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Anatomy of lower eyelid and eyelid—cheek junction

Anatomie de la paupière inférieure et de la jonction palpébrojugale

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KEYWORDS
Lower eyelid;
Facial fat compartments;
Aging;
Subcutaneous fat;
Soft tissue fillers;
Eyelid anatomy

Summary
Background. — Understanding the anatomy of the lower eyelid and the lid—cheek junction is important for surgical and non-surgical approaches. It is important to understand the correlation between the clinical presentation and the individual anatomy to direct an adequate treatment.
Methods. — A review of the literature based on the authors experience combined with anatomical dissections was conducted to reveal the current concepts of the surgical and non-surgical anatomy. The various anatomical structures important for the understanding of the symptoms and the proposed treatment are described in this article.
Results. — The anatomy of the lower eyelid and the lid—cheek junction has to be understood as a unit. Structures are continuous from the eyelid to the cheek influencing each other during aging. The concept of superficial, i.e. superficial to the orbicularis oculi muscle and deep facial fat compartments, i.e. deep to the orbicularis oculi muscle has to be applied in order to understand the relevant anatomy regarding the ligaments, fat compartments, muscular and tarsal structures and the vascularization.
Conclusion. — The understanding of the layered arrangement of the lower eyelid and eyelid-cheek junction anatomy enables practitioners to perform safe and effective surgical and non-surgical procedures.

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MOTS CLÉS
Paupière inférieure ;
Compartiments de graisse faciale ;
Vieillissement ;
Graisse sous-cutanée ;
Remplisseurs de tissu mou

Résumé
Introduction. — La compréhension de l'anatomie de la paupière inférieure et de la jonction palpébrojugale est importante pour les approches chirurgicales et non chirurgicales. Il est important de faire la corrélation entre la sémiologie, très variable selon l'individu et la structure anatomique pour proposer un traitement adéquat. Nous présentons ici les structures anatomiques présentées dans la littérature ainsi que des travaux originaux de dissection.
Matériel et méthodes. — Une revue de la littérature centrée sur les travaux de dissections anatomiques a été menée afin de révéler les concepts actuels de l'anatomie chirurgicale et non chirurgicale. Les différentes structures anatomiques importantes pour la compréhension des symptômes et le traitement proposé sont décrites dans cet article.
Résultats. — L'anatomie de la paupière inférieure et de la jonction palpébrojugale doit être comprise comme une unité. Les structures sont en continuité entre la joue et la paupière et sont fortement influencées par le vieillissement. Le concept de compartiment superficiel, c'est-à-dire superficiel au muscle orbiculaire-oculi et compartiments profonds, c'est-à-dire profondément au muscle orbiculaire, sera décrit ainsi que l'anatomie pertinente concernant les ligaments, les compartiments graisseux, les structures musculaire et tarsienne ainsi que la vascularisation.
Conclusion. — La connaissance et le respect de l'agencement de l'anatomie du visage en structures anatomiques indépendantes permet aux praticiens d'effectuer des procédures chirurgicales et non chirurgicales sûres et efficaces.

Introduction

Fighting the signs of facial aging using surgical or non-surgical approaches has become a popular and widely accepted method in today's society. As the eyes are the central component of the face and the first aspect when focusing someone's face the appearance of the eyes and their surroundings are the key target of most interventions.

The surrounding structures of the eye influence likewise the appearance, i.e. ''the look'' of the eye and have to thus be treated with greatest care including the forehead, the position of the eyebrows, the wrinkles of the glabellar area and the upper and the lower eyelid.

The lower eyelid however is of great importance as therapeutic options influence the appearance of the upper cheek and the eyelid cheek junction and should thus be considered as a unit when treating this area. Different lower eyelid and tear trough deformities can occur depending on the anatomical disposition of underlying structures from lower eyelid hollowness or dark circle to tear trough depression with or without fat herniation and skin excess (Fig. 1a—e).

As the underlying anatomy cannot be separated between the eyelid and the lid—cheek junction, it will be described in the following as a unit to provide a comprehensive understanding of this delicate anatomical region.

Anatomy of the lower eyelid

The lower eyelid can be separated into an anterior lamella containing the skin and the preseptal and pretarsal parts of the orbicularis oculi muscle and into a posterior lamella containing the tarsus, the orbital septum, the inferior tarsal muscle and the capsulo-palpaebral fascia (Fig. 2).

Skin

The skin of the lower eyelid can be regarded as one of the thinnest in the human body measuring in mean 0.82 ± 0.21 mm [1]. In the lateral lower eyelid portion, a thin layer of subcutaneous fat can be observed, which is absent in the medial part of the lower eye lid, i.e. the tear trough. Here the eyelid skin overlying the orbicularis oculi muscle is almost translucent and some authors attribute the resulting Tyndall-effect as the cause for the blueish appearance of the tear trough, which can also be observed on the lateral nasal wall medially to this area (Figs. 3a, b). The skin overlying the upper cheek (malar fat pad) is thicker than the skin of the lower eyelid and a substantial amount of subcutaneous fate can be identified here. The difference between these two types of skin (eyelid versus upper cheek) accentuates the eyelid—cheek junction deformity. During aging, however, the subcutaneous fat is likewise absent in the lateral part of the lower eyelid which can increase the palpaebromalar groove deformity and lead to the impression of a sunken eye and a skeletonized face.

