Facial Surgery

Anatomical Study of Temporal Fat Compartments and its Clinical Application for Temporal Fat Grafting

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Ru-Lin Huang, MD, PhD; Yun Xie, MD; Wenjin Wang, MD, PhD; Tanja Herrler, MD; Jia Zhou, MD, PhD; Peijuan Zhao, MD; Lee L.Q. Pu, MD, PhD; and Qingfeng Li, MD, PhD

Abstract

Background: Low satisfaction rates and severe complications are two major limitations for temporal hollowing augmentation using autologous fat grafting. Despite fat compartments in temporal region have been reported, its clinical applied anatomy for fat grafting have not been the subject of studies that show its benefits objectively and statistically.

Objectives: To investigate temporal fat compartments and relative neurovascular structures in cadavers, developing a safe and effective fat grafting technique for temporal hollowing augmentation.

Methods: The study was conducted on 8 cadavers (16 temples). The tissue layers, fat compartments, ligaments, and neurovascular structures in the temporal region were analysed. The variables were the number and location of sentinel veins, perforator vessels of the middle temporal vein. Measurements were taken with a digital calliper.

Results: Two separate fat compartments, the lateral temporal-cheek fat compartment and lateral orbital fat compartment, were found in the subcutaneous layer, and two separate septum compartments, the upper and lower temporal compartment, were found in the loose areolar tissue layer. One sentinel vein and 1 to 6 perforator vessels were found to travel through the subcutaneous tissue layer, traverse the overlapping tissue layers in the lower temporal septum region, and finally join in the middle temporal vein.

Conclusions: The four fat compartments in the temporal region are ideal receipt sites for fat grafting. The medial border of the junction of the hairline and temporal line is a safe and effective cannula entry site for temporal fat grafting. The anterior half of the lower temporal compartment is a "zone of caution" for temporal fat grafting.

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The young face is characterized by a smooth and convex contour of the temples in which the anterior bony margin is concealed. With age, however, the upper part of face becomes more concave and the bony margins of the zygomatic arch, temporal line, and lateral orbital rim appear more prominent. The resulting old and gaunt appearance may be aesthetically unpleasing and demand correction. Autologous fat grafting has been widely applied and advocated for facial contouring and body shape remodeling. Various techniques for autologous fat transfer have been introduced including the structural fat grafting technique,[1,2] the 3M3L technique,[3,4] the cell assisted

Drs Huang, Xie, Wang, Zhou, and Zhao are Plastic Surgeons, and Dr Li is a Professor, Department of Plastic and Reconstructive Surgery, Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China. Dr Herrler is an Attending Surgeon, Plastic Surgery and Burn Center, Trauma Center Murnau, Murnau, Germany. Dr Pu is a Professor of Plastic Surgery, Division of Plastic Surgery, University of California, Davis, Sacramento, CA, USA.

Corresponding Author:
Prof. Qingfeng Li, Department of Plastic and Reconstructive Surgery, Shanghai Ninth People's Hospital, Shanghai Jiaotong University School of Medicine, 639 Zhizaoju Road, Shanghai 200011, China.
E-mail: dr.liqingfeng@shsmu.edu.cn

lipotransfer (CAL) technique,[5,6] and the facial autologous muscular injection (FAMI) technique.[7,8] However, there is no consensus approach for the augmentation of temporal hollowing using autologous fat. This may be due to the complex anatomical structures, high risk of adverse events, and poor long-term outcomes in this area. According to Mojallal et al, the temporal region is one of the subunits with the lowest satisfaction rate after facial fat grafting.[9] Furthermore, an unnatural postoperative appearance including skin irregularities and edema[10] as well as severe complications such as blindness and cerebral fat embolism[11-13] have been reported.

In fact, a good understanding of the process of facial aging and anatomy of the recipient site are crucial in facial contouring using autologous fat. It is widely accepted that facial aging is characterized by loss of soft tissue volume and elasticity. Furthermore, the identification of facial fat compartmentalization by Rohrich et al demonstrated that facial fat is highly structured rather than uniform and continuous.[14-17] These fat compartments play distinct roles in sculpturing the facial contour and undergo distinct age-related changes. However, clinical applied anatomy of the temporal region, especially the temporal fat compartments, have not been the subject of research that proves its benefits objectively and statistically. We hypothesize that restoration of the physiological distribution and volume of fat compartments using anatomically adequate cannula entry sites and injection planes may not only avoid soft tissue and neurovascular injury but also improve the long-term outcomes for a youthful and natural-looking face. Our previous anatomical and clinical study on mid-face fat grafting have demonstrated the effective and safe profile of this hypothesis.[18] Therefore, in this study, we investigated the distribution of fat compartments and the characteristic of neurovascular structures in temporal region with the purpose of developing a concept of targeted volume restoration for temporal hollowing augmentation.

METHODS

The study was carried out in the anatomy laboratory at Shanghai Jiao Tong University School of Medicine after approval by the Ethics Committee from the Shanghai Ninth People's Hospital, Shanghai Jiao Tong University School of Medicine. To better understand the anatomical structures of the temporal region with regard to temporal fossa augmentation, we performed anatomic dissection studies of both temporal regions in 8 cadavers (16 temples) between September 2014 and January 2015. The temporal region was dissected based on the lamellar planes. Briefly, after removal of the skin through a coronal incision, the temporoparietal fasciae were dissected layer by layer. The superficial temporal artery was identified and followed until the intersection with the temporal line. The sentinel vein and the perforators of the middle temporal vessels were identified and dissected down to where they perforated the temporal fascia and drained into the middle temporal vessels. The number of perforator vessels was counted and their distance to the zygomatic arch/lateral orbital rim measured.

