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The Superficial Temporal Artery: Anatomy and Clinical Significance in the Era of Facial Surgery and Aesthetic Medicine

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Abstract

Objective. The aim of this review was to present the vascular pattern of the STA, as well as anatomical variations, and to accentuate the areas which should be taken into consideration during manipulations along the course of the artery. **Background.** The STA may be encountered during several aesthetic procedures on the face, and iatrogenic trauma could be an incriminating factor of diverse sequelae. The constant increase in demand for facial aesthetic procedures has rendered it imperative to maximize safety and patient satisfaction. **Methods.** We conducted a narrative literature review using the electronic databases of PubMed and Google Scholar, retrieving studies concerning the anatomy and variations of the STA. Moreover, we identified registered clinical cases presenting complications which involved the artery. **Discussion.** The anatomic morphology of the STA is described and classification systems summarized, on the basis of the studies retrieved. In addition, the STA is related to defined landmarks, and specific danger zones are emphasized. Finally, the clinical significance of the artery is reflected in registered cases of adverse events following specific aesthetic surgeries. **Conclusion.** Thorough knowledge of the anatomical variability of the STA, and awareness of the danger zones involved in aesthetic procedures, combined with intraoperative vigilance could increase safety and minimize the advent of relevant sequelae.

Key Words: Superficial Temporal Artery ▪ Anatomy ▪ Variations ▪ Aesthetic Surgery ▪ Temporal Rejuvenation.

Introduction

The superficial temporal artery (STA) constitutes a terminal branch of the external carotid artery, which surfaces posteriorly to the mandible in the parotid gland, and crosses the zygomatic process of the temporal bone (1-3). Large areas of the scalp and face derive their blood supply from the STA.

The substantial overall increase in demand for cosmetic facial surgeries, as well as minimally invasive procedures, engender the need to minimize the risk of inadvertent complications and maximize safety (4, 5). This spike in demand has been attributed to an increasing preoccupation with virtual platforms and engagement with social media, especially during the COVID-19 pandemic (4, 6). Knowledge of the localization of the STA and a thorough understanding of its topographical anatomy and clinically relevant arterial variations are crucial for improving safety in surgical and aesthetic procedures involving the vascularized region.

The purpose of this article is to present anatomical variations of the STA tree, assisting the surgeon in delineating a morphological map of the artery and the potential danger zones that could be encountered during facial surgical and minimally invasive procedures. The clinical significance of the artery may be appreciated in the light of the many different complications involving the STA during facial aesthetic procedures, as described in the literature. An assiduous knowledge of the anatomical variability of the artery enables the surgeon to prevent foreseeable complications, and maximize efficacy and safety.

Methods

We conducted a narrative literature review using the electronic databases of PubMed and Google Scholar, retrieving studies related to the anatomy and variations of the STA, published up to July 2022. In addition, articles regarding clinical cases in the field of cosmetic surgery presenting complications involving the STA were included. Associated articles cited in the reference lists of the identified studies were also reviewed. The following search terms were employed: superficial temporal artery OR STA AND anatomy OR variations OR plastic surgery OR cosmetic surgery OR aesthetic surgery OR variants OR pseudoaneurysm OR arteriovenous fistula OR bleeding OR rhytidectomy OR facelift OR fat-grafting OR otoplasty OR hair transplantation OR filler, temporal AND augmentation OR rejuvenation OR filler OR lifting OR hyaluronic acid. All evaluated articles were written in English.

The studies were categorized according to type, and data concerning the ethnicity of the population, the morphology and identified anatomical variations of the arteries were collected. With respect to the pertinent anatomy, a number of danger zones were suggested by different authors, aiming at facilitating safer dissections.

In the second part of the review, the clinical relevance of the STA in the field of aesthetic surgery was studied by identifying cases associated with complications arising from manipulation in areas vascularized by the STA and its variants. Cases involving the development of pseudoaneurysm or arteriovenous fistula of the STA following punch autograft hair transplantation were excluded, given the fact that this specific technique has been relinquished due to the overall drawbacks of the procedure.

