery; P, posterior; S, superior; SLA, superior labial artery.

Materials and Methods

The types, locations, variations, and prevalence of FA were investigated bilaterally in 19 adult formalin-fixed cadaveric heads 13 (68.4%) males and 6 (31.6%) females). However, the halves of two cadavers were traumatized, and the other halves were studied where the formations were observed (17 bilateral and 2 unilateral) (36 sides). The fixed cadaveric heads with trauma or morphological pathology were not included (n = 11). Cadavers used in the current research had normal anatomy and morphology of the face (n = 19). The cadaveric heads were perfused with colored silicone before dissection. To define and classify the types of FA, the following surgical dissections were performed and examined under the surgical microscope. The skin was dissected from tragus to the medial canthus (Mc), where the incision was continued along the nasal crest to the philtrum. It was dissected along the superior vermilion border to the Ch, vertically downward to the mental prominence, and then posteriorly to the mandibular angle. Afterward, the subcutaneous adipose tissue was eliminated, and the skin was retracted to identify the origin of the FA, its branches, and its distribution pattern. The FA was examined for the distinctive branching patterns and was classified into types based on the earlier method of categorization given by Mitz (1973) [9] and Niranjan et al. (1988) [10].

The lengths, diameters, and distances to the nearby surgical landmarks were measured on both sides. The measurements for morphometric analysis were taken with the help digital microcaliper and calculations were done to determine the technical error of measurement (TEM), the relative technical error of measurement (rTEM), and the coefficient of reliability in order to obtain intraobserver accuracy (R) [11–21]. The TEM was determined by taking the square root of the sum of the squared differences in two measurements and dividing that result by two times the size of the sample [15–19, 22]. The usual magnitude of error associated with exact measurement is known as the TEM, and it is used to evaluate the intraobserver accuracy of a measurement [15, 16, 18, 22]. The relative standard error of the mean (rTEM) is computed by taking the TEM value for a particular variable, dividing it by the mean

Table 3. Descriptive values for the whole study group

Parameters	*N*	Mean	SD	SEM	Min	Max
R Go-FA	17	21.4635	4.94521	1.19939	9.40	27.10
L Go-FA	19	21.0011	6.05292	1.38863	11.30	35.40
R Ch-FA	17	14.2106	4.54859	1.10319	8.20	23.60
L Ch-FA	18	13.4111	4.54234	1.07064	5.70	23.80
R Sto-FA	17	43.5629	6.34144	1.53802	32.60	55.10
L Sto-FA	19	42.2737	6.17628	1.41694	34.10	53.10
R AL-FA	14	11.7571	4.29073	1.14674	6.00	19.40
L AL-FA	17	12.9941	2.69385	0.65336	8.20	16.90
R AL-Tr	15	105.7867	4.98267	1.28652	95.90	113.80
L AL-Tr	17	105.8353	5.24189	1.27135	96.30	116.80
R Ch-EL	17	93.7600	8.18297	1.98466	79.70	108.50
L Ch-EL	18	96.0000	5.92174	1.39577	84.80	105.30
R r FA (origin)	17	3.5824	1.07426	0.26055	1.80	5.40
L r FA (origin)	19	3.2316	0.66921	0.15353	2.00	4.90
R r FA (Ch)	17	2.5059	0.49557	0.12019	1.70	3.40
L r FA (Ch)	18	2.3278	0.40845	0.09627	1.70	3.10
R r FA (O-Ch)	17	2.8000	0.52797	0.12805	1.80	3.80
L r FA (O-Ch)	18	2.6000	0.49941	0.11771	1.80	3.50
R r AA	16	1.5250	0.49464	0.12366	0.70	2.80
L r AA	18	1.2889	0.30849	0.07271	0.80	2.00
R Ch-O	17	46.3412	6.46017	1.56682	35.70	56.70
L Ch-O	18	46.2444	7.37406	1.73808	35.80	61.70
R Sto-MP	17	40.8765	6.96442	1.68912	30.20	52.70
L Sto-MP	19	41.4158	6.92197	1.58801	30.10	52.60
R SLA-Ch	14	9.1071	2.68857	0.71855	6.60	16.90
L SLA-Ch	16	9.5438	3.08868	0.77217	4.00	15.30
R SLA-Sto	13	6.4308	1.59759	0.44309	4.20	8.80
L SLA-Sto	16	6.1125	2.89595	0.72399	3.40	13.90
R r SLA (Sto)	13	1.5538	0.47190	0.13088	0.90	2.40
L r SLA (Sto)	16	1.5625	0.43031	0.10758	1.00	2.60
R r SLA (O)	14	2.1500	0.65838	0.17596	1.30	3.80
L r SLA (O)	17	2.0294	0.49087	0.11905	1.00	2.90
R ILA-Ch	14	12.0929	3.41388	0.91240	7.10	19.50
L ILA-Ch	18	14.0500	5.40221	1.27331	8.10	27.50
R ILA-Sto	13	6.9692	3.15394	0.87474	3.20	12.90
L ILA-Sto	18	9.6944	3.17666	0.74875	3.10	14.10
R r ILA (O)	14	2.0143	0.65381	0.17474	0.90	2.90
L r ILA (O)	19	1.9263	0.51838	0.11892	1.00	3.10
R r ILA (Sto)	13	1.4923	0.39468	0.10946	0.80	2.30
L r ILA (Sto)	19	1.4368	0.42845	0.09829	0.70	2.40
R Mc-AA	14	12.8500	4.06614	1.08672	7.40	20.30
L Mc-AA	18	10.1389	3.14271	0.74074	5.40	16.70
R Mid-AA	13	25.7231	6.34746	1.76047	14.40	36.60
L Mid-AA	17	28.9176	6.16484	1.49519	19.40	40.40
R Lc-AA	12	45.3333	8.78928	2.53725	32.40	59.80
L Lc-AA	17	44.7824	3.62168	0.87839	39.00	51.90
R PO line	15	73.2733	10.58364	2.73269	59.50	96.30
L PO line	17	76.7059	9.69210	2.35068	59.80	96.30

AA, angular artery; AL, ala of the nose; Ch, cheilion; EL, ear lobe; FA, facial artery; Go, gonion; ILA, inferior labial artery; L, left; Lc, lateral canthus; Mc, medial canthus; Mid, median plane of the eye; MP, mental prominence; O, origin; PO line, the distance between the ala of the nose and the origin of the facial artery; r, diameter; R, right; SLA, superior labial artery; Sto, stomion; Tr, tragus.