RESULTS

Arrangement of Tissue Layers

The temporal hollowing region is formed by the superior temporal line, lateral orbital rim, zygomatic arch, and temporal hairline (Figure 1). Our anatomical dissection studies consistently demonstrated distinct tissue layers of the temporal region in 16 temples of 8 cadavers (3 men and 5 women) with a mean age of 56 years (range, 26-83 years). From superficial to deep, the horizontal tissue layers of skin, subcutaneous tissue, superficial temporal fascia, loose areolar tissue, deep temporal fascia, temporalis muscle, and pericranium were identified as previously described.[19,20] The subcutaneous tissue layer in the temporal region was found to be notably thin, especially with advanced age. The superficial temporal fascia was thin, pliable, and highly vascularized. In the temporal hollowing region, it also contained the frontal branch of the superficial temporal artery, the sentinel vein (Figure 2), and temporal branches of the facial nerve (Figure 3). The loose areolar tissue layer located between the superficial and deep temporal fascia was shown to encompass one sentinel vein and several perforator vessels, but was otherwise mostly avascular. A total of 10 temples among the 8 cadavers in this study exhibited a thin layer of fat tissue in the loose areolar tissue layer. The deep temporal fascia was found to be a dense structure enclosing the underlying temporalis muscle. At the level of the superior orbital margin, the deep temporal fascia split into deep and superficial layers encompassing the superficial temporal fat pad.

In the temporal region, we identified a series of ligamentous structures perpendicular to the temporal fasciae. The superior temporal septum (STS) arose from the periosteum along the superior temporal line of the skull where the periosteum transitioned to the deep temporal fascia. The inferior temporal septum (ITS) was formed by fusion of superficial temporal fascia and deep temporal fascia originating from the lateral corner of the temporal ligamentous adhesion and extending obliquely towards the superior crus of the helix. The orbicularis retaining ligament (ORL) was shown to originate from the periosteum of the orbital rim, traverse the orbicularis oculi muscle, and enter the skin and lid – cheek junction. At the level of the lower zygoma, the adhesions comprise the zygomatic

