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A novel histologic description of the fibrous networks in the lid-cheek junction and infraorbital region

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Abstract: The aim of this study was to identify the anatomical feature of retaining ligament and fat compartment on the lower eyelid and infraorbital region using a histological method, and to investigate clear definitions for them which could be used generally in the clinical area. Eighteen specimens from eight fresh Korean cadavers were stained with Masson trichrome or hematoxylin and eosin. The ligamentous and fascial fibrous tissue were clearly identified. The ligamentous fibrous tissue which traversed in the superficial and deep fat layer was skin ligament and orbicularis retaining ligament (ORL). The fascial fibrous tissue enclosed the orbicularis oculi muscle (OOc) and circumferencial adipose tissue. Based on the ligamentous and fascial structure, three fat compartments, septal, suborbicularis oculi and infraorbital fat compartment, could be identified. The OOc attached to orbital rim and dermis by ORL and skin ligament, and the muscle fascicle and fat fascicle provided the connection point to the ORL and skin ligament as enclosing all muscle and fat tissue. The combination of the force made by the skin ligament in the lower eyelid and ORL may decide the level and form of the infraorbital grooves.

Key words: Orbicularis retaining ligament, Infraorbital fat compartment, Facial ligament

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Introduction

Due to a growing interest in the facial rejuvenation, studies about the etiology of aging signs based on the facial anatomy have been actively conducted during the past few decades. The retaining ligaments and fat compartments are the representative findings from the previous anatomical and clinical studies. It is well known that the structural imbalance between the tethering effect of retaining ligament and the volumetric change of the fat compartment appears as various aging signs such as nasojugal groove [1-3].

The retaining ligament firstly documented in the previous publication was described as a strong aponeurotic condensation which connects the skin and bone directly [4]. While the ligamentous structure exists in all skin, it has been regarded as a supporting structure especially in the facial skin due to the tiny dimension of the facial structure [5]. Thus, the manipulation of the retaining ligament became important in plastic surgery such as face lifting, and many knowledge of retaining ligament has been accumulated in the last century.

The concept of fat compartment appeared more recently

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than that of retaining ligament. The fat compartment has received a lot attention since the study of the Lambros [6]. He suggested that the fibrous network of the face is actually relatively immobile and the deflation of certain fat pads cause the changing morphology of the face [6].

However, as the knowledge of retaining ligament and fat compartment has been accumulated, the definition of them has become more confused. The meaning of retaining ligament increasingly expanded from aponeurotic condensation to all fascicular twigs. Thus there are numerous terminology (ex. skin ligament) and classification of the retaining ligament [2, 5, 7]. Also, the expanded concept of retaining ligament affected to the fat compartment because the concept of the fat compartment was based on the fascial condensation that travels from superficial fascia to dermis [6, 8, 9].

The confusion of the concepts originates from which the retaining ligament and fat compartment are not easily distinguishable to the naked eye and differentiation of them mainly relies on the sensation during surgical treatment. While there were some histological studies to identify these structures, it was not enough to define it clearly. Therefore, the concepts of them have been illustrated which results in the different illustration among papers and textbooks [3, 10, 11].

The infraorbital region appears various aging signs, so a huge amount of information about the orbicularis retaining ligament (ORL) and infraorbital fat compartments has been reported up to the present [3, 9, 10, 12-15]. Thus, we aimed to identify the anatomical feature of retaining ligament and fat compartment on the lid-cheek junction and infraorbital region using a histological method, and to investigate clear definitions for them which could be used generally in the clinical area.

Materials and Methods

Eighteen specimens from eight fresh Korean cadavers were used in the tissue staining. Two of the cadavers had prominent baggy lower lids and six did not. Four of the cadavers were male, and four were female. The mean age was 75.5 years (range, 58–85 years).

Full thickness specimens with a bony structure were obtained by amputating the anterior wall of the zygoma and maxilla, and the base of the orbit. The boundaries of the specimens were lower eyelid (superior), medial canthus (medial), lateral canthus (lateral), and alare of nose (inferior) (Fig. 1A). Immediately after acquiring the specimens, the sectional planes of the specimens were scanned and saved as JPEG images (Epson Perfection V33; Epson) (Fig. 1B). Afterwards, the specimens were stained with Masson trichrome or hematoxylin and eosin. The specimens were embedded in the plastic resin, and the sagittal section of the specimens was sliced with a diamond saw (Exakt; Leica). A histologic examination was conducted by using a microscope with a digital camera (DFC300 FX; Leica). Finally, the entire image of the specimen was acquired by stitching together partial images of the specimen (Fig. 1C). For more accurate observation of the fibrous structure, the color of original image was inverted by the photo editing program (Adobe Photoshop V13.0; Adobe) (Fig. 1D).