Table 4. Comparison of parameters according to gender

Parameters	Males						Females						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
R Go-FA	11	22.0891	3.67991	1.10953	13.80	27.10	6	20.3167	6.98095	2.84996	9.40	26.80	0.498
L Go-FA*	13	21.9631	6.65352	1.84536	16.10	35.40	6	18.9167	4.24614	1.73348	11.30	23.20	0.701
R Ch-FA	11	13.6436	3.69759	1.11486	8.20	18.80	6	15.2500	6.07116	2.47854	8.90	23.60	0.573
L Ch-FA	12	13.0000	4.89749	1.41378	5.70	23.80	6	14.2333	4.02078	1.64148	10.60	20.20	0.580
R Sto-FA	11	42.8882	5.04848	1.52217	32.60	49.60	6	44.8000	8.65286	3.53252	33.70	55.10	0.569
L Sto-FA	13	42.1231	5.87454	1.62931	34.80	53.10	6	42.6000	7.36994	3.00876	34.10	52.50	0.893
R AL-FA	8	13.6125	4.22626	1.49421	6.90	19.40	6	9.2833	3.16381	1.29162	6.00	14.40	0.049
L AL-FA	11	13.2727	2.52867	0.76242	10.10	16.90	6	12.4833	3.15431	1.28774	8.20	16.40	0.611
R AL-Tr	9	105.9667	5.53218	1.84406	95.90	112.30	6	105.5167	4.51682	1.84398	100.50	113.80	0.866
L AL-Tr	11	107.2273	5.92893	1.78764	96.30	116.80	6	103.2833	2.35492	0.96139	99.40	106.60	0.072
R Ch-EL	11	95.1473	9.78839	2.95131	79.70	108.50	6	91.2167	3.26400	1.33252	87.80	96.40	0.246
L Ch-EL	12	95.6917	6.55431	1.89207	84.80	105.30	6	96.6167	4.90241	2.00140	91.70	104.80	0.742
R r FA (origin)	11	3.8818	1.23030	0.37095	1.80	5.40	6	3.0333	0.32660	0.13333	2.70	3.60	0.052
L r FA (origin)	13	3.3769	0.69060	0.19154	2.00	4.90	6	2.9167	0.54191	0.22123	2.10	3.60	0.141
R r FA (Ch)	11	2.5545	0.58884	0.17754	1.70	3.40	6	2.4167	0.27869	0.11377	2.00	2.80	0.523
L r FA (Ch)	12	2.4583	0.42738	0.12337	1.70	3.10	6	2.0667	0.20656	0.08433	1.90	2.40	0.019
R r FA (O-Ch)*	11	2.9455	0.54289	0.16369	2.00	3.80	6	2.5333	0.41312	0.16865	1.80	2.90	0.121
L r FA (O-Ch)	12	2.7250	0.49932	0.14414	1.80	3.50	6	2.3500	0.43243	0.17654	1.80	2.90	0.127
R r AA	10	1.7200	0.48717	0.15406	1.20	2.80	6	1.2000	0.32249	0.13166	0.70	1.60	0.023
L r AA	12	1.3000	0.34112	0.09847	0.80	2.00	6	1.2667	0.25820	0.10541	1.00	1.70	0.821
R Ch-O	11	47.8091	6.18748	1.86560	38.30	56.70	6	43.6500	6.59902	2.69404	35.70	52.90	0.234
L Ch-O*	12	47.4833	7.95040	2.29508	37.00	61.70	6	43.7667	5.89667	2.40730	35.80	51.00	0.437
R Sto-MP	11	42.2364	6.90974	2.08337	30.20	52.70	6	38.3833	6.94217	2.83413	31.70	48.90	0.298
L Sto-MP	13	43.0385	6.81011	1.88878	30.10	52.60	6	37.9000	6.28522	2.56593	31.50	47.40	0.136
R SLA-Ch	8	8.6125	1.14821	0.40595	7.20	10.10	6	9.7667	4.00433	1.63476	6.60	16.90	0.449
L SLA-Ch	10	9.8500	2.37171	0.75000	6.70	14.20	6	9.0333	4.24201	1.73179	4.00	15.30	0.678
R SLA-Sto	7	6.4143	1.76298	0.66634	4.20	8.80	6	6.4500	1.54758	0.63180	4.40	8.30	0.970
L SLA-Sto	10	6.7700	3.21180	1.01566	3.60	13.90	6	5.0167	2.07019	0.84515	3.40	9.10	0.206
R r SLA (Sto)	7	1.7286	0.54989	0.20784	1.00	2.40	6	1.3500	0.28107	0.11475	0.90	1.70	0.145
L r SLA (Sto)	10	1.6900	0.46774	0.14791	1.20	2.60	6	1.3500	0.27386	0.11180	1.00	1.80	0.088
R r SLA (O)	8	2.4500	0.70508	0.24928	1.70	3.80	6	1.7500	0.30822	0.12583	1.30	2.10	0.031
L r SLA (O)	11	2.1182	0.44231	0.13336	1.50	2.90	6	1.8667	0.57504	0.23476	1.00	2.50	0.378
R ILA-Ch	9	11.9778	2.92736	0.97579	7.10	15.10	5	12.3000	4.54478	2.03249	8.10	19.50	0.891
L ILA-Ch	12	14.6500	6.29971	1.81857	8.10	27.50	6	12.8500	3.05336	1.24653	8.60	15.90	0.426
R ILA-Sto	8	7.2500	3.26584	1.15465	4.20	12.90	5	6.5200	3.28131	1.46745	3.20	10.70	0.705
L ILA-Sto	12	9.5833	2.93624	0.84762	3.10	13.70	6	9.9167	3.90559	1.59445	5.00	14.10	0.858
R r ILA (O)	9	2.3444	0.3972	0.13240	1.70	2.90	5	1.4200	0.62209	0.27821	0.90	2.40	0.025

Table 4 (continued)

Parameters	Males						Females						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
L r ILA (O)	13	2.0385	0.51078	0.14167	1.40	3.10	6	1.6833	0.48751	0.19903	1.00	2.20	0.176
R r ILA (Sto)	8	1.5125	0.42237	0.14933	0.90	2.30	5	1.4600	0.39115	0.17493	0.80	1.80	0.824
L r ILA (Sto)	13	1.5615	0.38630	0.10714	1.00	2.40	6	1.1667	0.41793	0.17062	0.70	1.80	0.081
R Mc-AA	9	12.9556	4.05651	1.35217	7.40	20.30	5	12.6600	4.55555	2.03730	7.60	18.90	0.907
L Mc-AA	13	10.6077	3.02365	0.83861	6.00	16.70	5	8.9200	3.46078	1.54771	5.40	14.40	0.372
R Mid-AA	8	25.3125	5.45827	1.92979	14.40	33.80	5	26.3800	8.23754	3.68394	18.70	36.60	0.806
L Mid-AA	12	29.9917	6.60488	1.90667	20.20	40.40	5	26.3400	4.50422	2.01435	19.40	31.80	0.214
R Lc-AA	7	42.8571	8.97865	3.39361	32.40	56.90	5	48.8000	8.10956	3.62671	39.10	59.80	0.728
L Lc-AA	12	44.5750	3.75866	1.08503	39.00	51.90	5	45.2800	3.63001	1.62339	39.60	49.40	0.728
R PO line	9	78.3778	10.52494	3.50831	60.70	96.30	6	65.6167	4.37603	1.78651	59.50	72.50	0.007
L PO line	11	80.5455	8.84560	2.66705	65.00	96.30	6	69.6667	7.22597	2.94999	59.80	81.00	0.018

AA, angular artery; AL, ala of the nose; Ch, cheilion; EL, ear lobe; FA, facial artery; Go, gonion; ILA, inferior labial artery; L, left; Lc, lateral canthus; Mc, medial canthus; Mid, median plane of the eye; MP, mental prominence; O, origin; PO line, the distance between the ala of the nose and the origin of the facial artery; r, diameter; R, right; SLA, superior labial artery; Sto, stomion; Tr, tragus. * Mann-Whitney U test.