When inspecting the lower eye-lid and the lid—cheek junction three creases can be observed (Fig. 1a—e). The most superior is the inferior palpaebral crease which is in general covered by the lower lid lashes and is regarded as the location where the inferior margin of the tarsus meets with the retractor muscles. The other two creases are medially the nasojugal crease (also termed fold, sulcus or groove) which is located at the inferior end of the tear through and represents the location of the angular vein. Laterally, a sulcus is visible, representing the end of the orbit and the lower eye lid and the beginning of the zygomatic bone (also termed here malar bone) (Figs. 1a—e). Another term for this visible depression is orbitomalar groove (or hollow), palpaebromalar sulcus (or groove or depression) or simply eyelid—cheek junction. However, the correct anatomical term according to the *nomina anatomica* [2] is *Sulcus infrapalpaebralis* which was interestingly not adopted by the last facial nomenclature consensus paper published in 1993 by George et al. [3].

Orbicularis oculi muscle

The orbicularis oculi is a thin muscle consisting of concentrically arranged muscles fibres encircling the orbit and can

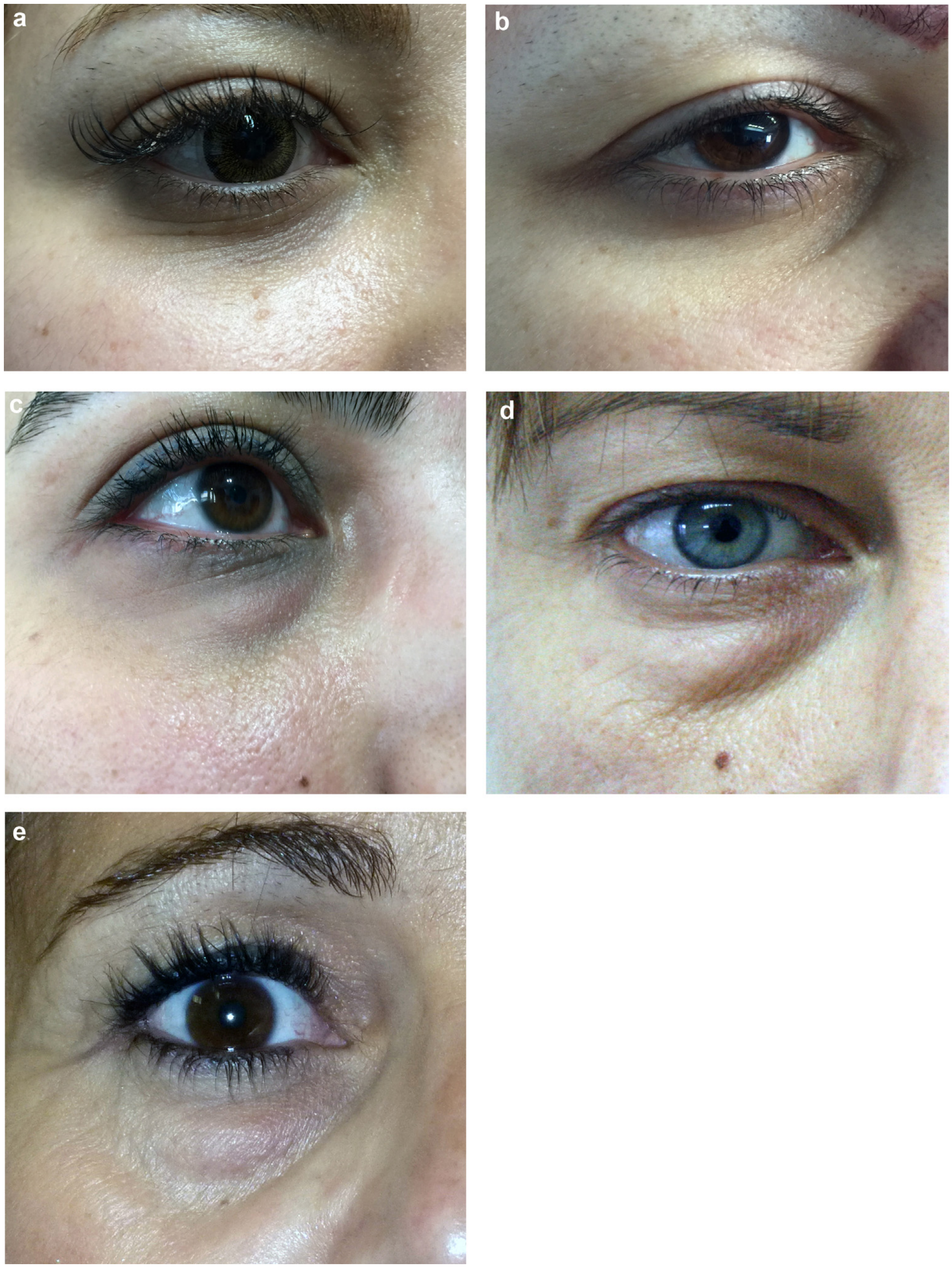

Figure 1 Presentation of different clinical cases: a: lower eyelid hollowness and ''dark circle''; b: prominent tear trough deformity (note: the deformity starts at the medial canthus and affects the medial 1/3 of the lower eyelid and eyelid-cheek junction); c: tear trough deformity, lower eyelid hollowness, intraorbital fat herniation and ''dark circle'' combined; d: tear trough deformity, intraorbital fat herniation and skin excess combined; e: total tear trough deformity, intraorbital fat herniation and skin excess combined.