Ethics statement

This study was conducted in compliance with the principles set forth in the Declaration of Helsinki. Consent was received from the families of the deceased patients before beginning the dissections.

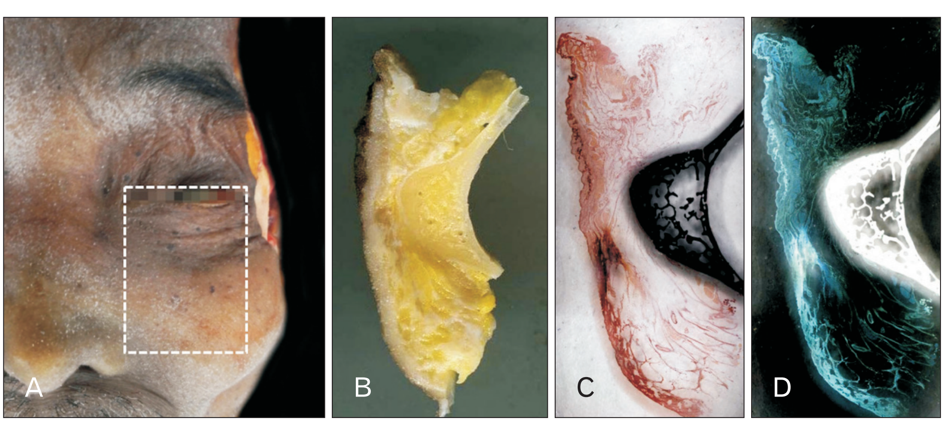

Fig. 1. Full thickness specimens with a bony structure. (A) The boundaries of the specimens were lower eyelid (superior), medial canthus (medial), lateral canthus (lateral), and alare of nose (inferior). (B) The sectional planes of the specimens were scanned. (C) The specimens were stained with Masson trichrome or hematoxylin and eosin. (D) The color of original image was inverted by the photo editing program.

Results

The layers of the facial skin were distinctly observed in all of the stained specimens: skin, superficial fat, orbicularis oculi muscle (OOc), deep fat, and periosteum (Fig. 2A). The superficial and deep fat layer was composed of fibrous tissue and adipose tissue (Fig. 2A, blue star), and there were two types of the fibrous tissue: ligamentous (Fig. 2A, red arrowhead) and fascial fibrous tissue (Fig. 2A, green arrowhead).

The ligamentous fibrous tissue traversed in the superficial and deep fat layer. However, the pattern of them was different between superficial and deep fat layer. While the ligamentous fibrous tissue in the superficial fat layer was observed thoroughly (Fig. 2B), that in the deep fat was observed near the orbital rim (Fig. 2C, black arrowheads). The latter was obviously ORL which attached deep aspect of the OOc to the periosteum of the orbital rim, thus the former was named skin ligament (livedo retinacularis cutis) which attach the OOc to dermis. The ORL bundled the deep aspect of the OOc, and the OOc of the attachment site was observed to be tugged inwards. The number of ORL strands and the tugged site of the OOc were equivalent (Fig. 2C) [16].

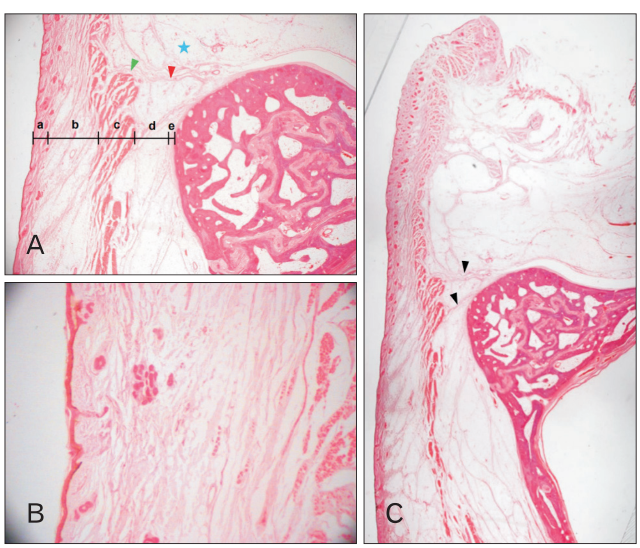

Fig. 2. The histological features of the infraorbital specimen (H&E staining, 8×). The superficial and deep fat layer was composed of fibrous tissue and adipose tissue (blue star), and there were two types of the fibrous tissue: ligamentous (red arrowhead) and fascial fibrous tissue (green arrowhead). (A) The layers of the facial skin: (a) skin, (b) superficial fat, (c) orbicularis oculi muscle (OOc), (d) deep fat, and (e) periosteum. (B) The skin ligament was observed thoroughly in the superficial fat layer. (C) The orbicularis retaining ligament (ORL, black arrowheads) bundled the deep aspect of the OOc, and the OOc of the attachment site was observed to be tugged inwards. The number of ORL strands and the tugged site of the OOc were equivalent (Fig. 2C). Adapted from Clinical anatomy of the face for filler and botulinum toxin injection. Springer, 2016, with permission [16].