Table 5. Comparison of parameters in relation to the body side

Parameters	Right						Left						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
Go-FA	17	21.4635	4.94521	1.19939	9.40	27.10	19	21.0011	6.05292	1.38863	11.30	35.40	0.193
Ch-FA	17	14.2106	4.54859	1.10319	8.20	23.60	18	13.4111	4.54234	1.07064	5.70	23.80	0.756
Sto-FA	17	43.5629	6.34144	1.53802	32.60	55.10	19	42.2737	6.17628	1.41694	34.10	53.10	0.451
AL-FA	14	11.7571	4.29073	1.14674	6.00	19.40	17	12.9941	2.69385	0.65336	8.20	16.90	0.314
AL-Tr	15	105.7867	4.98267	1.28652	95.90	113.80	17	105.8353	5.24189	1.27135	96.30	116.80	0.865
Ch-EL	17	93.7600	8.18297	1.98466	79.70	108.50	18	96.0000	5.92174	1.39577	84.80	105.30	0.356
r FA (origin)	17	3.5824	1.07426	0.26055	1.80	5.40	19	3.2316	0.66921	0.15353	2.00	4.90	0.222
r FA (Ch)	17	2.5059	0.49557	0.12019	1.70	3.40	18	2.3278	0.40845	0.09627	1.70	3.10	0.199
r FA (O-Ch)	17	2.8000	0.52797	0.12805	1.80	3.80	18	2.6000	0.49941	0.11771	1.80	3.50	0.300
r AA	16	1.5250	0.49464	0.12366	0.70	2.80	18	1.2889	0.30849	0.07271	0.80	2.00	0.043
Ch-O	17	46.3412	6.46017	1.56682	35.70	56.70	18	46.2444	7.37406	1.73808	35.80	61.70	0.979
Sto-MP	17	40.8765	6.96442	1.68912	30.20	52.70	19	41.4158	6.92197	1.58801	30.10	52.60	0.194
SLA-Ch	14	9.1071	2.68857	0.71855	6.60	16.90	16	9.5438	3.08868	0.77217	4.00	15.30	0.858
SLA-Sto	13	6.4308	1.59759	0.44309	4.20	8.80	16	6.1125	2.89595	0.72399	3.40	13.90	0.095
r SLA (Sto)	13	1.5538	0.47190	0.13088	0.90	2.40	16	1.5625	0.43031	0.10758	1.00	2.60	0.462
r SLA (O)	14	2.1500	0.65838	0.17596	1.30	3.80	17	2.0294	0.49087	0.11905	1.00	2.90	0.911
ILA-Ch	14	12.0929	3.41388	0.91240	7.10	19.50	18	14.0500	5.40221	1.27331	8.10	27.50	0.216

Table 5 (continued)

Parameters	Right						Left						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
ILA-Sto	13	6.9692	3.15394	0.87474	3.20	12.90	18	9.6944	3.17666	0.74875	3.10	14.10	0.014
r ILA (O)	14	2.0143	0.65381	0.17474	0.90	2.90	19	1.9263	0.51838	0.11892	1.00	3.10	0.517
r ILA (Sto)	13	1.4923	0.39468	0.10946	0.80	2.30	19	1.4368	0.42845	0.09829	0.70	2.40	0.848
Mc-AA	14	12.8500	4.06614	1.08672	7.40	20.30	18	10.1389	3.14271	0.74074	5.40	16.70	0.139
Mid-AA	13	25.7231	6.34746	1.76047	14.40	36.60	17	28.9176	6.16484	1.49519	19.40	40.40	0.189
Lc-AA	12	45.3333	8.78928	2.53725	32.40	59.80	17	44.7824	3.62168	0.87839	39.00	51.90	0.647
PO line	15	73.2733	10.58364	2.73269	59.50	96.30	17	76.7059	9.69210	2.35068	59.80	96.30	0.274
Males	Right						Left						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
Go-FA	11	22.0891	3.67991	1.10953	13.80	27.10	13	21.9631	6.65352	1.84536	16.10	35.40	0.633
Ch-FA	11	13.6436	3.69759	1.11486	8.20	18.80	12	13.0000	4.89749	1.41378	5.70	23.80	0.942
Sto-FA	11	42.8882	5.04848	1.52217	32.60	49.60	13	42.1231	5.87454	1.62931	34.80	53.10	0.642
AL-FA	8	13.6125	4.22626	1.49421	6.90	19.40	11	13.2727	2.52867	0.76242	10.10	16.90	0.985
AL-Tr	9	105.9667	5.53218	1.84406	95.90	112.30	11	107.2273	5.92893	1.78764	96.30	116.80	0.428
Ch-EL	11	95.1473	9.78839	2.95131	79.70	108.50	12	95.6917	6.55431	1.89207	84.80	105.30	0.977
r FA (origin)	11	3.8818	1.23030	0.37095	1.80	5.40	13	3.3769	0.69060	0.19154	2.00	4.90	0.259
r FA (Ch)	11	2.5545	0.58884	0.17754	1.70	3.40	12	2.4583	0.42738	0.12337	1.70	3.10	0.528
r FA (O-Ch)	11	2.9455	0.54289	0.16369	2.00	3.80	12	2.7250	0.49932	0.14414	1.80	3.50	0.678
r AA	10	1.7200	0.48717	0.15406	1.20	2.80	12	1.3000	0.34112	0.09847	0.80	2.00	0.010
Ch-O	11	47.8091	6.18748	1.86560	38.30	56.70	12	47.4833	7.95040	2.29508	37.00	61.70	0.775
Sto-MP	11	42.2364	6.90974	2.08337	30.20	52.70	13	43.0385	6.81011	1.88878	30.10	52.60	0.639
SLA-Ch	8	8.6125	1.14821	0.40595	7.20	10.10	10	9.8500	2.37171	0.75000	6.70	14.20	0.767
SLA-Sto	7	6.4143	1.76298	0.66634	4.20	8.80	10	6.7700	3.21180	1.01566	3.60	13.90	0.496
r SLA (Sto)	7	1.7286	0.54989	0.20784	1.00	2.40	10	1.6900	0.46774	0.14791	1.20	2.60	0.438
r SLA (O)	8	2.4500	0.70508	0.24928	1.70	3.80	11	2.1182	0.44231	0.13336	1.50	2.90	0.628
ILA-Ch	9	11.9778	2.92736	0.97579	7.10	15.10	12	14.6500	6.29971	1.81857	8.10	27.50	0.135
ILA-Sto	8	7.2500	3.26584	1.15465	4.20	12.90	12	9.5833	2.93624	0.84762	3.10	13.70	0.045
r ILA (O)	9	2.3444	0.39721	0.13240	1.70	2.90	13	2.0385	0.51078	0.14167	1.40	3.10	0.108
r ILA (Sto)	8	1.5125	0.42237	0.14933	0.90	2.30	13	1.5615	0.38630	0.10714	1.00	2.40	0.185
Mc-AA	9	12.9556	4.05651	1.35217	7.40	20.30	13	10.6077	3.02365	0.83861	6.00	16.70	0.428
Mid-AA	8	25.3125	5.45827	1.92979	14.40	33.80	12	29.9917	6.60488	1.90667	20.20	40.40	0.128
Lc-AA	7	42.8571	8.97865	3.39361	32.40	56.90	12	44.5750	3.75866	1.08503	39.00	51.90	0.837
PO line	9	78.3778	10.52494	3.50831	60.70	96.30	11	80.5455	8.84560	2.66705	65.00	96.30	0.914
Females	Right						Left						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
Go-FA	6	20.3167	6.98095	2.84996	9.40	26.80	6	18.9167	4.24614	1.73348	11.30	23.20	0.515
Ch-FA	6	15.2500	6.07116	2.47854	8.90	23.60	6	14.2333	4.02078	1.64148	10.60	20.20	0.720