be subdivided into 3 parts: orbital, preseptal and pretarsal (Fig. 2). The muscle is supplied by nerve fibers originating from the frontal, zygomatic and buccal branches of the facial nerve enabling the muscle to contract leading thus to various movements and functions. The muscle is attached to the anterior portion of the orbital aperture and some muscle fibers contain connective tissue fibers which intermingle with the periosteum of this area and form the orbicularis retaining ligament (Fig. 3b). In the tear trough area, the muscle is firmly attached to the bone where it forms the tear trough ligament (Fig. 4). Contraction of the orbital part of the muscle which is the part inferior/superior/medial/lateral to the orbital rim leads to forcible and voluntary eyelid closure, i.e. squeezing and winking, whereas contraction of the preseptal part, which spans from the orbital rim to the tarsal plate and medially to the posterior lacrimal crest (this part is called Jones muscle) leads to regular and voluntary eyelid closure, i.e. winking and blinking.

The preseptal part of the muscle overlies the tarsal plate and its contractions result in a horizontal movement of the eyelid and in the stabilization of the eyelid against the globe. This part of the muscle is attached with fibers to the anterior

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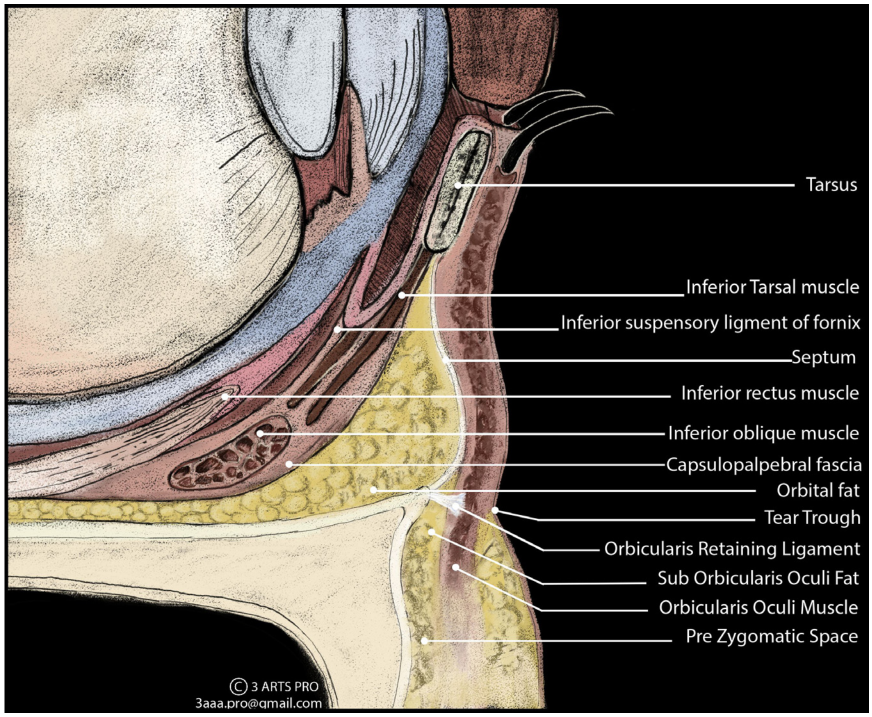

Figure 2 Schematic drawing of the right lower eyelid at the level of the mid-pupillary line (view from right side). Note that the projection of the superior aspect of the inferior orbital margin is located cranial to the skin representation of the tear trough. The latter can be accentuated by herniation of the intraorbital fat pads.