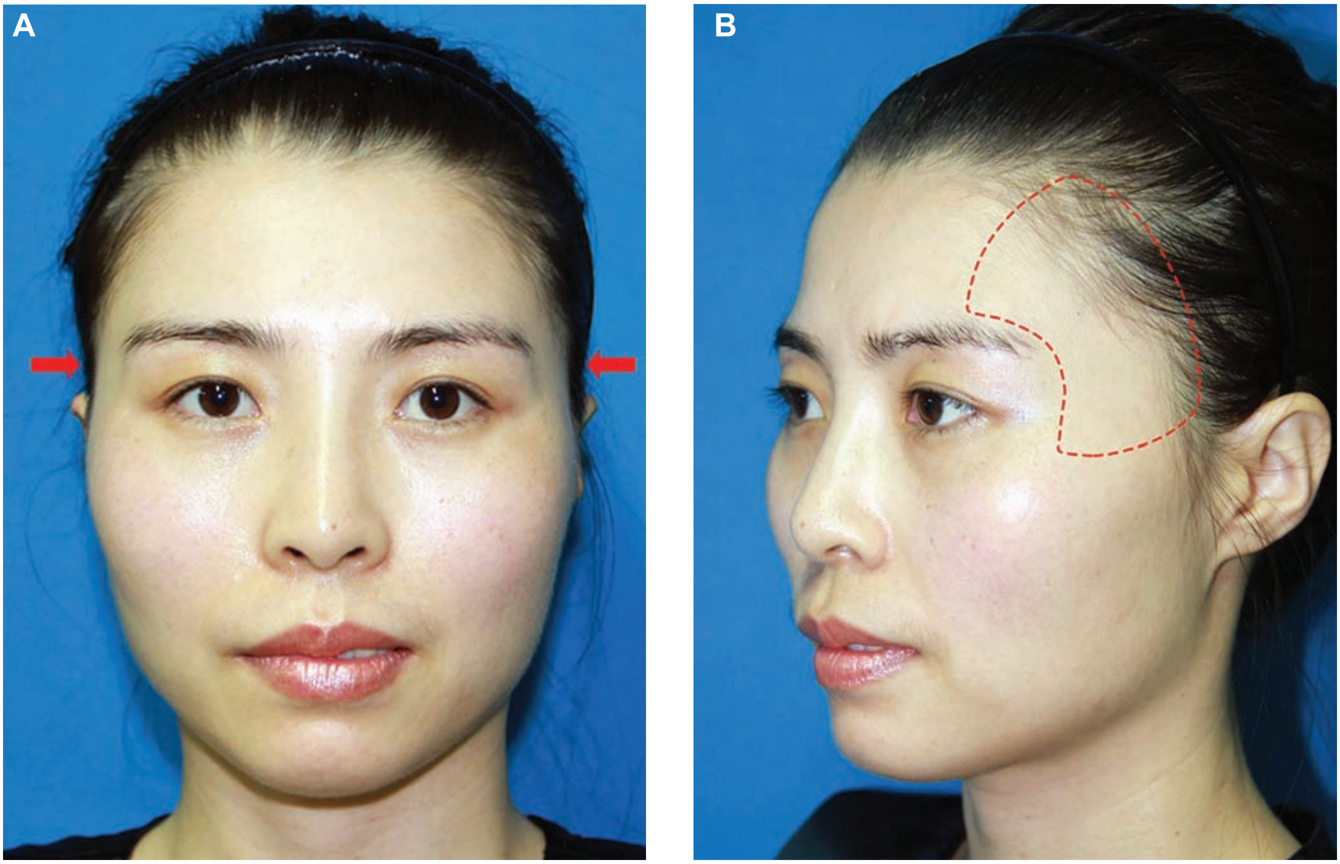

Figure 1. (A) Characteristics of temporal hollowing as demonstrated on a 37-year-old female patient. Temporal hollowing causes an old and gaunt appearance. (B) The temporal hollowing region is formed by the superior temporal line (superiorly), lateral orbital rim (anteriorly), zygomatic arch (inferiorly), and temporal hairline (laterally).

Figure 2. Visible sentinel vein running in the temporal region as demonstrated on a 56-year-old female patient.

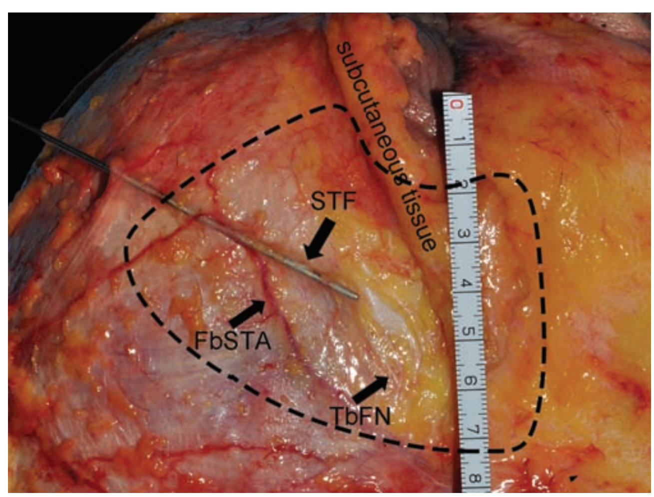

Figure 3. The superficial temporal fascia and neurovascular structures in the temporal region as demonstrated on a 72-year-old female cadaver. FbSTA, frontal branch of the superficial temporal artery; TbFN, temporal branch of the facial nerve; STF, superficial temporal fascia.

cutaneous ligaments (ZCL, Figures 4-5). These vertical ligamentous structures and horizontal tissue layers formed several separated compartments in the temporal region. In the subcutaneous tissue layer, the ITS divided the subcutaneous fat tissue into two dynamic fat compartments, the lateral temporal-cheek fat compartment

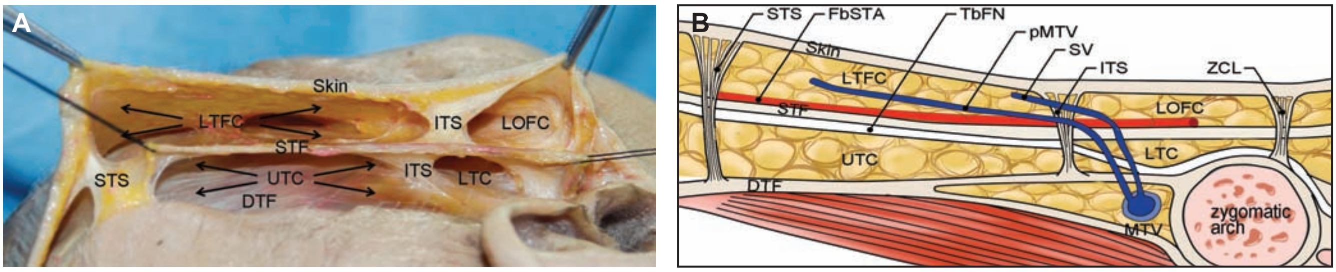

Figure 4. (A) The ligamentous and compartmental structures in the temporal region as demonstrated on a 64-year-old female cadaver. (B) Illustration demonstrating the ligamentous, compartmental, and neurovascular structures in the temporal region. In the temporal region, the three vertical ligamentous structures divide the two horizontal tissue layers into four separated compartments. The LTFC and LOFC are located at the subcutaneous tissue layer; the UTC and LTC are located at the loose areolar tissue layer. LTFC, lateral temporal-cheek fat compartment; LOFC, lateral orbital fat compartment; UTC, upper temporal compartment; LTC, lower temporal compartment; STS, superior temporal septum; ITS, inferior temporal septum; ORL, orbital retaining ligament; ZCL, zygomatic cutaneous ligament.