Table 5 (continued)

Parameters	Right						Left						*p* value
	N	mean	SD	SEM	min	max	*N*	mean	SD	SEM	min	max	
Sto-FA	6	44.8000	8.65286	3.53252	33.70	55.10	6	42.6000	7.36994	3.00876	34.10	52.50	0.589
AL-FA	6	9.2833	3.16381	1.29162	6.00	14.40	6	12.4833	3.15431	1.28774	8.20	16.40	0.069
AL-Tr	6	105.5167	4.51682	1.84398	100.50	113.80	6	103.2833	2.35492	0.96139	99.40	106.60	0.302
Ch-EL	6	91.2167	3.26400	1.33252	87.80	96.40	6	96.6167	4.90241	2.00140	91.70	104.80	0.111
r FA (origin)	6	3.0333	0.32660	0.13333	2.70	3.60	6	2.9167	0.54191	0.22123	2.10	3.60	0.707
r FA (Ch)	6	2.4167	0.27869	0.11377	2.00	2.80	6	2.0667	0.20656	0.08433	1.90	2.40	0.115
r FA (O-Ch)*	6	2.5333	0.41312	0.16865	1.80	2.90	6	2.3500	0.43243	0.17654	1.80	2.90	0.540
r AA	6	1.2000	0.32249	0.13166	0.70	1.60	6	1.2667	0.25820	0.10541	1.00	1.70	0.661
Ch-O	6	43.6500	6.59902	2.69404	35.70	52.90	6	43.7667	5.89667	2.40730	35.80	51.00	0.969
Sto-MP	6	38.3833	6.94217	2.83413	31.70	48.90	6	37.9000	6.28522	2.56593	31.50	47.40	0.245
SLA-Ch	6	9.7667	4.00433	1.63476	6.60	16.90	6	9.0333	4.24201	1.73179	4.00	15.30	0.746
SLA-Sto	6	6.4500	1.54758	0.63180	4.40	8.30	6	5.0167	2.07019	0.84515	3.40	9.10	0.134
r SLA (Sto)	6	1.3500	0.28107	0.11475	0.90	1.70	6	1.3500	0.27386	0.11180	1.00	1.80	1.000
r SLA (O)	6	1.7500	0.30822	0.12583	1.30	2.10	6	1.8667	0.57504	0.23476	1.00	2.50	0.723
ILA-Ch	5	12.3000	4.54478	2.03249	8.10	19.50	6	12.8500	3.05336	1.24653	8.60	15.90	0.986
ILA-Sto	5	6.5200	3.28131	1.46745	3.20	10.70	6	9.9167	3.90559	1.59445	5.00	14.10	0.207
r ILA (O)	5	1.4200	0.62209	0.27821	0.90	2.40	6	1.6833	0.48751	0.19903	1.00	2.20	0.365
r ILA (Sto)	5	1.4600	0.39115	0.17493	0.80	1.80	6	1.1667	0.41793	0.17062	0.70	1.80	0.423
Mc-AA	5	12.6600	4.55555	2.03730	7.60	18.90	5	8.9200	3.46078	1.54771	5.40	14.40	0.211
Mid-AA	5	26.3800	8.23754	3.68394	18.70	36.60	5	26.3400	4.50422	2.01435	19.40	31.80	0.992
Lc-AA	5	48.8000	8.10956	3.62671	39.10	59.80	5	45.2800	3.63001	1.62339	39.60	49.40	0.258
PO line	6	65.6167	4.37603	1.78651	59.50	72.50	6	69.6667	7.22597	2.94999	59.80	81.00	0.115

AA, angular artery; AL, ala of the nose; Ch, cheilion; EL, ear lobe; FA, facial artery; Go, gonion; ILA, inferior labial artery; L, left; Lc, lateral canthus; Mc, medial canthus; Mid, median plane of the eye; MP, mental prominence; O, origin; PO line, the distance between the ala of the nose and the origin of the facial artery; r, diameter; R, right; SLA, superior labial artery; Sto, stomion; Tr, tragus. * Wilcoxon-signed rank test.

Table 6. The most critical aspects of FA in previous studies by the year

Authors	Year	N	Place	Side	Study Design	Types
Aratani et al.	1960	208	Japan	Bilateral	Cadaver	Supratrochlear: 3.8% Angular: 12% Lateral nasal: 64.4% Inferior alar: 7.7% Superior labial: 2.9% Inferior labial: 5.8%
Mitz et al.	1973	50	France	Bilateral	Cadaver	Type 1 (nasal): 78% Type 2 (classic): 4% Type 3 (intermediate): 10% Type 4 (duplicate): 4% Type 5 (weak): 8%
Midy et al.	1986	40	France	Bilateral	Cadaver	Type 1 (angular): 27.5% Type 2 (labial): 40% Type 3 (nasal): 30% Type 4 (abortive): rare
Niranjan et al.	1988	50	The UK	Bilateral	Cadaver	Type I (nasal type): 26% Type II (angular type): 68% Type III (superior labial type): 4% Type IV (alar type): 2% Type V (Rudimentary): 10%
Soikkonen et al.	1991	69	Finland	Unilateral	Cadaver	Type A: 22% Type B: 49% Type C: 20% Type D: 9%
Dupoirieux et al.	1999	20	France	Bilateral	Cadaver	Angular (20%) Nasal dorsal (45%) Coronal labial (35%)
Brüe et al.	2000	319	France	Bilateral	Cadaver	Type 1 (angular type) Type 2 (nasal type): 70.5% Type 3 (superior labial type): 18.5% Type 4 (hypoplastic type): 11%
Koh et al.	2003	91	Korea	Bilateral (44), unilateral (3)	Cadaver	Supratrochlear: 4.4% Angular: 36.3% Lateral nasal: 44% Inferior alar: 3.3% Superior labial: 6.6% Inferior labial: 5.5%
Pınar et al.	2005	50	Turkey	Bilateral	Cadaver	Angular: 22% Nasal: 60% Alar: 12% Labial: 4% Hypoplastic: 2%
Loukas et al.	2006	200	USA	Bilateral	Cadaver	Type A (typical arrangement: 47.5%) Type B (nasal: 38.7%) Type C (superior labial-alar: 8.4%) Type D (duplex or long course: 3.8%) Type E (rudimentary: 1.4%)
Marx et al.	2008	2	India	Bilateral	Cadaver	Superior labial: 12% Inferior labial: 12%
Lohn et al.	2011	201	UK	Bilateral (89), unilateral (23)	Cadaver	Type 1 (angular type): 20% Type 2 (LNA type): 48% Type 3 (alar type): 17% Type 4 (superior labial type): 10% Type 5 (IL type): 3% Type 6 (not detected): 2%
Furukawa et al.	2013	187	Japan	Bilateral	CT	Type 1 (superior labial): 34.2% Type 2 (nasolabial): 39.6% Type 3 (lateral nasal): 24% Type 4 (dominant angular): 2.1%
Quadros	2013	50	India	Bilateral	Cadaver	Male right side: type I (100) left: (78%), type III (22%) Female right: type I (80%), type III (20%) Female left: type I (80%), type II (18%), type III (2%)