Results

A total of 19 studies that could provide appropriate data were included in our review. The morphological tree of the STA was mainly described in 4 studies and respective classifications were formed, whereas variations concerning additional, atrophic or absent branches were displayed in an additional 5 studies. Differences in the ethnicity of the populations studied were related to deviations in the branching patterns. Interestingly, a larger number of cases of African ethnicity showed the presence of double parietal or double frontal branches, in comparison to other ethnicities. Cases of trifurcation were also reported. Consequently, the ethnic background of a patient should be taken into consideration, as multiple vessels could be encountered during dissection. Ethnic differences were also observed in the levels of the division of the STA in relation to the zygomatic arch, which was the point of interest in 13 studies (Table 1). A greater percentage of arteries bifurcated on the level of the zygomatic arch among the Caucasian population compared to African and Asian ethnicities, which were associated with bifurcation points above the zygomatic arch. Such differences should be contemplated during the planning of procedures such as rhytidectomy.

Moreover, the majority of the anatomical patterns of the artery was inconsistent between the two sides of the same person. The anatomical pattern of the frontal branch of the superficial temporal artery (FBSTA) was determined in 3 studies introducing classification systems with regard to its branching structure, whereas 10 studies presented a topographical mapping of the STA in relation to defined landmarks.

In the context of understanding the implication of the artery in adverse events following aesthetic surgery, we identified 15 relevant clinical cases (Table 2). The formation of an arteriovenous fistula of the superficial temporal vessels or a pseudoaneurysm as well as bleeding were the most common complications following surgery, especially after rhytidectomy and malarplasty. Vascular complications concerning the ophthalmic as well as the cerebral arteries were, however, often encountered after autologous fat-grafting. Surgeons should reflect on the possibility of these sequelae, and delve into the anatomy and variations of the vessels, considering the suggested danger zones as well, before engaging on manipulations in the frontal and temporal region.

Table 1. The Bifurcation Point of the STA*

Author and year	Ethnicity	The zygomatic arch		
		Above (%)	Over (%)	Below (%)
Pinar Y, 2006 (2)	Caucasian	74.1	22.2	3.7
Stock A, 1980 (3)	American	60	32	8
Jean-Philippe H, 2021 (7)	Caucasian	61.5	26.9	1
Koziej M, 2019 (8)	Caucasian	75.6	9.7	14.7
Medved F, 2015 (9)	Caucasian	60	26	3
Mwachaka P, 2010 (10)	African	80	13.3	6.7
Marano S, 1985 (11)	American	96	4	-
Chen T, 1999 (12)	Asian	86.5	3.8	9.6
Kim B, 2013 (13)	Asian	82.6	10.1	7.2
Kuruoglu E, 2014 (14)	Caucasian	40	58	2
Tayfur V, 2010 (15)	Caucasian	62	38	-
Cobb M, 2016 (16)	American	96	4	-
Rusu M, 2021 (17)	Caucasian	87	11.6	1.4

*The superficial temporal artery.

Table 2. Complications Involving the STA Following Aesthetic Surgeries

Author and year	Procedure	Complication
Kim Y, 2010 (18)	Intraoral mandibular angle ostectomy	Bleeding
Owsley T, 2009 (19)	Otoplasty	Bleeding
Grazer F, 1992 (20)	Facelift	Late bleeding
Goldwyn R, 1990 (21)	Facelift	Late bleeding
Lin K, 2004 (22)	Facelift	Pseudoaneurysm
Wang D, 2014 (23)	Autologous fat-grafting	Cerebral infarction, embolism of internal and external carotid arteries
Shen X, 2016 (24)	Autologous fat-grafting	Cerebral infarction, embolism of external and internal carotid arteries
Thaunat O, 2004 (25)	Autologous fat-grafting	Cerebral infarction, embolism of anterior cerebral artery
Kominami S, 2012 (26)	Facelift	Arteriovenous fistula
Hua C, 2018 (27)	Rhinoplasty, nasal tip-grafting with concha cartilage	Arteriovenous fistula
Wang X, 2018 (28)	Autologous fat-grafting	Cerebral infarction, embolism of STA
Hu J, 2011 (29)	Autologous fat-grafting	Cerebral infarction, middle cerebral artery embolism
Lu L, 2013 (30)	Autologous fat-grafting	Chorioretinal infarction
Chen Y, 2014 (31)	Autologous fat-grafting	Opthalmic artery embolism
Kim J, 2015 (32)	Reduction malarplasty	Arteriovenous fistula

