Tear Trough Deformity: Study of Filling Procedures for Its Correction

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Abstract: The aim of this work is to discuss the anatomy of the tear trough region with relative danger areas, and to describe 2 different options to correct this deformity.

The tear trough is a concave deformity of the orbital fat that is noticeable as a result of inherited anatomic differences and aging. However, the periorbital region is a complex area with its own septa and ligaments, fat compartments, muscles, vascularization, and lymphatic drainage and presents anatomic characteristics that must be taken into account in order to achieve good results and avoid complications.

The use of hyaluronic acid gel or autologous fat for soft tissue correction is a good option.

A total of 96 patients with periorbital hollowing were divided into 2 groups; each group received a different treatment, from December of 2013 to December of 2015, with hyaluronic- or lipo-filling.

Key Words: Hyaluronic acid, lipo-filling, periorbital hollowing, tear trough deformity

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The periorbital region is one of the most affected areas by aging, with the appearance of periorbital wrinkles, deep lacrimal groove, palpebral and malar bags, blepharochalasis, a loss of skin elasticity, and a downwards tilt in the external canthus. The tear trough is a concave deformity of the orbital fat that is noticeable as a result of inherited anatomic differences and aging.

In a youthful face, transitions between the preseptal portion and the orbital portion of the orbicularis muscle, and between the eyelid fat and cheek compartments, should be smooth and not very pronounced. With the age process, these transitions become progressively pronounced, with the appearance of grooves like the lacrimal and the palpebromalar groove.

Natural facial rejuvenation has been achieved with the use of hyaluronic acid (HA) gel or autologous fat for soft tissue augmentation. Cosmetic treatments designed to improve this region combine different techniques such as botulinum toxin, filler injection, fat grafting, lower blepharoplasty with fat repositioning, or combining fat grafting in the tear trough.

However, the periorbital region is a complex area with its own septa and ligaments, fat compartments, muscles, vascularization, and lymphatic drainage and presents anatomic characteristics that must be taken into account in order to achieve good results and avoid complications. The tear trough is a 2 or 3 cm depression, inferior to the pseudo herniated orbital fat of the lower eyelid. It is characterized by a sunken appearance of the lower eyelid that results in the casting of a dark shadow over the nasal lower eyelid giving the patient a fatigued appearance.

The aim of this article is to discuss the anatomy of the tear trough region with relative danger areas, and to describe 2 different options to correct the tear trough deformity.

Anatomy

Adhering to the skin we find the orbicularis oculi (OO) muscle. This acts as a sphincter around the eye and allows the eyelids to close. It is responsible for periocular expression wrinkles that can be treated with botulinum toxin. The inferomedial edge of the OO muscle anatomically coincides with the lacrimal groove. The tear trough that crosses the cheek of some patients also anatomically coincides with the lower edge of the OO muscle.

The deep fat compartments of the infraorbital region have a great importance.

The lower eyelid has 3 eye fat bags: inner, medial, and outer. With age the orbital septum containing these bags weakens and the bags herniate leading to the appearance of eyelid bags.

The treatment involves the excision of these bags by surgery (lower blepharoplasty). They can also be disguised by using fillers in the lacrimal groove.

The suborbicularis oculi fat (SOOF) is located behind the OO muscle and is divided into a medial portion and a lateral portion.[1] The medial SOOF extends from the medial limbus of the iris to the external canthus, while the lateral SOOF runs from the external canthus to the temporary fat compartment. The lower limit of the SOOF is the lacrimal groove.

Finally the deep medial cheek fat compartment (DMC), this corresponds to the medial edge of the SOOF. The DMC atrophies during aging,[2] being more noticeable the transition between the orbital fat compartments and the cheek fat compartments, making the lacrimal groove deeper. Restoring volume in the DMC with fillers rejuvenates the middle third of the face and reduces the transition between the lower eyelid and the cheek.

The deep infraorbital fat compartments—SOOF and DMC—can be filled to improve the lacrimal groove and rejuvenate this region.

The septum malaris is an anatomic structure first described by Pessa[3,4] and is of great relevance in lacrimal groove treatments with fillers. It is a thin facial structure that originates in the periosteum of the orbital rim and continues in the direction of the skin, dividing the SOOF into 1 upper portion and 1 lower portion. Before reaching the skin, it crosses the OO muscle and interdigitates with the fibrous septum of the surface fat in the cheek. It is inserted into the dermis at a point 3 cm below the external canthus. It is an impermeable

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membrane that prevents the diffusion of pigments and fluids from the periorbital region to the cheek. It is responsible for 4 different clinical conditions (malar edema, malar bag, periorbital ecchymosis, and festoons), which share the same anatomic area because all of them have their lower limit approximately 2.5 to 3 cm below the external canthus. If the filler is placed in the area marked by the septum malaris, due to its impermeability, this may compress surface lymphatic vessels and cause chronic lymphedema. Therefore, fillers in the tear trough should preferably be introduced below the septum malaris to avoid chronic lymphedema, a characteristic complication of this region. If a supraperiosteal injection is performed, then the filler will be injected safely.