Table 6 (continued)

Authors	Year	N	Place	Side	Study Design	Types
Dickson et al.	2014	40	The UK	Bilateral (19), unilateral (2)	Cadaver	Type I: 27.5% Type II: 15% Type III: 15% Type IV: 7.5% Type V: 7.5% Type VI: 27.5%
Camuzard et al.	2015	20	France	Bilateral	Cadaver	Type I: 55% Type II: 15% Type III: 10% Type IV: 20% Type V: not observed
Pilsl et al.	2016	60	Austria	Bilateral	Cadaver	Type 1 (angular): 41.7% Type 2 (no angular): 26.7% Type 3 (superior labial): 18.3% Type 4 (two branches): 13.3%
Ten et al.	2016	168	Turkey	Bilateral	Doppler ultrasonography	Type A (permanent pattern): 54.8% (right), 50% (left) Type B (variant pattern): 17.9% (right), 28.6% (left) Type C (alternative pattern): 10.7% (right), 13.1% (left) Type D (latent pattern): 16.7% (right), 8.3% (left)
Vasudha et al.	2018	50	India	Bilateral	Cadaver	Angular artery in 28 (56%) SLA in 15 (30%) LNA in 6 (12%) Abortive course 1 (2%)
Vijayal.akshmi et al.	2018	42	India	Bilateral	Cadaver	Angular type Submental type Labial type Angular type (ratio is not defined)
Koziej et al.	2019	255	Poland	Bilateral (124), unilateral (7)	Tomographic angiography	Type I: 24.7 Type II: 31.4 Type III: 40 Type IV: 1.6 Type V: 2.4
Niemann et al.	2019	39	South Africa	Bilateral (19), unilateral (1)	Cadaver	Type 1: 64.10% Type 2: 17.95% Type 3: 2.56% Type 4: 2.56% Type 5: 2.56% Type 6: 2.56%
Ogut et al..	2020	1	Turkey	Unilateral	Cadaver	Angular type, trifurcation of FA
Money at al..	2021	36	Georgia	Bilateral	Cadaver	Angular Lateral nasal Superior labial Hypoplastic
Present study	2022	19 (36 sides)	Turkey	Bilateral	Cadaver	Angular Lateral nasal Superior labial Alar

value for that variable, and then multiplying the result by 100 [15–18, 22]. rTEM is an estimate of the magnitude of the inaccuracy expressed in percentage of the size of the item [16]. R is a value that could be determined using TEM and can vary from around 0 to 1. R could be determined by applying the following equation to the data: R equals one minus the TEM squared divided by the standard deviation, where SD is the overall measurement standard deviation [15–19]. R is a measure of the fraction of the intersubject variation that is independent of measurement error [15, 16, 18, 20, 22]. The photographs of FA were carried out in the manner that Barut et al. [23] had outlined. The parameters 1–24 were measured twice (Fig. 1). SPSS 25.0 (IBM, USA) was used for all statistical analyses. Descriptive statistics of continuous variables were given with mean, median, SD, standard error of mean (SEM), minimum and maximum values, and frequency of categorical variables. The Shapiro-Wilk test was used as a test of normality. The independent samples *t* test was used for two independent group comparisons of normally distributed variables, and the Mann-Whitney U test was used for non-normal distributed variables (gender comparison). Paired samples *t* test was used for two dependent

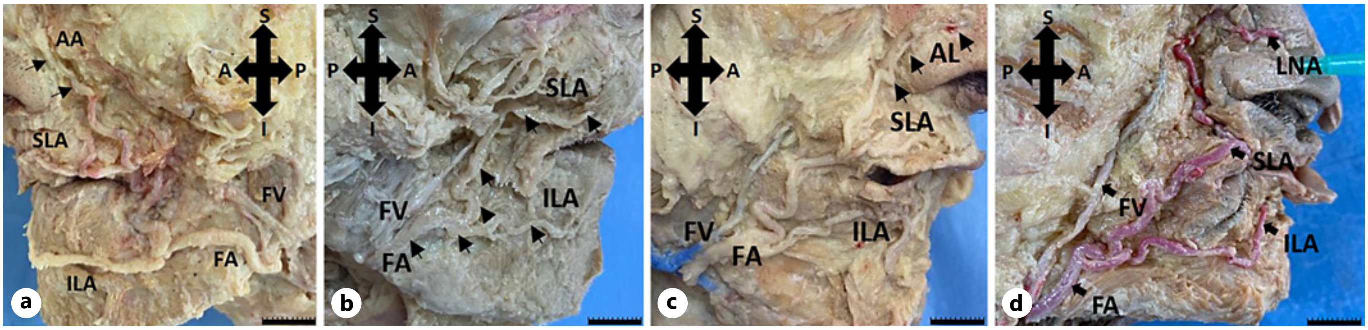

Fig. 3. The termination patterns of FA. **a** The FA comes out of the inferior margin of the mandible with the FV. It gives first the ILA branch and then the SLA branch. It continues as AA (black arrows). **b** The FA emerges from the inferior margin of the mandible with the FV and terminates by giving off the ILA and SLA branches (black arrows). **c** After the FA emerges from the inferior margin of the mandible with the FV, it first gives off the ILA and SLA branches and then terminates at the AL level by giving the alar branch (black arrows). **d** After the FA comes out of the lower border of the mandible with the FV, it first gives off the ILA and SLA branches. It terminates by giving the LNA branch on the lateral side of the nose above the AL (black arrows). A, anterior; AA, angular artery; AL, ala of the nose; FA, facial artery; FV, facial vein; i, inferior; ILA, inferior labial artery; LNA, lateral nasal artery; P, posterior; S, superior; SLA, superior labial artery.

group comparisons of normally distributed variables, and the Wilcoxon signed rank test was used for non-normal distributed variables (body side comparison). χ^2 test was used for the comparison of categorical variables and $p < 0.05$ was assumed to indicate statistical significance.