Discussion

The superficial temporal artery (STA) courses inside the superficial temporal fascia, which is an extension of the galea and the muscular aponeurotic system of the face, and usually bifurcates into two branches: an anterior frontal branch and a posterior parietal branch (7, 33, 34). Apart from the main branches, the STA gives rise to the transverse facial, zygomatico-orbital, auricular and middle temporal arteries (8). As it approaches the temporal crest, the STA traverses layer 2 (the subcutaneous plane) reaching the occipitofrontalis muscle in the forehead (33).

Branching patterns of the superficial temporal artery

The morphological tree of the STA and its main branches have been described on the basis of cadaver studies and radiological examinations, and respective classifications have been configurated by various authors (Tables 3 and 4). Medved et al. introduced a classification system of the anatomical variations of the STA, depending on the terminal branching pattern. According to this classification system, five types of STA were recognized, with eleven variations (9). Specifically, type A referred to the classic pattern where the main trunk divides into a frontal and a parietal branch, whereas type B concerned additional branches, either frontal (B1) or parietal (B2), or both branches

Table 3. Retrieved Studies and Their Characteristics

Author and year	Ethnicity	Type of study	Arteries (N)
Pinar Y, 2006 (2)	Turkey	Cadaver	27
Stock A, 1980 (3)	USA	Cadaver	15
Stock A, 1980 (3)	USA	Radiological	25
Jean-Philippe H, 2021 (7)	Belgium	Radiological	114
Koziej M, 2019 (8)	Poland	Radiological	419
Medved F, 2015 (9)	Germany	Radiological	93
Mwachaka P, 2010 (10)	Kenya	Cadaver	60
Marano S, 1985 (11)	USA	Cadaver	50
Chen T, 1999 (12)	China	Cadaver	52
Kim B, 2013 (13)	Korea	Radiological	70
Kuruoglu E, 2014 (14)	Turkey	Radiological	53
Tayfur V, 2010 (15)	Turkey	Cadaver	26
Cobb M, 2016 (16)	USA	Radiological	25
Rusu M, 2021 (17)	Romania	Radiological	86
Manoli T, 2016 (35)	Germany	Radiological	76
Lee J, 2015 (36)	Korea	Cadaver	64
Hong W, 2020 (37)	China	Radiological	107
Kleintjes W, 2007 (38)	South Africa	Cadaver	60
Imanishi N, 2002 (39)	Japan	Cadaver	30
Lei T, 2005 (40)	China	Cadaver	30

Table 4. Anatomical Variations of the STA*

Author	Classic (%)	DF/PB† (%)	Trifurcation (%)	AF/PB‡ (%)	AF/PB§ (%)
Jean-Philippe H, 2021 (7)	73.7	26.3	-	-	-
Koziej M, 2019 (8)	11.4	1.4	-	11.2	76
Medved F, 2015 (9)	39.8	8.6	-	10.7	22.6
Mwachaka P, 2010 (10)	53.3	40	6.7	-	-
Marano S, 1985 (11)	66	12	-	8	8
Rusu M, 2021 (17)	80.2	-	-	19.8	-
Manoli T, 2016 (35)	40.8	9.2	-	9.2	31.6

*The superficial temporal artery; †Double frontal/parietal branch; ‡Absent frontal/parietal branch; §Atrophic frontal/parietal branch.

(B3). In type C, atrophic branches were noted either as frontal (C2) or parietal (C1), or both (C3). Subsequently, type D lacked bifurcation, while the STA followed a frontal (D1) or a parietal course (D2). Finally, type E was characterized by the presence of an additional superior auricular artery emanating from the main trunk (E1) or the parietal branch (E2) (9).