The fascial fibrous tissue enclosed the OOc and circumferencial adipose tissue. The fascial fibrous tissue of OOc followed the general fascicular system which was composed of endomysium, perimysium and epimysim. The fascicular system was also found the fascial fibrous tissue which enclosed the adipose tissue in superficial and deep fat layer. Many adipose cells constituted a fat unit, and a few fat units constituted again the fat compartment, such as inferior orbital fat and the sub orbicularis oculi fat (SOOF). Thus, the fascicle that enclosed an adipose cell, a fat unit, and a fat compartment were named the endoadiposium, the peiadiposium, and the epiadiposium respectively (Fig. 3).

Based on the ligamentous and fascial structure, three fat compartments could be identified: septal, suborbicularis oculi and infraorbital fat compartment (Fig. 4). The septal fat compartment which located superior to the ORL and deep to the OOc had distinct epiaiposium relative to other fat compartment. The suborbicularis oculi fat compartment which located in the prezygomatic space [13] had longitudinal fat unit relative septal fat compartment. The infraorbital fat compartment which located inferior to lower eyelid and superficial to OOc had a relatively small fat unit.

There were some histological features in the specimens appearing baggy lower lid (Fig. 5). First, septal fat compartment protruded anteriorly as the deep fatty layer thickened,

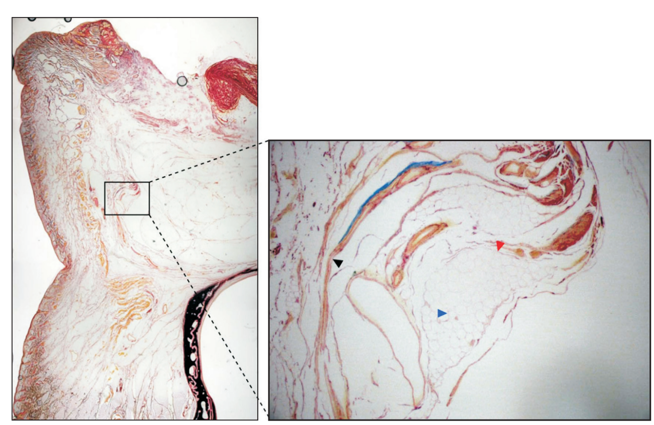

Fig. 3. The fascicular system of the fat tissue. Many adipose cells constituted a fat unit, and a few fat units constituted again the fat compartment, such as inferior orbital fat and the sub orbicularis oculi fat. The fascicle encircles an adipose cell, a fat unit, and the fat compartment could be named the endoadiposium (blue arrowhead), peiadiposium (red arrowhead), and epiadiposium (black arrowhead), respectively.

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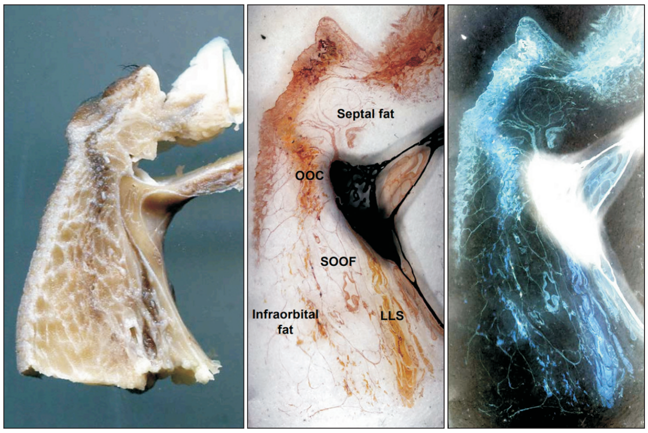

Fig. 4. Three fat compartments in the infraorbital area: septal, suborbicularis oculi and infraorbital fat compartment. OOc, orbicularis oculi muscle; SOOF, sub orbicularis oculi fat; LLS, levator labii superioris.