Results

The TEM values for each of the variables that were measured were 0.12–0.83 mm, values for rTEM were found to be 0.45–14.85%. R values were quite near 1 for the majority of these factors. Table 1 contains the TEM, rTEM, and R values for each of the variables that were assessed. Four types of FA were detected. The most frequent type was an angular type (73.7%). It was followed by alar, labial, and nasal types (5.3%) (Fig. 2). The hypoplastic type of FA was not detected during our cadaver dissections. The angular type was detected on the left side in both genders. It was found that there were no gender differences in terms of the incidence of the types on the right side ($\chi^2 = 3.132$, $p = 0.536$) (Table 2). The lack of significant differences between genders according to FA types may be due to the small sample size. Descriptive values for the parameters are given in Table 3. The differences between the genders were significant according to the following parameters; the distance between the AL-FA on the right side (9.28 ± 3.16 mm, females, 13.61 ± 4.22 mm, males; $p = 0.049$), the diameter of FA at the Ch on the left side (2.06 ± 0.2 mm, females, 2.45 ± 0.42 mm, males; $p = 0.019$), the diameter of angular arteries (AA) on the right side (1.2 ± 0.32 mm, females, 1.72 ± 0.48 mm, males; $p = 0.023$), the diameter of SLA at the origin on the right side (1.75 ± 0.30 mm, females, 2.45 ± 0.70 mm, males; $p = 0.031$), the diameter of ILA at the origin on the right side (1.42 ± 0.62 mm, females, 2.34 ± 0.39 mm, males; $p = 0.025$), PO Line ($p = 0.007$, right; $p = 0.018$, left) (Table 4). For the parameters mentioned above, the values obtained from males were higher than those obtained from females, the difference was statistically significant (p value < 0.05). There were no variations found in any of the other criteria based on sex (Table 4). The diameter of the AA on the right side (1.52 ± 0.49 mm) was higher than on the left side (1.28 ± 0.3 mm), and the difference was statistically significant according to the body side ($p = 0.043$). Left ILA-Sto (9.69 ± 3.17 mm) was greater than on the right side (6.96 ± 3.15 mm), and there were considerable differences between them ($p = 0.014$). There were no significant differences seen between any of the other FA variables ($p > 0.05$) (Table 5). The distance between the ILA-Sto on the left side (7.25 ± 3.26 mm) was greater than on the right side (9.58 ± 2.93 mm) in males, and the difference was statistically significant ($p = 0.045$). Similarly, the diameter of the AA on the right side (1.72 ± 0.48 mm) was higher than on the left side (1.3 ± 0.34 mm) in males, and there was a statistically significant difference between the 2 groups according to the body side ($p = 0.010$). In females, there were no statistically significant differences seen between any of the other variables ($p > 0.05$).

Discussion

The literature shows discrepancies in classifications according to the types, incidence, and termination patterns of FA [6] (Table 6). The termination pattern of the FA varies in the literature, including the superior labial (SL), LNA, AA, and others [1, 6]. Early termination of the FA has also been reported in the submental, inferior labial (IL), and alar arteries [6]. Koh et al. [24] reported that 54.5% of the 44 specimens were symmetrical. Similarly, Lohn et al. [1] reported that the branching patterns of FA were symmetrical in 53%, and it was terminated as LNA (49%). According to the findings of Pinar et al. [25], the FA was symmetrical in 17 out of 25 heads (68%) [25]. It was over as AA (22%), nasal (60%), alar (12%), SLA (4%), and hypoplastic (2%) in facial halves. Niranjan reported that the symmetry of FA was 68% and the termination of FA as an AA in 34 (68%), LNA in 13 (26%), SLA (4%), and alar type (2%) [10]. Although there were five types of FA in Mitz's classification [9], Dupoirieux et al. [26] found the following types in their dissections: angular (20%), nasal dorsal (45%), and coronal labial (35%). The literature contains several descriptions of the course of the FA [6, 7, 27]. Furukawa et al. [27] found four different branches of the FA: type 1 (SL 34.2%), type 2 (nasolabial 40%), type 3 (LNA, 24%), and type 4 (AA, 2%). Eighty-four percent of type 3 FA predominated at the facial-submental artery bifurcation [27]. It was reported that FA termination patterns were observed to be grouped into five categories [6]. However, some studies reported six or more types (with subtypes) due to the variable course and individual differences in termination patterns [28]. Termination of the FA was ILA (5.13%), SLA (10.26%), the inferior (10.26%) and superior (46.15%) alar arteries, LNA (5.13%), and AA (20.51%) [28]. Males (48.72%) were found to have more variations than females (41.03%) [28]. According to the 2,119 studies, it usually finishes as the LNA or AA with a frequency of 69.81% (59.8–78.94%) [6]. Type 1 of the FA has a short course and ends proximally to the SLA as the superior or ILA; type 2 of the FA ends distally to the SLA close to the nasolabial fold as an inferior alar artery; type 3 of the FA reaches as far as the angular branch or the lateral branch of the nose and runs in the alar-facial crease; type 4 of the FA forms a duplex with the lateral angular branch, and type 5 was hypoplastic FA [6, 27]. In our study, types of FA were recorded as angular 73.1% (n = 14, right; n = 19, left), labial 5.3% (n = 1, right), alar 5.3% (n = 1, right), and nasal types 5.3% (n = 1, right) (Fig. 3). Koh et al. [24] reported six branches of the FA. It has been reported that the FA terminated as LNA, supratrochlear (4.4%), AA (36.3%), inferior alar (3.3%), SLA (6.6%), and ILA (5.5%) [24]. Loukas et al. [29] reported five types of termination patterns of FA (type A-E). In type A, FA terminated as SLA and LNA (47.5%), in type B, FA terminated as SLA, LNA, and superior alar artery (38.7%), in type C, FA terminated as SLA (8.4%), in type D, AA arises from FA trunk and ending as superior alar artery (3.8%), in type E, FA terminated as a rudimentary artery (1.4%) [29]. In our study, FA terminated as an AA in 73.7%, alar in 5.3%, labial in 5.3%, and nasal in 5.3%. On the contrary, all dissections on the left side showed an angular pattern of FA. In male, right-sided dissections showed 61.5% angular, 7.7% alar, 7.7% labial, and 7.7% nasal; all left-sided dissections were angular. FA terminated as AA in females on both sides. The differences between the studies might be due to ethnicity, individual variations, or scale of the study [24]. Studies with larger sample sizes will reduce standard errors and provide significant differences between groups according to type.

The separate origin of FA from ECA was found in 69%, the common linguofacial trunk (31%), the bilateral linguofacial trunk (24%), unilateral (14%), the high origin of FA (2%), and hypoplastic or rudimentary FA (2%) [3]. Niemann et al. [28] reported a linguofacial trunk (12.82%) and a high origin of FA (2.56%), and males revealed a higher number of linguofacial trunk origins than females. It was reported that the most frequent source (51.9%) was between the inferior border of the mandible and ILA [30]. Pinar et al. [25] stated that ILA emerged from the FA located superior to the angle of the mouth (22%), inferior to the angle of the mouth (8%), and over the angle of the mouth (8%), and at the angle of the mouth (60%). In our study, the FA originated between the ILA and the lower edge of the mandible, and no variant origin was detected in all cadavers.