On the basis of this classification, Manoli et al. concluded that the anatomical morphology of the STA in the same person is random. Interestingly, in only 26% of the studied cases was the branching pattern consistent on both sides (35). Mwachaka et al. examined the anatomy of 30 cadavers of Kenyan ethnicity, and reported 4 branching patterns. The classical bifurcation was observed in 53.3% of cases, while double frontal branches were reported in 26.7% of the cadavers, and double parietal branches in 13.3% of the cadavers. Remarkably, two cases of trifurcation were identified (10). Compared to other relevant studies, deviations in the branching pattern were related to ethnic differences. Marano et al. proposed a classification in 1985 depending not only on the number of branches but also their diameter, as well as the diameter of their common trunk, rendering those with diameter <1mm atrophic, and the position of the bifurcation in relation to the zygoma. No additional superior auricular artery was reported at the time (11).

The temporal region constitutes a target for rejuvenation techniques, rendering the FBSTA vulnerable to trauma. Lee et al. classified the FBSTA into two categories depending on the number of branches and their course in relation to the frontal belly of the occipitofrontalis muscle. In type I, a single frontal branch reached a single point on the lateral aspect of the frontal belly (Ia) or issued two branches before traversing the frontal belly (Ib). On the other hand, type II arteries consisted of a double frontal branch, which either coursed above the borders of the orbicularis oculi muscle (IIa) or were covered by the muscle (IIb). Remarkably, the type I structural pattern was found in 96.9% of cases (36). Hong et al. published a study of 66 cadavers, differentiating the FBSTA into two types depending on their course over the temporal crest. 89.7% of the arteries turned abruptly by almost 90^{o} upon traversing the temporal crest, whereas 10.3% of them supplied the superior portion of the forehead, turning by a lesser degree (52.3^{o}) (37).

According to Kleintjes et al., the FBSTA reaches the forehead at various transverse levels along a vertical line traversing the lateral orbital rim. In this region, the FBSTA usually issues an ascending branch and a transverse branch, described as the ascending frontal artery and the transverse frontal artery, respectively (38). An anastomosis was often reported between the oblique branch of the supraorbital artery and either the transverse frontal artery or the FBSTA. Notably, the frontal branches anastomose on the galea on the forehead, as well as with the supraorbital and supratrochlear arteries (2, 33). Additionally, perforating branches originating from the FBSTA were observed in a circular area, with a radius of approximately 9 mm situated 40.5 mm laterally from the midline, and 53.6 mm superior to the supraorbital rim (41).

Traditionally, the STA divides into its terminal branches at a point about 5 cm above the zygomatic process of the temporal bone. According to a meta-analysis conducted by Koziej et al., 79.1 % of STAs bifurcated above the zygomatic arch, 11.1% of cases on the arch and 6.7% of them below the arch (42). Morphological differences in the anatomic distribution of the STA with regard to the zygomatic arch were ascertained in a cadaver study of the Chinese population in comparison to corresponding studies in Caucasian adults. Chen et al. observed a classical bifurcation pattern above the zygomatic arch in 86.5% of cases, while 3.8% of the STAs issued their terminal branches on the zygomatic arch and 9.6% below that level (12). A similar distribution was demonstrated in a cadaver study of African ethnicity by Mwachaka et al. (80%, 13.3%, 4%), as well as in a radiological study of Korean patients by Kim et al. (82.6%, 10.1%, 7.2%) (10, 13). Studies on Caucasian patients showed differences in this distribution. Specifically, Stock et al. found a bifurcation above the zygomatic arch in 60% of cases, over the arch in 32% and below it in 8% of cases (3). Similar results were published by Kuruoglu et al. (58%, 40%, 2%), Tayfur et al.

(62%, 38%) and Pinar et al. (74.1%, 22.2%, 3.7%), Hardy et al. (61.5%, 26.9%, 11.54%) (2, 7, 14, 15). According to Imanishi et al. the terminating points of the STA are mainly located in the posterior fourth of the area between the external canthus and the root of the helix, or near this region (39).