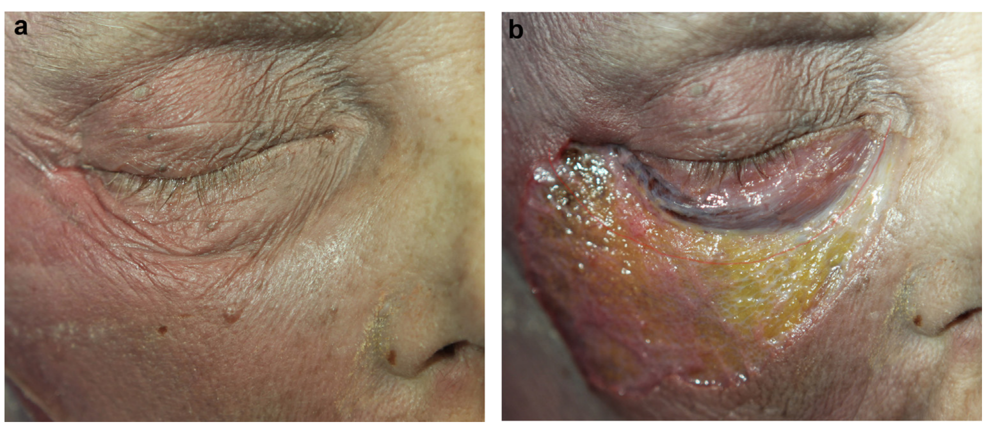

Figure 3 Anatomic dissection of a male cephalic specimen: a: undissected view revealing differences in skin quality, thickness and texture between eyelid and cheek skin; b: removal of skin reveals the absence of subcutaneous fat superficial to the pre-septal part of the orbicularis oculi muscle. In the orbital part of the muscle (red line) a substantial amount of subcutaneous fat can be identified. Here medial subcutaneous cheek fat (= malar fat pad).

and to the posterior lacrimal crest forming the lacrimal sack diaphragm together with the lacrimal sack fascia and the deep crus of the medial palpaebral/canthal ligament/tendon, with the posterior fibers being called tensor tarsi muscle of Horner. According to the Jones and Wobig theory, closure of the eyelid creates a negative pressure in the lacrimal sack due to the contractions of the Jones and the Horner muscles (absorbtion into the lacrimal sack) and creates additionally a medial ''peristaltic'' movement in the lacrimal canaliculi system which is directed medially towards the lacrimal sack due to contraction of the pretarsal part of the orbicularis oculi muscle.

Orbicularis retaining ligament

The orbicularis retaining ligament can be regarded as the pan-orbital connection between the orbicularis oculi muscle and the anterior aspect of the bony orbit both in the supra- and infraorbital area (Fig. 5). In the lateral part at the level of the mid-pupillary line a broad and firm connection between muscle and bone is detectable which is termed the lateral orbital thickening (Fig. 6) [4]. In the lateral aspect of the infraorbital portion, the orbicularis retaining ligament can be separated into two lamellae which fuse in the area of the tear trough into one single layered ligament [5]. There

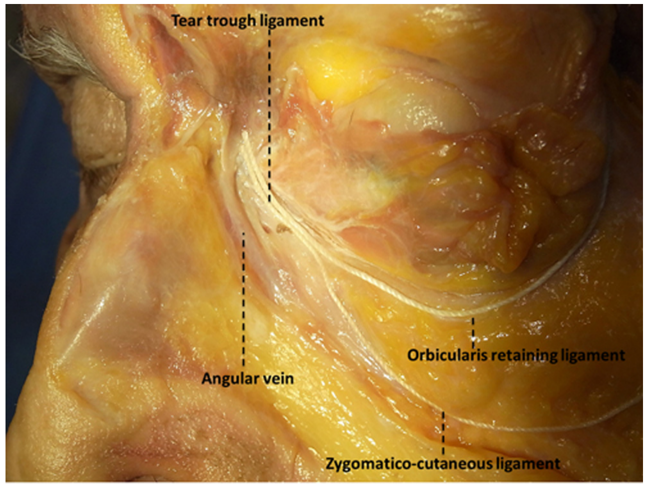

Figure 4 The orbicularis oculi muscle is fixed to the bone by the orbicularis retaining ligament. In the medial part, the muscle is firmly attached to the bone. This is the area of convergence of both orbicularis retaining ligament and zygomatico-cutaneous ligament. The angular vein lies inferior to the tear trough ligament at the level of the nasojugal groove. Between the nasojugal groove and the location of the tear trough ligament the tear trough deformity and the ''dark circles'' can be identified clinically.

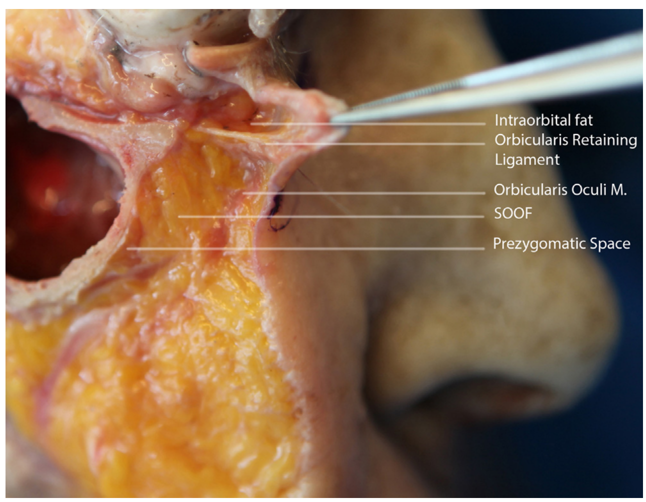

Figure 5 Section of a cephalic specimen at the level of the lateral margin of the eye globe. Lower eyelid and eyelid-cheek junction are shown.

the orbicularis-retaining ligament changes its name towards tear trough ligament before it inserts next to the medial canthal tendon (Fig. 7).