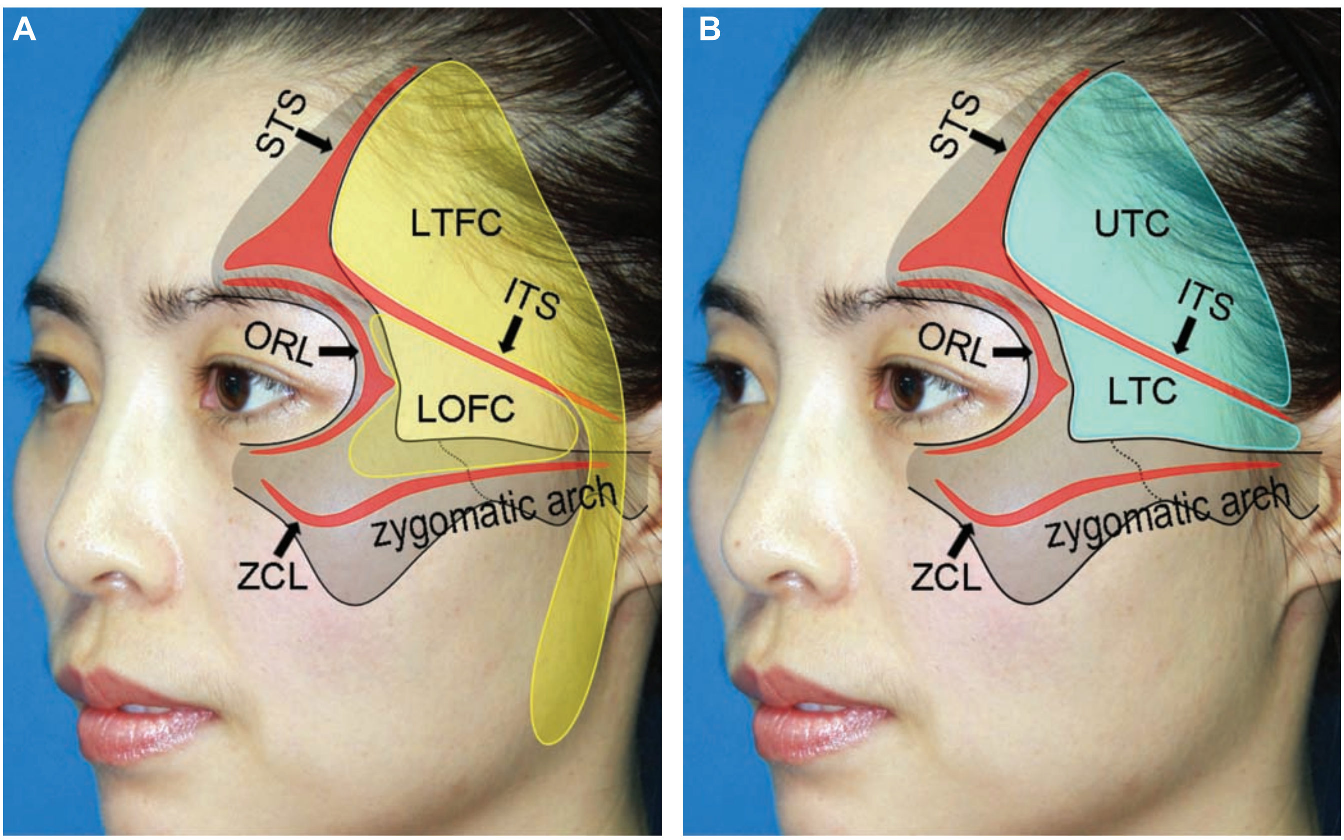

Figure 5. Surface projection of fat compartments (A) and septum compartments (B) in the temporal region as demonstrated on a 37-year-old female patient. LTFC, lateral temporal-cheek fat compartment; LOFC, lateral orbital fat compartment; UTC, upper temporal compartment; LTC, lower temporal compartment; STS, superior temporal septum; ITS, inferior temporal septum; ORL, orbital retaining ligament; ZCL, zygomatic cutaneous ligament.

(LTFC) and the lateral orbital fat compartment (LOFC, Figures 4-5), consistent with previous reports.[14] In the loose areolar tissue layer, the two deep septum compartments, upper temporal compartment (UTC) and lower temporal compartment (LTC), were separated by the ITS (Figures 4-5).

Vascular and Nerval Anatomy

The neurovascular anatomy of the temporal region was consistent in this dissection series. The frontal branch of the superficial temporal artery was found in the temporal hollowing region within the superficial temporal fascia. It