Cobb et al. studied the course of the STA around the zygomatic arch, discovering a characteristic "C shaped half-buttonhole configuration" when the artery is traced over the zygomatic arch (96% of STAs studied). In two cases the STA was located posterior to the condylar process of the mandible (16). Furthermore, a radiological study of 43 patients in 2021 showed that the STA was documented to be retrocondylar in 65.1% of cases. The rest of the arteries were located laterally to the mandibular condyle (laterocondylar). The same study demonstrated the existence of kinking and coiling of the STA in 88.4% of the patients (17). Surgeons need to be aware of these structural variability to avoid injury during lateral approaches.

A transverse facial artery was discovered in all specimens in a cadaver study published by Pinar et al., whereas 22.2% issued no zygomatico-orbital artery (ZOA). Interestingly, the zygomatico-orbital artery emanated from the FBSTA in cases where the bifurcation point of the STA was over the zygomatic arch (2). According to a recent study by Park et al., the ZOA was identified in 85.2% of cases, branching from the FBSTA and coursing within ±1cm along a line demarcated by the tragus and the superciliary arch. Occasionally, the ZOA bifurcates from the middle temporal or parietal branch of the STA. Due to its connection to the supraorbital artery and the lacrimal artery, the course of the ZOA is considered a danger zone during filler treatment (43).

Landmarks for Identifying Its Course

The location of the STA has been defined according to distinct anatomical landmarks, specifically the tragus or bony external auditory canal, the zygomatic arch and the lateral canthus (Table 5). The distance measured between the STA and the tragus was 16.68+-0.35 mm in a study by Pinar et al. (2). On the eye-tragus-line, the location of the artery was measured at 15.55+-4.5 mm in front of the tragus (7). Furthermore, the STA was found to be located 12.31+-12.83 mm away from the zygomatic arch in a study published by Hardy et al. Regarding the level of its course, the STA was found to run within a depth of approximately 2.31 mm, while the bifurcation point was identified within a depth of 3.25 mm (7, 44). Remarkably, differences were reported in other studies which were also attributed to ethnic variability (7, 10, 13).

Chen et al. suggested that the distance of the incision from the external auditory canal during facelift procedures should be shorter than 1 cm, in

Table 5. Distance of STA* to Specific Landmarks (in cm)

Author and year	Tragus	Bifurcation to ZA†	EA‡	BEAC§
	Mean±SD	Mean±SD	Mean±SD	Mean±SD
Pinar Y, 2006 (2)	1.68±0.03	-	-	-
Stock A, 1980 (3)	-	-	1.39±0.29	0.94±0.38
Jean-Philippe H, 2021 (7)	-	1.23±1.28	-	-
Koziej M, 2019 (8)	-	2.38±1.14 (center)		
Mwachaka P, 2010 (10)	4.41±1.85	5.08±2.09 (center)	-	-
Chen T, 1999 (12)	-	-	1.22±0.79	1.14±0.32
Kim B, 2013 (13)	-	2.17±1.58 (superior margin)	-	-
Kuruoglu E, 2014 (14)	-	1.41±0.77 (superior margin)	-	-
Tayfur V, 2010 (15)	-	1.2-2.3 (superior margin)	-	-
Lee J, 2015 (36)	1.72±0.82	-	-	-

*The superficial temporal artery; †The zygomatic arch; ‡Ear attachment; Bony external auditory canal.

order to avoid lesion of the STA (12). The position of the temporal branches of the facial nerve can be predicted depending on the location of the FBSTA with regard to the superior orbital rim, and thus protected during a rhytidectomy procedure (40). Traditionally, the temporal branches can be traced 1-2 cm anteriorly and inferiorly to the FBSTA, however a minority of cases present a course just inferior to the FBSTA (45). Nevertheless, the galea separates the artery from the temporal branch, as the latter is located in the subgaleal fat pad (46).