Orbital septum

Whilst the orbicularis retaining ligament can be understood to be attached to the anterior aspect of the orbit, the orbital septum lies in a perpendicular, i.e. cranio-caudal orientation emerging from upper aspect of the orbital rim forming a 90 degrees angle with it in young individuals (Figs. 2, 5, 7). During aging, which also includes processes of bone resorption, this 90 degrees angle can change between the points of origin of these two ligamentous structures facilitating the pseudo-prolapse of the intra-orbital fat pads.

The orbital septum is a thin sheet of fibrous connective tissue separating the intra-orbital from the extra-orbital structures which has great importance in the spread of infections and hematomas. The septum is thicker in the lateral part, i.e. lateral to the mid-pupillary line and thinner in the medial part. Before it attaches to the inferior margin of the tarsal plate, the orbital septum fuses with the inferior tarsal muscle and the capsulo-palpaebral fascia (Figs. 2, 5, 7). Medially the septum travels with the overlying preseptal part of the orbicularis oculi muscle and inserts majorly into the posterior lacrimal crest whereas laterally it inserts into the lateral orbital tubercle.

The tarsal apparatus

The tarsal plate together with the medial and the lateral canthal ligaments are crucial for maintaining the position and the function of the lower eyelid and can be thus termed as the tarsal apparatus. The inferior tarsal plate of the lower eyelid measures 4 to 5 mm in the mid-pupillary line in cranio-caudal orientation and has a convex curve following the

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Figure 6 Anatomic dissection of the right lower eyelid and eyelid-cheek junction. The lateral orbital thickening and the lateral (posterior) part of the orbicularis retaining ligament is the firm connection between the orbicularis oculi muscle and the lateral orbital rim. This adherence is located several millimeters lower than the orbital rim and gives a bony appearance of the lateral part of the eyelid.

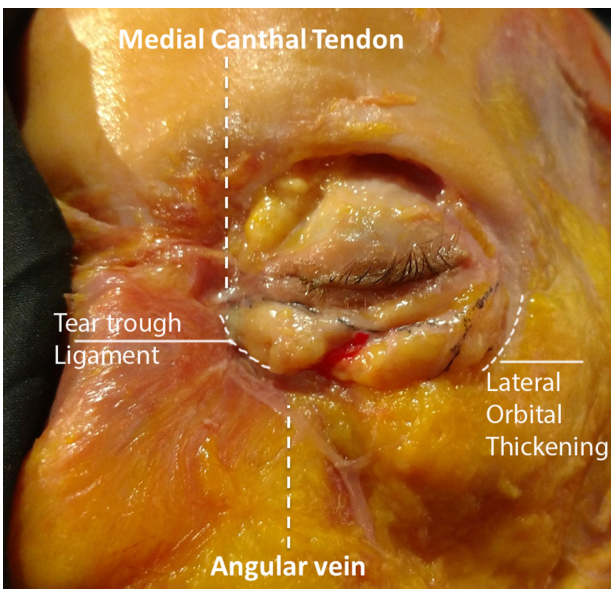

Figure 7 Anatomic dissection of the left peri-orbital region with removal of the orbicularis oculi muscle and the orbital septum. The tear trough ligament inserts in close proximity to the medial canthal ligament. Laterally the lateral orbital thickening and the lateral/inferior part of the orbicularis retaining ligament (dotted lines) is indicated.

Figure 8 Anatomic dissection of the right lower eyelid and the eyelid-cheek junction. The inferior tarsal plate is exposed after the orbicularis oculi muscle is removed.

curvature of the eyeball (Fig. 8). Inferiorly the attachment of the orbital septum and the lower eyelid retractors can be found, whereas in the superior margin oil-secreting meibomian glands can be identified in a vertical alignment. Their orifices are visible at the eyelid margin just posterior to the gray line and anterior to the mucocutaneous junction. The tarsal plates are covered posteriorly by conjunctiva and are anchored via the medial and the lateral canthal tendons to the medial and lateral bony aspects of the orbit.

The medial palpaebral/canthal ligament/tendon (MCT) is formed by the superior and the inferior crus of the upper and the lower eyelid tarsal plates and is located deep to the orbicularis oculi muscle and superficial to the conjunctiva (Fig. 7). The MCT inserts with 3 portions into the medial aspect of the orbit: the deep portion runs posterior to the canaliculi and is attached to the posterior lacrimal crest; the superficial portion lies superficial to the lacrimal sack and the canaliculi and attaches to the frontal process of the maxilla anterior and superior to the anterior lacrimal crest; the superior supporting portion arises anterior to the other portions and attaches to the orbital process of the frontal bone. Of those 3 portions provides the superficial portion the major support for the medial canthal angle.

