Forces Required to Pull the Superficial Fascia in Facelifts

Les forces nécessaires pour tirer le fascia superficiel en cas de redrapage du visage et du cou

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Abstract

Purpose: The aims of this study were to characterize the histology of the sideburn and cheek area and to measure the force required to pull the superficial fascia (SF) of Asians in facelift procedures. **Methods:** The hemiface of a formalin-fixed Korean male adult cadaver (77 years old) was used to study the histology of the sideburn and cheek area. In 42 patients during facelift procedures, the force needed to pull the overlying skin at the midpoint between the sideburn and nasolabial fold 2 mm was measured using a tensiometer. **Results:** In the cheek, the superficial fatty layer of the superficial fascia (SFS) was found to maintain its thickness throughout the region between the dermis and the membranous layer of the superficial fascia (MSF). The MSF was continuous with the superficial temporal fascia (STF). In the sideburn, the MSF and parotid fascia closely adhered to each other. The force required to move the overlying skin 2 mm when pulling the MSF (10.27 ± 3.64 N) was more than twice as great (217%) as the force required when pulling the SFS (4.73 ± 2.15 N; $P < .001$). The forces required when pulling the MSF and SFS to move the overlying skin 2 mm were significantly greater in the sideburn area (11.56 ± 3.37 N and 5.52 ± 2.08 N, respectively) than in the cheek area (8.97 ± 3.43 N and 5.52 ± 2.08 N, respectively; $P < .001$). **Conclusion:** When lifting the SF at the cheek or sideburn area, lifting the SFS requires less tension than MSF to move the overlying skin. In the cheek area, less tension is needed to move the overlying skin than in the sideburn area.

Résumé

Objectif : La présente étude visait à caractériser l'histologie de la zone des favoris et des joues et à mesurer la force nécessaire pour tirer le fascia superficiel (FS) lors du redrapage du visage et du cou de visages asiatiques. **Méthodologie :** Les chercheurs ont utilisé l'hémiface d'un cadavre adulte coréen de sexe masculin de 77 ans fixé dans le formol pour étudier l'histologie des régions des favoris et des joues. Chez 42 patients pendant un redrapage du visage et du cou, les chercheurs ont mesuré la force nécessaire pour tirer la peau sus-jacente de 2 mm au point médian entre les favoris et le pli nasolabial à l'aide d'un tensiomètre. **Résultats :** Dans les joues, les chercheurs ont découvert que la couche de graisse superficielle du fascia superficiel (GFS) conservait son épaisseur dans toute la région entre le derme et la couche membraneuse du fascia superficiel (MFS). La MFS était continue avec la GFS. Dans les favoris, la MFS adhérait étroitement au fascia de la parotide. Les forces nécessaires pour déplacer la peau sus-jacente de 2 mm en tirant sur la MFS ($10,27 \pm 3,64$ N) étaient plus de deux fois plus élevées (217 %) que celles nécessaires pour tirer la GFS ($4,73 \pm 2,15$ N; $P < 0,001$). Les forces nécessaires pour tirer la MFS et la GFS afin de déplacer la peau sus-jacente de 2 mm étaient considérablement plus élevées dans la région des favoris ($11,56 \pm 3,37$ N et $5,52 \pm 2,08$ N, respectivement) que dans celle des joues ($8,97 \pm 3,43$ N et $5,52 \pm 2,08$ N, respectivement) ($P < 0,001$). **Conclusions :** Lorsque le FS est soulevé dans la région des favoris ou des joues, il faut moins de tension pour soulever la GFS que la MFS pour tendre la peau sus-jacente. Dans la région des joues, il faut moins de tension pour déplacer la couche de peau supérieure que dans la région des favoris.

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Introduction

The traditional superficial musculoaponeurotic system (superficial fascia [SF]; SMAS) technique involves separating the skin from the SMAS.¹ However, unlike in Caucasian faces, these techniques do not adequately lift the thick aged skin and soft tissue in Asians. In the literature, English people have been reported to have thicker thigh skin than Chinese.²

In our previous paper, in the cheek, horizontal fibrous connective tissues connected with the zygomaticus major were seen as a continuous membrane (membranous layer of superficial fascia [MSF]). The MSF divided the SF into the superficial fatty layer of superficial fascia (SFS) and the deep fatty layer of superficial fascia (DFS; Figure 1).³ The aim of this study was to characterize the histology of the sideburn and cheek area and to measure the force required to pull the SF of Asians in facelifts.