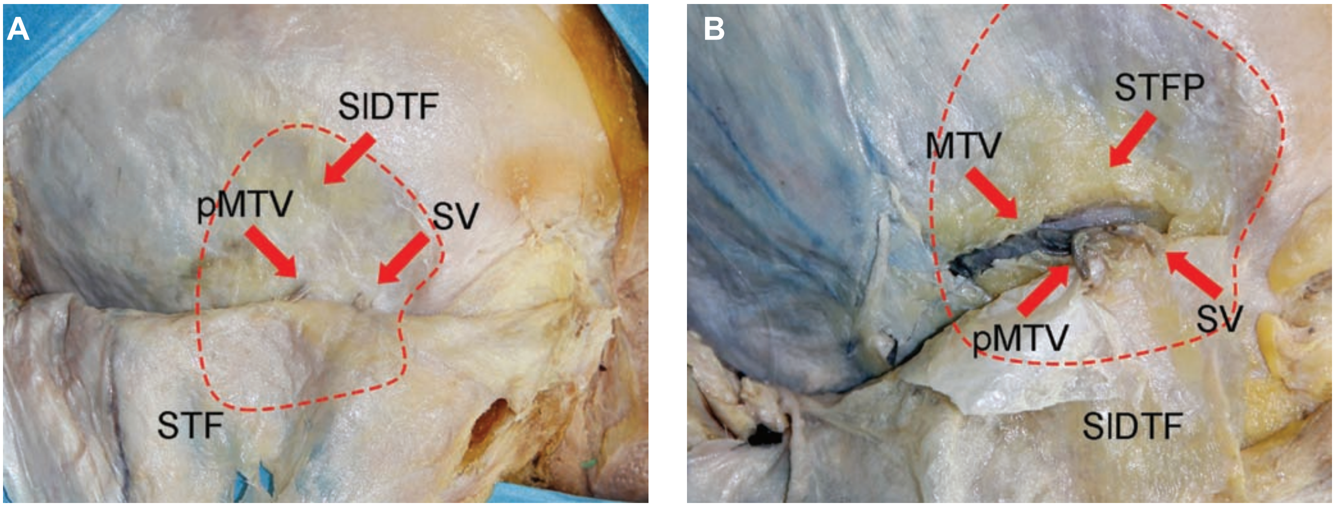

Figure 6. Vascular structures perforating the temporal fasciae as demonstrated on a 64-year-old male cadaver. The perforators (A) originating from the middle temporal vessels (B) and the sentinel vein travel through the superficial layer of the deep temporal fascia, loose areolar tissue, and superficial temporal fascia, into the subcutaneous tissue. SlDTF, superficial layer of the deep temporal fascia; STF, superficial temporal fascia; STFP, superficial temporal fat pad; pMTV, perforator of the middle temporal vein; SV, sentinel vein.

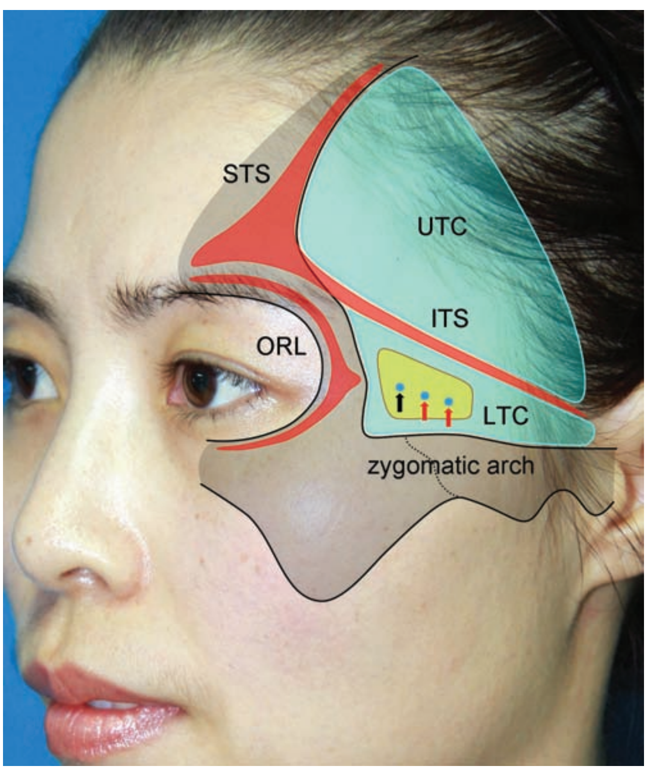

Figure 7. Surface projection of the "zone of caution" as demonstrated on a 37-year-old female patient. The zone of caution is located in the lower temporal compartment at its anterior half, where the sentinel vein and branches of the middle temporal vessels perforate the temporal fascia and travel in the subcutaneous tissue layer. UTC, upper temporal compartment; LTC, lower temporal compartment; STS, superior temporal septum; ITS, inferior temporal septum; ORL, orbital retaining ligament.

supplied several small vessels along its course in the temporal hollowing region. In this plane, we also identified 2 to 4 temporal branches of the facial nerve which crossed the zygomatic arch obliquely one fingerbreadth behind the posterior margin of the zygomatic process of the frontal bone and ran caudally parallel to the frontal branch of the superficial temporal artery (Figure 3). The sentinel vein was consistently found lateral to the lateral orbital rim passing from the subcutaneous layer through the superficial temporal fascia and then perforating the superficial layer of the deep temporal fascia to join in the middle temporal vein (Figure 6A). The middle temporal vein was buried in the superficial temporal fat pad and traveled between the superficial and deep layers of the deep temporal fascia (Figure 6B). Several perforator vessels (number on average: 2.6, range: 1-6) that traversed the superficial temporal fascia layer, loose areolar tissue layer, and superficial layer of the deep temporal fascia were found to originate from or join in the middle temporal vessels (Figure 6B). The highest density of perforators was located at the junction of the zygomatic arch and lateral orbital rim and 24 mm on average (range, 18-32 mm) cranial to the anterior half of the zygomatic arch (Figure 7).

DISCUSSION

Autologous fat grafting is a well-accepted technique for soft tissue augmentation. However, temporal augmentation using fat grafting is associated with a low patient satisfaction and a high complication rate.[9,11] In our previous anatomical and clinical study regarding midface fat grafting we developed a new concept for a fat grafting technique that advocates targeted volume restoration of fat compartments in the face.[18] In this study, we followed the advocated notion in that study and demonstrated the physiological distribution of temporal fat compartments and identified a caution zone for temporal fat grafting. Based on our anatomical study, we have therefore developed a safe and effective treatment technique.