Location of Safe and Danger Zones

The use of fillers has become a significant part of our armamentarium in the treatment of patients seeking rejuvenation (47). However, an increased incidence of adverse events has been noted alongside the widespread use of filler treatment, while a turn from 2-dimensional management of wrinkles to 3-dimensional treatment of the entirety of the face gives rise to the amplified risk of vascular compromise (47). Precise injection techniques using anatomical landmarks, as well as detailed knowledge of the target regional anatomy, are of outmost importance in order to maximize safety (48, 49). Various studies have elucidated areas of interest along the course of the STA, emphasizing the need to be aware of them during surgical procedures and aesthetic manipulations (8). These areas are referred to as danger zones. Koziej et al. detected a triangular artery-free region, using the zygomatic bone as an anatomical landmark. The vertical and horizontal sides are formed by the zygomatic bone, and the superior, oblique side consists of the FBSTA. The artery-free zone extends 25.7 mm on the vertical plane and 31.4 mm on the horizontal plane (8). However, a large number of perforators of the middle temporal vessels can be encountered in the anterior half of the lower temporal compartment, that is, the area of the loose areolar tissue layer below the inferior temporal septum, as well as the temporal branches of the facial nerve and the sentinel vein (50). Therefore, it is crucial to ensure that manipulations are limited to the level above the temporoparietal fascia (8). Another safe zone lies in the preauricular region that, however, extends nearly 5.6 mm in front of the external auditory meatus. Moreover, a wide arterial zone is situated 34.7-74.5 mm superior to the external auditory meatus, where the parietal branch of the STA runs. Another danger zone lies superior to the supraorbital rim, as the FBSTA courses about 47 mm superior to this landmark, accompanied by the temporal branches of the facial nerve, running inferior and parallel to it (8, 51). The FBSTA runs within the temporoparietal fascia, transitioning to the subcutaneous plane as it approaches the border of the occipitofrontalis muscle (51). According to Lee et al. the area located 2.5 cm lateral and 3 cm superior to the intersection point between the vertical plane through the lateral epicanthus and the uppermost eyebrow point comprises a danger zone, where the FBSTA crosses the lateral border of the occipitofrontalis muscle. A straightforward clinical way of detecting this area is to position the thumb between these two planes, and avoid the part extending from the tip of the thumb to the first interphalangeal joint (36).

Anatomical Considerations Related to the Use of Fillers

The temporal region has a complex vascular anatomy owing to the multitude of vessels coursing through its different layers, as well as the robust arterial and venous connections to the internal carotid artery and the cavernous sinus (44, 52). The branches of the STA and the zygomatico-orbital artery run within the laminae of the superficial temporal fascia, while the middle zygomatico-temporal vein is detected within the deep fat of the temple, between the superficial temporal fascia and the deep temporal fascia (52). Thus, it is suggested that filler treatment should take place subcutaneously or deep in the supraperiosteal plane (49). Interestingly, a histological study by Chundury et al. showed that even when hyaluronic acid is injected within the subcutaneous tissues, a certain amount of it could unintentionally be placed at deeper levels, as well as within the perivascular tissues (53).

The transverse facial artery runs 2 cm superiorly to the zygomatic arch, and parallel to it. The middle temporal artery emanates from the STA above the superior border of the zygomatic arch, and runs towards the superior border of the orbital rim at a depth of 4.01mm. Its cutaneous branch courses subcutaneously. However, a muscular branch enters the temporalis muscle at a depth of 6.31mm (44). Vascular complications may also arise if filler is injected into the middle temporal vein, which is identified within the superficial temporal fat pad approximately 2 cm superiorly to the zygomatic arch (47, 53). Due to its large diameter, deep injections should be avoided in this area and rather be performed several centimeters superiorly to the zygomatic arch (51, 52). The anterior deep temporal artery is identified in the anterior portion of the temporalis muscle, while the posterior deep temporal artery runs in its middle aspect at a depth of 14.13 mm, and communicates with the middle temporal artery at the center of the temporal area (44, 52).

According to De Maio et al. a safe access point for temple volumization is located 1 cm lateral to the temporal crest and 1 cm superior to the lateral orbital rim, as the middle temporal artery and the deep temporal artery course more posteriorly. The filler should be injected in the supraperiosteal plane (48). Cotofana et al. suggest six injection techniques targeting volumization and lifting in the temporal region subdermally, in the supraperiosteal and interfascial plane. However, the muscular branch of the middle temporal artery, the sentinel vein and branches of the facial nerve could be encountered in the latter (44, 52). Huang et al. suggest injecting in the upper temporal compartment and the lower temporal compartment of the loose areolar tissue layer, entering medially to the junction of the hairline and the temporal crest, and avoiding the anterior half of the lower temporal compartment where the sentinel vein, perforators of the middle temporal artery and temporal branches of the facial nerve are identified (50). Deep injections in the lower or posterior temporal fossa superiorly to the zygomatic arch should be avoided (48).