The lateral palpaebral/canthal tendon (LCT) is formed in a similar fashion like the MCT by the crura of the upper and lower eyelid tarsal plate and insert into a bony aspect called the lateral orbital tubercle also called Whitnall's tubercle. The upper and lower eyelid pretarsal parts of the orbicularis oculi muscle attach to the LCT and the lateral horn of the levator aponeurosis fuses with its fibers. Together with the LCT, the lateral check ligament, fibers of the connective

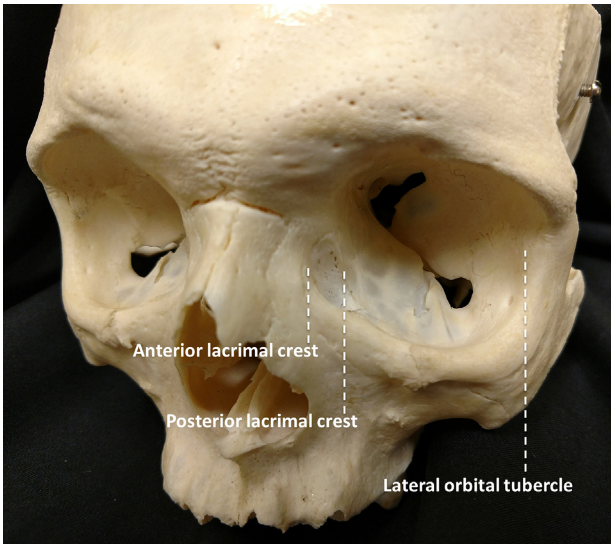

Figure 9 Image of the left bony orbit in view from superior and lateral.

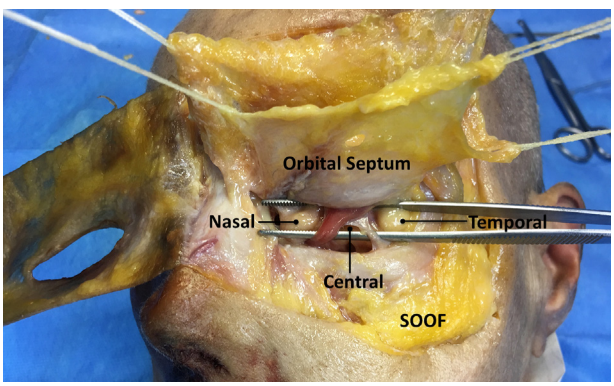

Figure 10 Anatomic dissection of the left infraorbital region with exposure of the intraorbital structures: The three intraorbital fat pads: nasal,central and temporal. The nasal fat pad is separated from the central fat pad by the inferior oblique muscle whereas the central fat pad is separated from the temporal fat pad by the arcuate expansion of the ligament of Lockwood.

tissue sheet of the rectus lateralis muscle and the both the suspensory ligaments of Lockwood and Whitnall attach in form of a broad insertion of about 10 mm to the lateral orbital tubercle (Fig. 9).

Intra-orbital fat pads posterior to the lower eyelid

Posterior to the orbital septum of the lower eyelid 3 intraorbital fat pads can be identified: nasal, central and temporal (Fig. 10). The nasal is separated from the central by the inferior oblique muscle, whereas the central is separated from the temporal by the arcuate expansion of the ligament of Lockwood, which forms the inferior suspension of the globe (Fig. 10) [6,7]. The fat appears to be more orange and more solid as compared to the extra-orbital fat and it has been shown that this fat can be classified as visceral white adipose tissue according to a recent summary [8].

Nerves of the lower eyelid

Sensory supply of the lower eyelid and the lid—cheek junction is provided medial to the lateral canthus by the infraorbital nerve a branch of the maxillary nerve (cranial nerve 5 [CN 5]), emerging from the infraorbital foramen located between the levator labii superioris and the levator anguli oris muscle. Lateral to the lateral canthus by the branches of the zygomaticofacial nerve (maxillary division of CN 5) and in smaller parts by the infraorbital nerve [9].

Motor supply to the orbicularis oculi muscle is provided by buccal, zygomatic and frontal branches of the facial nerve which is cranial nerve number 7 (CN 7). Motor supply to the lower eyelid retractors is provided by branches of the oculomotor nerve which is cranial nerve number 3 (CN 3) and enters the orbit via the superior orbital fissure after travelling the medial wall of the cavernous sinus.

Vessels of the lower eyelid and lid—cheek junction

Arteries

The major arteries providing arterial blood supply to this region are the facial, angular, infraorbital, zygomaticoorbital, transverse facial and the anterior branch of the superficial temporal artery (Fig. 11) [10]. All of these arteries are terminal branches of the external carotid artery and are subject to high variation. They run towards the lower eyelid and form the arterial plexus which is majorly represented by the inferior-medial palpebral and superior medial palpebral arteries (Fig. 12).