Materials and Methods

Histology of the Sideburn and Cheek Area

A hemiface of a formalin-fixed Korean male adult cadaver (77.2 years) was used. Two full-thickness specimens were harvested from the sideburn and cheek area. A rectangle measuring 0.6×3.0 cm was harvested at the upper border of the zygomatic arch 0.5 cm anterior to the tragus (sideburn). Another rectangle measuring 0.6×3.0 cm was harvested from the anterior border of the sideburn superior to the zygomatic arch (cheek; Figure 2).

The specimens were removed from the underlying bone, fixed in 10% neutral buffered formalin, and embedded in paraffin. One vertical section and 1 horizontal section were made. Ten-micrometer sections were stained with Masson trichrome and observed under a light microscope.

Measuring the Traction Force

From October 2014 to September 2015, the force required to improve the nasolabial fold was measured in 42 patients during facelift procedures (age range: 36-67 years; 41 females and 1 male). A silk string (surgical suture, non-absorbable 100% silk, No. 3; Won Industry, Siheung, Korea) was passed below the periosteum with a 3-mm bite using a No. 1 rounded tip needle (IRI Co, Busan, Korea), the string was wound, and a 3-cm loop was then made and pulled away using a tensiometer (Basic Force Gauge [BFG] 200 N; Mecmecin Co, Sinfold, United Kingdom). The force needed to improve the nasolabial fold was measured.

Two incisions were made in the sideburn area. A horizontal fusiform incision 1 cm in length and 1 to 3 mm in width was made at the upper border of the zygomatic arch 0.5 cm anterior to the tragus. Another vertical fusiform incision was made at

the anterior border of the sideburn, 5 mm superior to the zygomatic arch. Through the horizontal incision, a sling was made by biting the SFS, and another sling biting the MSF was pulled inward 20° to 30° (Figure 3). Through the vertical incision, a sling was made by biting the SFS, and another sling biting the MSF was pulled inward 45° to 60° .³

The force needed to pull the overlying skin at the midpoint between the sideburn and nasolabial fold 2 mm was measured (Figure 4). While pulling the loop with tensiometer, a scale was placed and the force needed to pull the overlying 2 mm of skin movement was measured. Forces were measured twice, and the average values were recorded.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

Results

Histology of the Sideburn and Cheek Area

Cheek: *Upper border of the zygomatic arch anterior to the tragus.* The SFS was found to maintain its thickness throughout the region between the dermis and the MSF and to contain a vertically oriented septated structure composed of dense collagen. The MSF was continuous with the Superficial temporal fascia (STF). The DFS was located below the MSF and above the muscle investing the fascia (Figure 5, top).

Sideburn: *Anterior border of the sideburn superior to the zygomatic arch.* The SFS was found to maintain its thickness throughout the region between the dermis and the MSF. The MSF and parotid fascia closely adhered to each other. The DFS was inconspicuous (Figure 5, bottom).

Traction Forces

The force required when pulling the MSF of the upper cheek to move the overlying skin 2 mm was 11.16 ± 3.59 N on the right side and 11.70 ± 3.56 N on the left side. No significant difference was found between the right and left sides ($P = .889$ [independent 2-sample t test]).

The force required when pulling the SFS on the upper cheek to move the overlying skin 2 mm was 5.50 ± 2.35 N on the right side and 5.54 ± 1.78 N on the left side. No significant difference was found between the right and left sides ($P = .079$ [independent 2-sample t test]).

The force required when pulling the MSF on the lower cheek to move the overlying skin 2 mm was 8.43 ± 3.40 N on the right side and 9.51 ± 3.40 N on the left side. The force needed on the left side was significantly greater than on the right side ($P = .006$ [independent 2-sample t test]; Table 1).