Fig. 5. Various number of the orbicularis retaining ligament (ORL, arrowheads). The number of ORL different among specimens, actually, it was impossible to count the number of ORL because it was condensed fibrous structure. OOc, orbicularis oculi muscle.

and the more-inwardly tugged OOc compensated for the increased space. In other words, while there was no difference in the length of the ORL, the OOc was tugged considerably more inwards. Second, the level of the groove was not the same with the level of ORL but rather equivalent to the level of the orbital rim or the inferior border of the septal fat compartment. Third, the superficial fatty layer as well as the deep fatty layer was thickened. In other words, the laxity of skin ligament was increased.

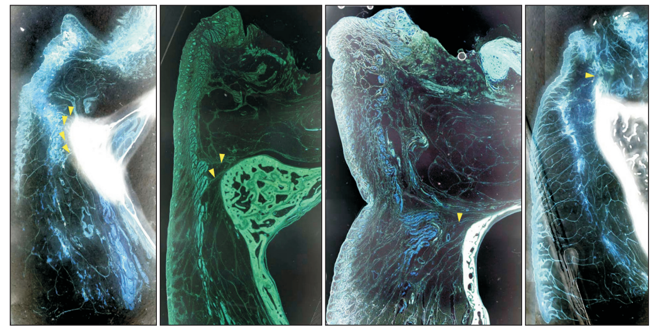

Fig. 6. The histologic features of the infraorbital skin showing baggy lower lid. The septal fat compartment protruded anteriorly as the deep fatty layer thickened, and the more-inwardly tugged orbicularis oculi muscle (OOc) compensated for the increased space. In other words, while there was no difference in the length of the orbicularis retaining ligament (ORL, yellow arrowheads), the OOc was tugged considerably more inwards. And, the level of the groove was not the same with the level of ORL but rather equivalent to the level of the orbital rim or the inferior border of the septal fat compartment. Also, the superficial fatty layer as well as the deep fatty layer was thickened. In other words, the laxity of skin ligament was increased.

Discussion

Stuzin described the structure of face as six layers: skin, subcutaneous fat, superficial fascia, mimetic muscle, deep fascia (parotidomasseteric fascia), plane (containing the facial nerve, parotid duct, and buccal fat pad) [2]. And the 5th and 6th layer of the Stuzin's classification varied according to the basements of the facial structure [17]. According to the present study, the layer of infraorbital area considerably corresponded with Stuzin's description. However, the superficial and deep fascia of OOc seems an extension of the fascicular system from dermis and periosteum because it was too weak to be regarded as a layer. Therefore, the infraorbital area was described as being composed of 5 layers in this study; skin, superficial fat, mimetic muscle (OOc), deep fat, basement (periosteum).

In this study, we classified the fibrous tissue into ligamentous and fascial fibrous tissue, and defined all fibrous structures: skin ligament, retaining ligament (ORL), muscle fascicle, and fat fascicle. These structures were all connected with a fibrous network and constituted a whole architecture of the infraorbital area. The OOc attached to orbital rim and dermis by ORL and skin ligament, and the muscle fascicle and fat fascicle provided the connection point to the ORL and skin ligament as enclosing all muscle and fat tissue. These findings of the ORL considerably corresponded with previous knowledge of ORL. However, the number of ORL was different among specimens, actually, it was impossible to count the number of ORL because it was condensed fibrous structure although Wong et al. [3] described that the ORL was bilayered structure (Fig. 6).

The histological findings in this study supported that the immobility of ORL and relative deflation of fat compartments causes aging signs. Based on this concept, releasing the ORL [1, 11, 18-22] and repositioning of the septal fat [23, 24] become the basic principle for correcting various aging signs on the infraorbital area. However, it could not explain the level difference between the groove and the ORL, shown in Fig. 5. So, we focused on the skin ligament observed in the lower eyelid. While the tethering force of the skin ligament in the lower eyelid seems week compared to that of the ORL, the short and wide distribution of skin ligament seem to fulfill strong tethering effect on the septal fat protrusion. The combination of the force made by the skin ligament in the lower eyelid and ORL may decide the level and form of the infraorbital grooves.

We described three fat compartments based on the ligamentous and fascicular structure. And the histological feature of septal fat and SOOF was clearly identified. However, the zygomatic ligament which known as the lower boundary of the prezygomatic space was not observed clearly like ORL [13]. And the lower boundary of the infraorbital fat compartment was not also investigated. Therefore, we expect that more study about these structures could be performed with malar region.

In this study, we defined the fibrous structures which support infraorbital architecture. We believe these finding will be helpful during various cosmetic treatments and contribute to the development of facial clinical anatomy.

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Author Contributions

Conceptualization: KHY. Data acquisition: JHB, YJC. Data analysis or interpretation: YCG, KSH. Drafting of the manuscript: KHY, SHL. Critical revision of the manuscript: KHY. Approval of the final version of the manuscript: all authors.

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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