The palpaebral arteries however, receive blood also from branches of the internal carotid artery (Fig. 11). These anastomoses are formed by the lacrimal, dorsal nasal, anterior

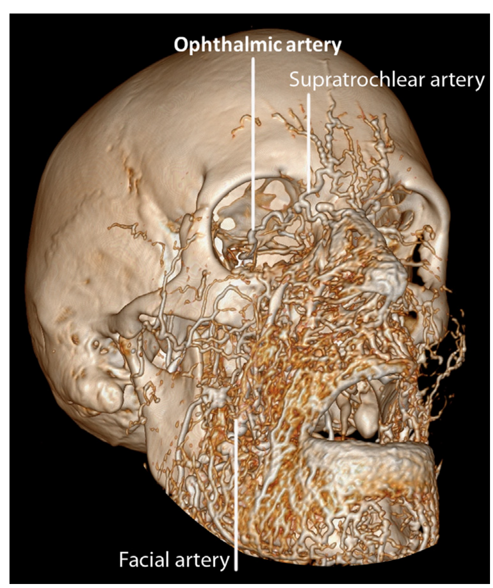

Figure 11 Contrast enhanced CT-angiography after application of contrast agent into the right facial artery. Note the density of the arterial network of the face and peri-orbital region with connections to the internal carotid artery system.

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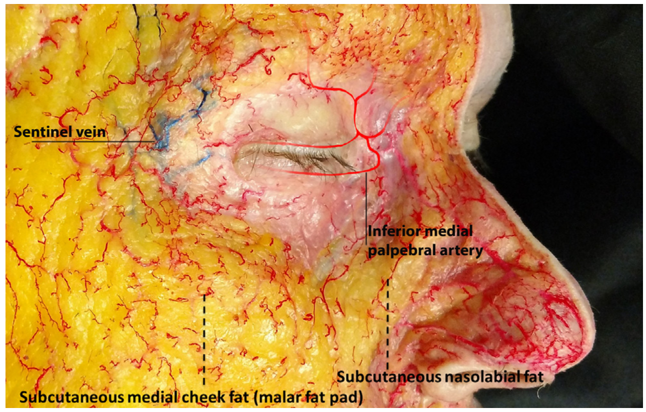

Figure 12 Anatomic dissection of the right peri-orbital regoin after injection of red dye into the common carotid artery. Note the dense peri-orbital and the palpaebral arterial network.

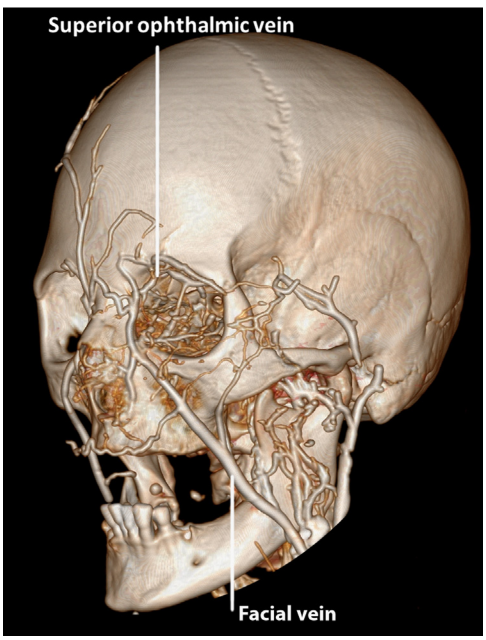

Figure 13 Contrast enhanced CT-angiography after application of contrast agent into the left facial vein. Note the connections to the temporal and intraorbital veins.

and posterior ethmoid arteries which are all together connected via the ophthalmic artery. In cases of internal carotid artery stenosis the blood flow is reversed and branches of the external carotid artery warrant cerebral perfusion via these anastomoses and ultimately by the ophthalmic artery.

Veins

Venous blood of the lower eyelid and lid—cheek junction is drained via the angular and lateral nasal vein towards the facial vein and via the superior and inferior ophthalmic vein into the cavernous sinus or into the pterygoid venous plexus. Other venous drainage pathways are central forehead, the sentinel and the superficial temporal veins. In the inferior-medial wall of the suborbicularis occuli fat (SOOF) the angular vein can be identified which runs superficial to the levator labii superioris muscle at the level of the nasojugal groove and in distance of 4 mm to the inferior orbital rim before it reaches the medial canthus (Figs. 5, 7, 13) [11].

Lymphatic system

The lymphatic system of the eyelids is divided into a superficial and a deep system. The superficial system drains the skin and the orbicularis oculi muscle, whereas the deep system drains the tarsal apparatus and the conjunctiva. Medial to the midpupillary line lymphatic drainage follows the submandibular nodes whereas laterally drainage occurs into the preauricular and deep parotid nodes.