In general, the temporal hollowing region is different from the anatomical term "temporal fossa" and outlined by the superior temporal line, temporal hairline, zygomatic arch, and lateral orbital rim (Figure 1). In our anatomical, physiological distribution of horizontal tissue layers, vertical septa/ligaments, fat compartments, and neurovascular structures were clearly identified and found to be consistent with previous studies in the temporal region.[19,21-25] Among these tissue structures, the fullness of the four temporal fat compartments is a major characteristic of a youthful temple. Etiologically, various factors including ageing, weight loss, skeletal growth inhibition, and soft tissue or bone injury, may cause volumetric loss of the temporal fat compartments. To safely and effectively rebuild a round and convex facial contour, restoration of volume loss and physiological distribution of the fat compartments in the temporal region is essential. So far, there is no consensus approach for fat grafting in the temporal region. Considering the aetiology and anatomy of temporal hollowing, we suggest fat injection in a multi-plane technique to address deep and superficial planes. The deep injection plane is located in the loose areolar tissue layer. Here, fat grafting into the UTC and LTC enabled considerable restoration of the main volumetric loss in the temporal hollowing region. However, the remaining skin irregularities may require subtle facial contour adjustment by superficial injection into the subcutaneous tissue layer. Major neurovascular structures were widely absent in these two planes. However, based on our anatomical study, we have first defined a "zone of caution" in the temporal region that contains several important neurovascular structures including the sentinel vein (Figure 2), perforators of the middle temporal vessels, and temporal branches of the facial nerve, perforating or traveling along the overlaying fascia. This zone of caution is located at the anterior half of the LTC. Special attention should be paid to this area to avoid complications (Figure 7).

The site of cannula insert site for fat injection is also an important aspect in lipofilling for temporal hollowing. An adequate access site not only reduces neurovascular and tissue injury, but also allows for anatomically correct placement of the fat graft. Several entry points in the temporal region have been suggested at the temporal hairline or lateral border of the orbital rim.[7,26] Based on our anatomical study, we advocate placing the cannula entry site at the medial side of the intersection of hairline and temporal line (Figure 8). This is a special transition area between the common border of the temporal and frontal regions, where the galea aponeurotica is substituted by the superficial temporal fascia[19] thus forming a continuous dense fascial structure (the superficial muscular aponeurotic system, SMAS) and dividing the temporal compartments into a superficial and a deep plane. In clinical practice, after making a small incision at the entry site, insert a cannula into the incision and puncture through the galea aponeurotica, then push the cannula toward to the temporal region, the cannula will pass through the upper temporal septum and land into the deep plane. For the superficial plane, insert the cannula into the incision and puncture through the subcutaneous tissue, then push the cannula toward to the temporal region, the cannula will land into the superficial layer. The continuous fascial structure (SMAS) ensures accurate cannula insertion into the two planes and correct placement of the fat graft into the temporal fat compartments. We advocate using this access site in temporal fat grafting based on the following advantages: firstly, this incision site is located within the hairline which is associated with a more hidden and mostly invisible scar. Secondly, according to our anatomical study, using this entry point may decrease the incidence rate of injuries to the sentinel vein and the temporal branch of the facial nerve. Thirdly, the cannula is not only easily inserted into the deep and superficial injection planes via this access, but also into the transition area between the temporal

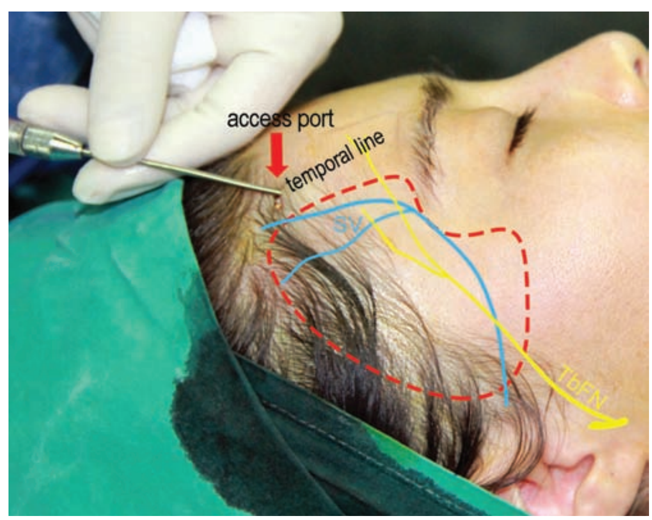

Figure 8. The cannula entry site for temporal augmentation using fat grafting as demonstrated on a 37-year-old female patient. The entry site was placed medially to the junction of hairline and temporal line in an area that is relatively free of neurovascular structures. TbFN, temporal branch of the facial nerve; SV, sentinel vein.