Pilsl et al. [31] divided FA into four groups: type 1 (typical course of FA), type 2 was duplex, and type 3 terminated as SLA. In type 4, the FA gives off anterior and posterior branches after the release of the ILA, and then the anterior branch of the FA releases the SLA and LNA. On the other hand, in the study of Padur et al. [32], the FA gave off lateral branches posteriorly. These pre-masseteric branches were considered FA variations [30, 33]. One of the variations other than pre-masseteric branches was the hypoplastic/rudimentary type [3, 6, 7, 10, 25, 28]. Soikkonen et al. [34] reported the followings; 22% of cases were type A, 49% were type B, 20% were type C, and 9% of cases were hypoplastic type D; however, it was not dependent on age or sex. The tortuosity of FA showed a significant increase with age, and a correlation was found between the dominance and the tortuosity of the FA [34].

In our study, hypoplastic type FA was not recorded because this type mainly occurs due to impairment or agenesis of the developmental process of FA. Another reason for the absence of this rare type may be due to the small sample size.

The measurements of length and diameters of FA are essential to provide a suitable facial artery perforator (FAP) for reconstructive surgery [35]. Hofer et al. [35] reported that the mean length of the FA was 123.7 ± 21 mm and diameter of FA was 1.2 ± 0.3 mm, FAP was 25.2 (13–51) mm, and the mean diameter of FAP was 1.2 (0.6–1.8) mm [35]. It was measured as 116 ± 22 mm (length), 2.62 ± 0.74 mm (diameter), 14.12 ± 3.46 mm (FAP length), and 0.94 ± 0.29 mm (FAP diameter) by Ng et al. [36]. Camuzard et al. [33] reported that the mean length and diameter of all FAPs were 17.6 ± 1.9, and 0.91 ± 0.2 mm. The mean diameter of all lateral branches of the FA was 0.7 mm and of pre-masseteric branches was 0.8 mm [30]. Brüe et al. [7] measured the diameter of FA at different points: at the origin (2.7 mm) and Ch (1.9 mm). Quadros et al. [5] reported that the diameter of the FA was 3.2 mm (right) and 3.1 mm (left) in males, and they measured the diameter of the FA as 3 mm on right side and 3.2 mm on left side in females. Furukawa et al. [27] measured the SLA as 2 mm, the nasolabial branch as 2.24 mm, the LNA as 2.3 mm, and the AA as 2.58 mm. The various length of FA was reported as 120.6 ± 18.4 mm by Qassemyar et al., 119.3 mm by Coronel-Banda et al., and 122.5 ± 15.7 mm by Camuzard et al. The diameter of FA was reported as 2.6 mm by Pinar et al., 2.78 ± 0.44 mm by Qassemyar et al., 2.5 mm by Coronel-Banda et al., 0.91 ± 0.16 mm by Camuzard et al., 1.56 ± 0.35 mm (at the mandibular origin) with Doppler Ultrasonography by Ten et al. 1.8 mm by Koziej et al., 2.45 mm with CTA by Herrera-Núñez et al., 1.9 mm by Lee et al., 1.15 mm (with CT) by Takeshita et al. and 1.41 mm by Money et al. In our study, it was reported that 3.88 ± 1.23 mm (right), 3.37 ± 0.69 mm (left) at the mandibular level and 2.55 ± 0.58 mm (right), 2.45 ± 0.42 mm (left) at the Ch level in males. Similarly, it was reported as 3.03 ± 0.32 mm (right), 2.91 ± 0.54 mm (left) at the mandibular level and 2.41 ± 0.27 mm (right), 2.06 ± 0.20 mm (left) at the Ch level in females.

It was reported that the SLA was 1.6 mm (width range: 0.6–2.8 mm) at its origin, and ILA was 0.5–1.5 mm [25]. It might be due to the original location of ILA and SLA varying between the lateral edge of the lower jaw and the corner of the mouth [25]. The average distance between the inferior alar branch and LNA was 15.9 mm, and 25.2 mm between the SLA and the inferior alar branch [24]. The branching point of the ILA was 30.9 mm apart on average from SLA [24]. It has been reported that the courses of the FA showed no significant differences according to laterality or sex [24]. However, some studies reported that males had a larger diameter of the FA at its origin and the anteroinferior angle of the masseter muscle [5]. The current study revealed significant differences according to the diameter of some branches of FA, such as AA and ILA. It can be suggested that the branches of FA show an asymmetric distribution, and it should be considered in surgery. Moreover, radiological methods give lower values than cadaver studies. Differences in studies might be due to the sample size (*n*), studied materials (CT or CTA images, ultrasonography, fixed cadaveric skulls), or study design (cadaveric study, retrospective study with patients, or 3D studies).

Knowledge about the variational branches of FA and their connections is vital for preventing difficulties in reconstructive and reparative maxillofacial, craniofacial, and plastic surgery in order to reduce the risk of FA [4]. The significant differences in gender according to the distance of the FA and its branches from the origin or termination should be considered to reduce complications in reconstructive surgery for FAP, facial transplant grafts, and oral and maxillofacial surgery [1, 2, 31]. Another theory claimed that the variations of FA were formed by regional hemodynamic balances of arteriovenous malformations of the face [7]. Stenoses, hypervascular conditions, ligations, and embolizations can all impact anatomical patterns and hemodynamics of the arterial supply of the face [37]. Variations of the FA stem from the aberrant development of one or more components of the pharyngeal arch, which might affect the hemodynamic balance of the face. Hence, it is crucial to comprehend vascular anatomy, variations, and hemodynamics to understand the pathologic conditions and prepare a treatment strategy for intravascular surgery [37].

The present study investigated branching patterns of the FA and its relative distances to surgical landmarks. Differences in parameters according to gender on both sides suggest that the values show an asymmetrical distribution, which should be considered in surgery. The observation of different types of FA, the absence of some types, asymmetric distribution, variations, and gender differences should be considered in the preoperative evaluation.

Limitations

The estimations (means and percentages) of the parameters have big standard errors because of the small sample size. It does not mean there is no difference between the groups but means no evidence of the significant difference base on the current data due to the small sample size and low power. Therefore, there is a need for large-scale studies on FA variations and types.

Conclusion

The significant differences in gender according to the distance between the ala of the nose and the origin of the FA and the diameters of branches of the FA should be considered to reduce complications during surgery. The differences in studies according to the types and variations of FA might be due to the scale of the study, gender, or study design.

Acknowledgments

The authors sincerely thank those who donated their bodies to science so that anatomical research could be performed. Results from such study can potentially increase mankind's overall knowledge, improving patient care. Therefore, these donors and their families deserve our highest gratitude.

Statement of Ethics

All cadavers used in this study, from Bahcesehir University Faculty of Medicine, were individuals who donated their bodies to research and science. All procedures performed in studies involving human participants were conducted under the ethical standards of the Ethics Committee of Bahcesehir University Faculty of Medicine (approval number: 2021-13/01) and in conformity with the 1964 Helsinki Declaration.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Funding Sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contributions

C.B. and E.O. contributed to the conception and design of the study. C.B., E.O., Z.A., and HA were involved in data collection and acquisition of data. C.B. and E.O. contributed to the data management and interpretation of data. C.B. analyzed the data. C.B. and E.O. participated in drafting the article and revising it critically for valuable intellectual content and the writing of the manuscript. All authors have read the final approval of the version to be submitted.