Anatomy the lid—cheek junction

The appearance of the lid—cheek junction is less accentuated in younger individuals before the process of fat redistribution takes place [12—14]. Here a smooth transition from the structures of the lower eyelid to the cheek is given. Albeit separated by the orbicularis retaining ligament, the orbicularis oculi muscle extends into the cheek area and can

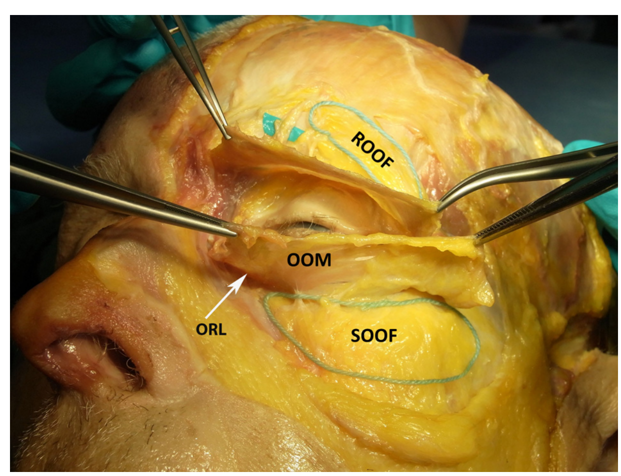

Figure 14 Anatomic dissection of the left peri-orbital area revealing the deep fat compartments, located deep to the orbicularis oculi muscle. SOOF: suborbicularis oculi fat; ROOF: retroorbicularis oculi fat; OOM: orbicularis oculi muscle.

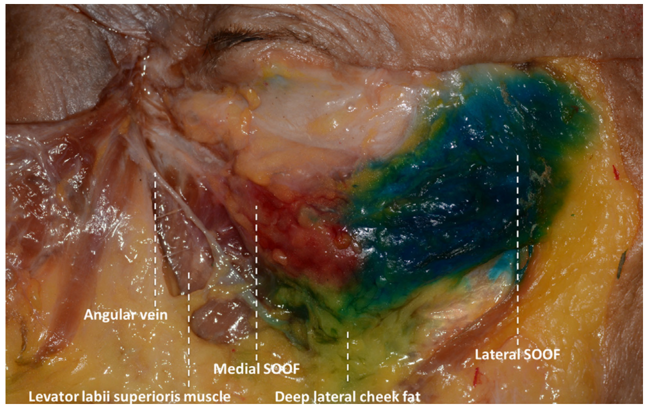

Figure 15 Lateral and medial SOOF. The prezygomatic space and the deep fat compartments are located below the SOOF.

be identified in the same plane as the superficial musculo-aponeurotic system (SMAS) (Fig. 2) [15]. Superficial to the orbicularis oculi muscle the superficial facial fat compartments are identifiable, with the medial cheek fat compartment (also termed the malar fat pad) being close to the lateral aspect of the lower eyelid and the superficial nasolabial fat compartment being close to the medial aspect. The nasolabial fat compartment however, is separated from the medial aspect of lower eyelid by the tear trough and the nasojugal groove represents the boundary between the tear trough and the upper margin of the superficial nasolabial fat compartment. The size of the triangular shaped space, i.e. the space between the two superficial fat compartments (nasolabial vs. medial cheek) increases with age due to the volume loss of the subcutaneous medial cheek fat and the inferior displacement of the nasolabial fat compartment can be subject to the treatment with soft tissue fillers when recontouring and/or restoring volume deficiencies in this area.

Deep to the orbicularis oculi muscle the sub-orbicularis oculi fat (SOOF) can be identified being bounded superiorly by the orbicularis retaining ligament and inferiorly by the zygomatico-cutaneous ligament (Fig. 14) [15]. Laterally this deep fat compartment is connected via the temporal tunnel to the inferior temporal compartment, which is bounded superiorly by the lateral orbital thickening and the inferiorly by the McGregors patch [16]. The SOOF extends medially until 2—4 mm medial to the mid-pupillary line and forms thus the deep lateral boundary of the tear trough. (Note that the tear trough consists of 3 layers only: skin, muscle and periosteum). The SOOF has been shown to consist of 2 sub-compartments, i.e. medial and lateral SOOF [15] and authors have indicated that the superficial lamina of the deep temporal fascia separates the SOOF from the prezygomatic space [15], which contains deepest facial fat (Fig. 15) [17]. Interestingly this fascia is also suggested to be continuous with the orbital septum, but robust evidence still needs to be presented.

Conclusion

Respecting the layered arrangement of the facial anatomy enables practitioners to perform safe and effective surgical and non-surgical procedures. Understanding the anatomy of the lower eyelid and the lid—cheek junction as a unit is crucial especially when fighting the signs of facial aging. Depending on the deformity identified in each patient it is important to direct the consecutive therapeutic applications:

- type 1 deformity: non-surgical techniques, i.e. minimally invasive applications (f.i. soft tissue fillers);
- type 2 deformity: non-surgical or surgical techniques;
- type 3 deformity: surgical approach is necessary with great importance to preserve the function of the orbicularis oculi muscle and to prevent eyelid retraction by a preventive cathal support. Preoperative meticulous clinical assessment is the key of any surgical approach to type 3 deformity.

Disclosure of interest

The authors declare that they have no competing interest.

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