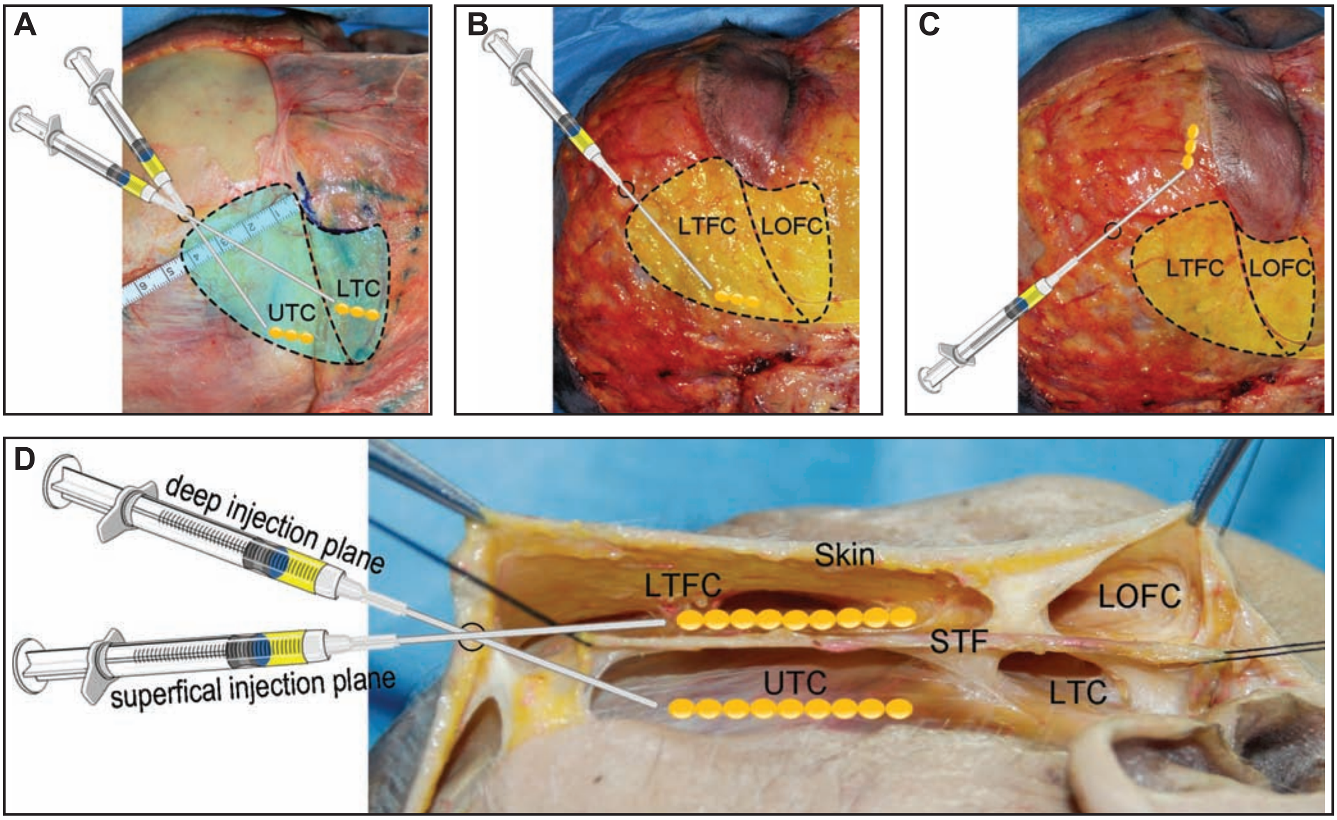

Figure 9. Illustration demonstrating targeted fat grafting for temporal hollowing augmentation as demonstrated on a 72-year-old female cadaver. In this technique, the cannula entry is located medial to the junction of hairline and temporal line. The fat tissue is injected into the deep injection plane (A) in the loose areolar tissue layer (UTC and LTC), to restore the majority of volumetric loss, followed by an injection into the superficial injection plane (B) in the subcutaneous tissue layer (LFFC and LOFC), to achieve a smooth and round facial contour, and the transition zone (C) in the subcutaneous tissue layer of the frontal region, to achieve a smooth and round facial contour. (D) Illustration demonstrating the relationship of the superficial injection plane and the deep injection plane. UTC, upper temporal compartment; LTC, lower temporal compartment; LTFC, lateral temporal-cheek fat compartment; LOFC, lateral orbital fat compartment; UTC, upper temporal compartment; LTC, lower temporal compartment.

and frontal regions to form a round and convex facial contour (Figure 9).

Recently published fat grafting techniques mainly focused on the methodological aspects of fat harvesting, refining, and grafting skills in general. However, lipofilling results differed depending on the treated body regions[9] which may be explained by the variability in anatomical structures in the recipient site. Ideally, the anatomical structure of the fat recipient site, as well as characteristic age-related changes, should be considered in soft tissue augmentation with autologous fat grafting. Targeted fat grafting in an anatomically correct site via an anatomically appropriate incision not only allows for the restoration of the volumetric loss and reduces the risk of tissue and neurovascular injury, but also preserves the grafted fat in situ, enhances fat graft survival, altogether improving the efficacy and safety of the fat grafting procedure. Our previous study on mid-face fat grafting have demonstrated that the compartment-based fat grafting technique is a promising and supplementary lipofilling technique for the recently published fat grafting techniques and may be also effective in other facial anatomical units.[18] The current study on temporal region provides a solid theoretical basis for the targeted fat grating technique for temporal hollowing augmentation. However, clinical verification of a safe and effective profile of this technique is the major limitation of this study.

CONCLUSIONS

The four separated temporal fat compartments are ideal receipt sites for temporal hollowing augmentation using fat grafting. The medial border of the junction of hairline and temporal line is a safe and effective cannula entry site for temporal fat grafting. Furthermore, the caution zone located at the lower temporal compartment should be carefully during fat grafting procedure. Targeted restoration of the temporal fat compartments allows for a safe and effective long-term correction of temporal hollowing and may improve clinical outcomes of soft tissue augmentation in facial contouring and increase patient satisfaction.