Complications Involving the Artery after Aesthetic Surgery

Inadvertent injury to the vessels could result in hemorrhage or in the gradual development of a pseudoaneurysm, whose rupture could be the cause of massive bleeding (18). Excessive use of epinephrine locally can also lead to hematoma due to the rebound effect as the vasoconstricting effect dissipates (19, 20). Bleeding has occurred in cases of otoplasty, rhytidectomy and mandibular angle osteotomy. Another source of vascular complications could be the impingement of the artery by a needle (36, 54). The formation of a pseudoaneurysm following partial transection of the artery, or needle penetration during instillation of local anesthetic, has also been reported (21, 22). A pseudoaneurysm of the STA constituted a complication following rhytidectomy and thread-lifting. Likewise, an arteriovenous fistula could form as a result of surgical maneuvers. This complication was observed in cases of rhytidectomy, reduction malarplasty and retrieval of a cartilage graft as part of a rhinoplasty procedure. The propensity for injury of the STA may be explained by the lack of a protective tissue cushion between it and the bones. Finally, embolism and ischemic lesions of the ophthalmic as well as the cerebral arteries were reported after autologous fat-grafting. As a result of an inflow of fat particles, vascular obstruction could occur, coupled with devastating consequences, such as vision loss and cerebral infarction (36). The presence of anastomosis between the STA, the ocular artery and the facial artery, and the abundant arterial connections between the internal and external carotid systems explain the embolic events occurring by the intravasation and retrograde flow of fat. Cases of massive cerebral infarction due to fat embolism of the internal and external carotid artery have been reported (23, 24, 55).

Conclusion

Thorough knowledge of the anatomical variability of the STA, especially in the lateral forehead region is indispensable for aesthetic surgeons, in line with the basic principle "first, do no harm". Furthermore, awareness of the danger zones involved in each procedure, combined with intraoperative vigilance, can assist surgeons, as well as injectors, in improving safety and minimizing the occurrence of unwanted sequelae. This review aims to improve the surgeon's understanding of the anatomy and clinical relevance of the STA, and highlight the areas that need to be safeguarded, hence, contributing to the overall improvement of safety during surgery and aesthetic treatment.

What Is Already Known on This Topic:

The anatomical variability of the superficial temporal artery has been elucidated in various cadaveric as well as radiological studies. Moreover, the course of the artery has been described in relation to defined landmarks, rendering its preservation and protection possible during surgical procedures involving relevant areas of the face. Due to the complexity of the overall vascular anatomy of the temporal region traversed by the STA and the rising popularity of aesthetic procedures in the region, for the sake of rejuvenation, several authors have presented specific danger zones in order to provide surgeons with anatomical pathways to avoid injury and relevant sequelae following aesthetic manipulations in the temporal region.

What This Study Adds:

The aim of this review was to collect the available data concerning the anatomical particularities of the superficial temporal artery, its relationship to defined adjacent landmarks, as well as the location of danger zones involving relevant regions of the face, which could be encountered during aesthetic manipulations and surgical procedures of the face. Multiple terminal branches and diverse levels of division of the artery could have an impact on the invasive outcome as inadvertent trauma or compression of the artery could occur. Surgeons need to be aware of the traditional course of the artery as well as possible deviations, and proceed with vigilance. When in doubt, preoperative confirmation of the course of the artery can be undertaken radiologically so that the surgeon can anticipate a familiar path during the dissection or the use of minimally invasive facial techniques, and avoid damage to the vessels.

Authors' contributions: Conception and design: DD, DC and TT; Acquisition, analysis and interpretation of data: DD; Drafting the article: DD; Revising it critically for important intellectual content: AM; Approved final version of the manuscript: AM, DC and TT.

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