Figure 1. Gross specimen, histology, and MRI of a human cheek at intertragic notch level. The SF was observed at the parotid and cheek area. Superficial fascia was located from the dermis to just superficial to the P and M. In the cheek, both histology and MRI showed horizontal fibrous connective tissues which were connected with the Z, visualized as a continuous membrane (MSF). The MSF divided the SF into the SFS and DFS. Reproduced with permission from *Aesthetic Plast Surg.* Adapted from Figure 2 of *Aesthetic Plast Surg.* 2016;40:566-577. DFS indicates deep fatty layer of the superficial fascia; M, masseter muscle; MRI, magnetic resonance imaging; MSF, membranous layer of the superficial fascia; P, parotid gland; SFS, superficial fatty layer of the superficial fascia; SF, superficial fascia; Z, zygomaticus major muscle.

The force required when pulling the SFS on the lower cheek to move the overlying skin 2 mm was 4.05 ± 1.79 N on the right side and 3.82 ± 2.04 N on the left side. No significant difference was found between the right and left sides ($P = .258$ [independent 2-sample t test]).

Figure 2. Two full-thickness specimens were harvested from the sideburn (S, at the upper border of the zygomatic arch anterior to the tragus) and cheek (C, anterior border of the sideburn superior to the zygomatic arch).

Figure 3. Biting the SFS (green layer, bitten by red thread), and another sling biting the MSF (grey layer, bitten by black thread). MSF indicates, membranous layer of the superficial fascia; SFS, superficial fatty layer of the superficial fascia.

Overall, the force required when pulling the MSF (10.27 ± 3.64 N) to move the overlying skin 2 mm was more than twice as great (217%) than was necessary when pulling the SFS

Figure 4. The force needed to pull 2 mm of overlying skin at the sideburn area was measured.

Figure 5. Histology of the cheek and sideburn areas (top, cheek; bottom, sideburn). DFS indicates deep fatty layer of the superficial fascia; MSF, membranous layer of the superficial fascia; P, parotid gland; SFS, superficial fatty layer of the superficial fascia.

(4.73 ± 2.15 N; $P < .001$ [independent 2-sample t test]; Figure 6). In the sideburn area, the force required when pulling the MSF (11.56 ± 3.37 N) to move the overlying skin 2 mm was significantly greater than was required for the SFS

Table 1. Forces Needed to Pull the Overlying Skin 2 mm.

Point	Side	Force Required When Pulling (N)		P Value
		SFS	MSF	
Sideburn	Right	5.50 ± 2.35	11.16 ± 3.59	$<.001$
	Left	5.54 ± 1.78	11.70 ± 3.56	$<.001$
	Subtotal	5.52 ± 2.08	11.56 ± 3.37	$<.001$
Cheek	Right	4.05 ± 1.79	8.43 ± 3.40	$<.001$
	Left	3.82 ± 2.04	9.51 ± 3.40	$<.001$
	Subtotal	3.94 ± 1.91	8.97 ± 3.43	$<.001$
Total		4.73 ± 2.15	10.27 ± 3.64	$<.001$

Abbreviations: MSF, membranous layer of the superficial fascia; SFS, superficial fatty layer of the superficial fascia.

Figure 6. The force needed to pull the overlying skin 2 mm for SFS and MSF. MSF indicates membranous layer of the superficial fascia; SFS, superficial fatty layer of the superficial fascia.

(5.52 ± 2.08 N; $P < .001$ [independent 2-sample t test]). In the cheek area, the force required when pulling the MSF (8.97 ± 3.43 N) to move the overlying skin 2 mm was also significantly greater than was required for the SFS (3.94 ± 1.91 N; $P < .001$ [independent 2-sample t test]; Figure 7).

The force required when pulling the MSF (11.56 ± 3.37 N) to move the overlying skin 2 mm was significantly greater in the sideburn area than in the cheek area (8.97 ± 3.43 N; $P < .001$ [independent 2-sample t test]). The force required when pulling the SFS (5.52 ± 2.08 N) to move the overlying skin 2 mm was greater in the sideburn area than in the cheek area (3.94 ± 1.91 N; $P < .001$ [independent 2-sample t test]; Figure 8).

Discussion

Gray's anatomy defined "Superficial fascia is found immediately beneath the integument over almost the entire surface of the body. It connects the skin with the deep or aponeurotic fascia, and consists of fibro-areolar tissue, containing in its meshes pellicles of fat in varying quantity."^{4(p. 269)} Skoog wrote

Figure 7. The force needed to pull the overlying skin 2 mm for each layer in cheek and sideburn area. MSF indicates membranous layer of the superficial fascia; SFS, superficial fatty layer of the superficial fascia.