Data Availability Statement

Authors can confirm that all relevant data are included in the article and/or its supplementary information files.

References

1 Lohn JWG, Penn JW, Norton J, Butler PEM. The course and variation of the facial artery and vein: implications for facial transplantation and facial surgery. Ann Plast Surg. 2011;67(2):184–8.
2 Bhattacharya A, Sharma R, Armstrong C, Solis L. Case report of unique anastomosis between facial and inferior alveolar arteries. Surg Radiol Anat. 2020;42(5):603–6.
3 Vijayalakshmi M, Mohanraj K, Kumar C. A study of variations in the origin of facial artery. Drug Invention Today. 2018;10:2400–3.
4 Ogut E, Barut C. Trifurcation of the facial artery at the inferior border of the mandible: a case report. Surg Radiol Anat. 2021;43(3):451–4.
5 Quadros LS, Babu A, D'Souza AS. Facial artery on face: a study on south Indian cadavers and specimens. J Health Allied Sci NU. 2020;03(03):072–6.
6 Koziej M, Bonczar M, Ostrowski P, Piątek-Koziej K, Bonczar T, Pasternak A, et al. Termination points of the facial artery: a meta-analysis. Clin Anat. 2022;35(4):469–76.
7 Brüe E, Bey E, Cariou JL. [Facial artery. Embryological review, descriptive and functional anatomy based on a review of the literature]. Ann Chir Plast Esthet. 2000;45(4):461–84.
8 Lee HJ, Won SY, O J, Hu KS, Mun SY, Yang HM, et al. The facial artery: a comprehensive anatomical review. Clin Anat. 2018;31(1):99–108.
9 Mitz V, Ricbourg B, Lassau JP. [Facial branches of the facial artery in adults. Typology, variations and respective cutaneous areas]. Ann Chir Plast. 1973;18(4):339–50.
10 Niranjan NS. An anatomical study of the facial artery. Ann Plast Surg. 1988;21(1):14–22.
11 Ogut E, Armagan K, Barut C. Reappraisal of the types of trigeminal porus and importance in surgical applications. Surg Radiol Anat. 2021;43(7):1169–78.
12 Sekerci R, Ogut E, Keles-Celik N. The influences of porus acusticus internus on ethnicity and importance in preoperative and intraoperative approaches. Surg Radiol Anat. 2021;43(11):1829–38.
13 Akdag UB, Ogut E, Barut C. Intraforaminal dural septations of the jugular foramen: a cadaveric study. World Neurosurg. 2020;141:e718–27.
14 Ogut E, Akdag UB, Kilincli MF, Barut C. Reappraisal of the types of hypoglossal canal: endocranial approach. Anat Sci Int. 2022;97(4):399–408.
15 Barut C, Dogan A, Buyukuysal MC. Anthropometric aspects of hand morphology in relation to sex and to body mass in a Turkish population sample. Homo. 2014;65(4):338–48.
16 Barut C, Sevinc O, Sumbuloglu V. Evaluation of hand asymmetry in relation to hand preference. Coll Antropol. 2011;35(4):1119–24.
17 Goto R, Mascie-Taylor CGN. Precision of measurement as a component of human variation. J Physiol Anthropol. 2007;26(2):253–6.

18 Özer CM, Oz II, Şerifoğlu I, Buyukuysal MC, Barut C. Evaluation of eyeball and orbit in relation to gender and age. J Craniofac Surg. 2016;27(8):e793–800.
19 Ulijaszek T, Lourie J. Intra- and inter-observer error in anthropometric measurement. Anthropometry: the individual and the population. Cambridge: Cambridge University Press; 1994.
20 Weinberg SM, Scott NM, Neiswanger K, Marazita ML. Intraobserver error associated with measurements of the hand. Am J Hum Biol. 2005;17(3):368–71.
21 Regoli M, Ogut E, Bertelli E. An osteologic study of human ethmoidal foramina with special reference to their classification and symmetry. Ital J Anat Embryol. 2016;121(1):66–76.
22 Kemper CJ, Schwerdtfeger A. Comparing indirect methods of digit ratio (2D:4D) measurement. Am J Hum Biol. 2009;21(2):188–91.
23 Barut C, Ertilav H. Guidelines for standard photography in gross and clinical anatomy. Anat Sci Educ. 2011;4(6):348–56.
24 Koh KS, Kim HJ, Oh CS, Chung IH. Branching patterns and symmetry of the course of the facial artery in Koreans. Int J Oral Maxillofac Surg. 2003;32(4):414–8.
25 Pinar YA, Bilge O, Govsa F. Anatomic study of the blood supply of perioral region. Clin Anat. 2005;18(5):330–9.
26 Dupoirieux L, Plane L, Gard C, Penneau M. Anatomical basis and results of the facial artery musculomucosal flap for oral reconstruction. Br J Oral Maxillofac Surg. 1999;37(1):25–8.
27 Furukawa M, Mathes DW, Anzai Y. Evaluation of the facial artery on computed tomographic angiography using 64-slice multidetector computed tomography: implications for facial reconstruction in plastic surgery. Plast Reconstr Surg. 2013;131(3):526–35.
28 Niemann K, Lazarus L, Rennie C. An anatomical study of the facial artery. Int J Morphol. 2019;37(4):1310–5.
29 Loukas M, Hullett J, Louis RG Jr, Kapos T, Knight J, Nagy R, et al. A detailed observation of variations of the facial artery, with emphasis on the superior labial artery. Surg Radiol Anat. 2006;28(3):316–24.
30 Park JA, Yeo IS, Lee HI, Shin HJ, Koh KS, Song WC. Lateral branches of the facial artery and its clinical implications. Clin Anat. 2022;35(8):1142–6.
31 Pilsl U, Anderhuber F, Neugebauer S. The facial artery-the main blood vessel for the anterior face? Dermatol Surg. 2016;42(2):203–8.
32 Padur AA, Kumar N. Unusual branching pattern and termination of facial artery and its clinical implications for facial operations. J Vasc Bras. 2019;18:e20190021.
33 Camuzard O, Foissac R, Georgiou C, Andot L, Alcaraz F, Baque P, et al. Facial artery perforator flap for reconstruction of perinasal defects: an anatomical study and clinical application. J Craniomaxillofac Surg. 2015;43(10):2057–65.
34 Soikkonen K, Wolf J, Hietanen J, Mattila K. Three main arteries of the face and their tortuosity. Br J Oral Maxillofac Surg. 1991;29(6):395–8.
35 Hofer SOP, Posch NA, Smit X. The facial artery perforator flap for reconstruction of perioral defects. Plast Reconstr Surg. 2005;115(4):996–1003.
36 Ng ZY, Fogg QA, Shoaib T. Where to find facial artery perforators: a reference point. J Plast Reconstr Aesthet Surg. 2010;63(12):2046–51.
37 Berenstein A, Lasjaunias P, Kricheff II. Functional anatomy of the facial vasculature in pathologic conditions and its therapeutic application. AJNR Am J Neuroradiol. 1983;4(2):149–53.