Disclosures

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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REFERENCES

1. Coleman SR. Facial augmentation with structural fat grafting. *Clin Plast Surg*. 2006;33(4):567-577.
2. Coleman SR. Structural fat grafting. *Aesthet Surg J*. 1998;18(5):386, 388.
3. Xie Y, Zheng DN, Li QF, et al. An integrated fat grafting technique for cosmetic facial contouring. *J Plast Reconstr Aesthet Surg*. 2010;63(2):270-276.
4. Xie Y, Li Q, Zheng D, Lei H, Pu LL. Correction of hemifacial atrophy with autologous fat transplantation. *Ann Plast Surg*. 2007;59(6):645-653.
5. Yoshimura K, Sato K, Aoi N, et al. Cell-assisted lipotransfer for facial lipoatrophy: efficacy of clinical use of adipose-derived stem cells. *Dermatol Surg*. 2008;34(9):1178-1185.
6. Matsumoto D, Sato K, Gonda K, et al. Cell-assisted lipotransfer: supportive use of human adipose-derived cells for soft tissue augmentation with lipoinjection. *Tissue Eng*. 2006;12(12):3375-3382.
7. Amar RE, Fox DM. The facial autologous muscular injection (FAMI) procedure: an anatomically targeted deep multiplane autologous fat-grafting technique using principles of facial fat injection. *Aesthetic Plast Surg*. 2011;35(4):502-510.
8. Butterwick KJ. Fat autograft muscle injection (FAMI): new technique for facial volume restoration. *Dermatol Surg*. 2005;31(11 Pt 2):1487-1495.
9. Mojallal A, Shipkov C, Braye F, Breton P, Foyatier JL. Influence of the recipient site on the outcomes of fat grafting in facial reconstructive surgery. *Plast Reconstr Surg*. 2009;124(2):471-483.
10. Lambros V. A technique for filling the temples with highly diluted hyaluronic acid: the "dilution solution". *Aesthet Surg J*. 2011;31(1):89-94.
11. Hu J, Chen W, Wu Y, et al. Middle cerebral artery occlusion following autologous bitemporal fat injection. *Neurol India*. 2011;59(3):474-475.
12. Jiang X, Liu DL, Chen B. Middle temporal vein: a fatal hazard in injection cosmetic surgery for temple augmentation. *JAMA Facial Plast Surg*. 2014;16(3):227-229.
13. Lu L, Xu X, Wang Z, Ye F, Fan X. Retinal and choroidal vascular occlusion after fat injection into the temple area. *Circulation*. 2013;128(16):1797-1798.
14. Rohrich RJ, Pessa JE. The fat compartments of the face: anatomy and clinical implications for cosmetic surgery. *Plast Reconstr Surg*. 2007;119(7):2219-2227; discussion 2228-31.
15. Rohrich RJ, Pessa JE, Ristow B. The youthful cheek and the deep medial fat compartment. *Plast Reconstr Surg*. 2008;121(6):2107-2112.
16. Rohrich RJ, Pessa JE. The retaining system of the face: histologic evaluation of the septal boundaries of the subcutaneous fat compartments. *Plast Reconstr Surg*. 2008;121(5):1804-1809.
17. Wan D, Amirlak B, Giessler P, et al. The differing adipocyte morphologies of deep versus superficial midfacial fat compartments: a cadaveric study. *Plast Reconstr Surg*. 2014;133(5):615e-622e.
18. Wang W, Xie Y, Huang RL, et al. Facial contouring by targeted restoration of facial fat compartment volume: the mid-face. *Plast Reconstr Surg*. 2016 Nov 21. [Epub ahead of print]
19. O'Brien JX, Ashton MW, Rozen WM, Ross R, Mendelson BC. New perspectives on the surgical anatomy and nomenclature of the temporal region: literature review and dissection study. *Plast Reconstr Surg*. 2013;131(3):510-522.
20. Davidge KM, van Furth WR, Agur A, Cusimano M. Naming the soft tissue layers of the temporoparietal region: unifying anatomic terminology across surgical disciplines. *Neurosurgery*. 2010;67(3 Suppl Operative):ons120-ons129; discussion ons129.
21. Sykes JM. Applied anatomy of the temporal region and forehead for injectable fillers. *J Drugs Dermatol*. 2009;8(10 Suppl):s24-s27.
22. Jung W, Youn KH, Won SY, Park JT, Hu KS, Kim HJ. Clinical implications of the middle temporal vein with regard to temporal fossa augmentation. *Dermatol Surg*. 2014;40(6):618-623.
23. Kim S, Matic DB. The anatomy of temporal hollowing: the superficial temporal fat pad. *J Craniofac Surg*. 2005;16(5):760-763.
24. Alghoul M, Codner MA. Retaining ligaments of the face: review of anatomy and clinical applications. *Aesthet Surg J*. 2013;33(6):769-782.
25. Moss CJ, Mendelson BC, Taylor GI. Surgical anatomy of the ligamentous attachments in the temple and periorbital regions. *Plast Reconstr Surg*. 2000;105(4):1475-1490; discussion 1491.
26. Marten TJ, Elyassnia D. Fat grafting in facial rejuvenation. *Clin Plast Surg*. 2015;42(2):219-252.