Figure 8. Comparison of the force needed to pull the overlying skin 2 mm in the cheek and sideburn areas.

that the superficial, or subcutaneous, fascia is fixed to the dense, deep fascia by fibrous adhesions in the temporal, preauricular, and the parotid area.⁵

Nakajima who investigated subcutaneous adipofascial tissue over the entire body said the subcutaneous adipofascial tissue was made up of 2 adipofascial layers. The superficial layer (protective adipofascial system) is formed by the solid structure because it protects against external forces. The deep layer (lubricant adipofascial system) is a mobile structure which lubricates musculoskeletal movement.⁶ According to Macchi, in parotid, zygomatic, nasolabial fold, and buccal regions, 2 different fibroadipose connective layers were bounded to the laminar connective tissue layer (SMAS). The superficial fibroadipose layer, vertically oriented fibrous septa, connected the dermis with the superficial aspect of the SMAS. Deep fibroadipose connective layer, obliquely oriented fibrous septa, connected the deep aspect of the SMAS to the

Table 2. Nomenclature of Each Layer of the Superficial Fascia.

Author (Year)	Superficial Layer	Membranous Layer	Deep Layer
Gray (1901) ⁴	Superficial fascia		
Skoog (1974) ⁵	Superficial, or subcutaneous, fascia		
Nakajima et al (2004) ⁶	Protective adipofascial system (PAFS)	Superficial fascia	Lubricant adipofascial system (LAFS)
Macchi et al (2010) ⁷	Superficial adipose tissue (SAT)	Superficial fascia	Deep adipose tissue (DAT)
Hwang et al (2016) ^{2,3}	Superficial fatty layer of superficial fascia (SFS)	Membranous layer of superficial fascia (MSF)	Deep fatty layer of superficial fascia (DFS)

parotid-masseteric fascia.⁷ In our previous paper (2016), in the cheek, horizontal fibrous connective tissues, which were connected with the zygomaticus major, were seen as a continuous membrane (MSF). The MSF divided the SF into the SFS and the DFS³ (Table 2).

In the cheek, the SFS was found to maintain its thickness throughout the region between the dermis and the MSF. The MSF was continuous with the STF. In the sideburn, the MSF and parotid fascia closely adhered to each other, and the DFS was inconspicuous (Figure 5).

Our findings concord well with those of our previous paper and with those of Macchi, who reported that just in front of the ear, the SMAS and the underlying parotid gland fascia were tightly adherent and that little movement therefore occurred between the 2 structures.^{3,7} To determine the effectiveness of power transmission among the layers of the soft tissue in the facelift procedure, we measured the tension required to lift the SFS and the MSF layer with a force gauge. The force needed to pull the overlying skin at the midpoint from the sideburn to the nasolabial fold 2 mm was measured (Figure 4).

It is noticeable that the force required when pulling the MSF (10.27 ± 3.64 N) to move the overlying skin 2 mm was more than twice as great (217%) than was required for the SFS (4.73 ± 2.15 N; $P < .001$). This is thought to have occurred because the SFS is more proximal than the MSF to the dermis, which enables the force to be transmitted more easily.

It is well known that the SMAS overlying the parotid is relatively immobile compared to the SMAS in the cheek.⁸⁻¹¹ We could not find any publication that has compared this between Asian and Caucasians before. In this article, we compared the forces required pulling the MSF and SFS to move the overlying skin in sideburn area (parotid area) and anterior cheek and found that significantly greater force is needed in the sideburn area (11.56 ± 3.37 N and 5.52 ± 2.08 N, respectively) than in the cheek area (8.97 ± 3.43 N and 3.94 ± 1.91 N, respectively; $P < .001$). These results show that in Asians,

like Caucasians, SMAS overlying the parotid is relatively immobile than cheek.

We suggest that the reason for this is that the MSF and parotid fascia adhere closely in the sideburn area. When lifting the SF at the cheek or sideburn area, lifting the SFS requires less tension than MSF to move the overlying skin. In the cheek area, less tension is needed to move the overlying skin than in the sideburn area.

Declaration of Conflicting Interests

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