When filling a tear groove, consideration must be given to 2 main arteries: the infraorbital artery and the angular artery. The infraorbital foramen is easily located medial to the pupillary line and approximately 1 cm from the infraorbital rim. The angular artery, a branch of the facial artery, runs along the inner canthus of the eye and anastomoses with the supratrochlear and supraorbital arteries; lesions to these arteries must be avoided. An infraorbital hematoma will increase pressure on soft tissue and may trigger a lymphatic insufficiency and malar lymphedema. An embolism in the angular artery could have catastrophic consequences if it causes an occlusion of the ophthalmic artery or central retinal artery, which could cause a rare but very serious complication, such as blindness.

The main function of cutaneous lymphatic vessels is to maintain fluid balance and the load of lymph proteins draining interstitial fluid from the skin to the venous circulation. Lymphatic transport capacity is the maximum lymphatic flow per unit of time, corresponding to 10 times the basal lymphatic flow. Lymphatic insufficiency occurs when lymphatic load exceeds transport capacity, inevitably leading to interstitial edema.

Facial lymphatic drainage occurs through different types of lymph vessels.[5]

The lymph vessels of the dermis are approximately 0.014 to 0.15 mm and are valveless. They form a mesh-like network in the dermis and are the first to receive lymphatic drainage from the skin.

The precollector lymph vessels are approximately 0.1 to 0.3 mm in diameter and already have valves, giving them a tubular shape resembling a bamboo trunk. They run from the dermis into the subcutaneous cellular tissue in search of collector vessels.

The collector lymph vessels are approximately 0.1 to 2 mm in diameter, have valves, and are located in the subcutaneous cellular tissue. They are tubular in shape and are classified as afferent (in the direction of the node), internodal (between nodes), and efferent (leaving the node).

Facial lymph vessels are superficially located in the dermis and in subcutaneous cellular tissue. Therefore, superficial injections of fillers can potentially compromise lymphatic drainage even more than deep injections. However, injections can be made superficially at other locations of the face where the risk of lymphedema is lower than in the periorbital region. This is explained by the presence of the septum malaris, which increases the risk of edema in the periorbital region, since it is an impermeable area at the surface, just where the lymphatic vessels that could be potentially compromised are located.

Regarding the lymphatic drainage of the lower eyelid and inner canthus of the eye are generally drained to a submandibular node.[6]

PATIENTS AND METHODS

We conducted a 2-year retrospective single center study of the period from December of 2013 to December of 2015, with a follow-up period until December 2016. A total of 96 patients with periorbital hollowing underwent treatment with hyaluronic- or lipo-filling (Figs. 1-2).

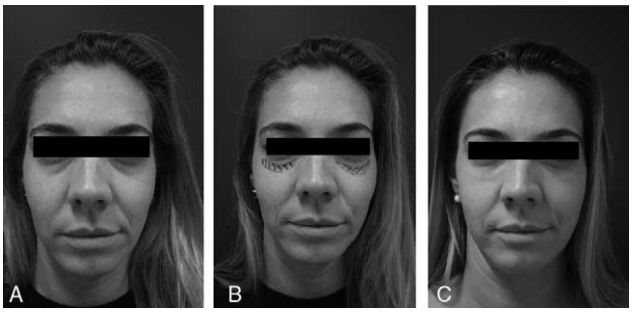

FIGURE 1. (A) Preoperative picture of a patient with Grade 2 deformity treated with hyaluronic acid. (B) Preoperative marking. (C) Result 6 mo after treatment.

The study was designed with the definition of the following inclusion criterion: contour abnormalities in the periorbital area with functional or esthetic indication for treatment. Patients presented hollow eye rings or hollow cavities. All patients underwent clinical ophthalmologic examination, including ophthalmologic assessment and photographic documentation.

This study population was divided into 2 groups; each group received a different treatment.

The treatment was carried out by senior surgeons with advanced experience in the field.

Group A (n = 52) underwent a treatment with the HA gel Redensity II Eyes (Teoxane, Geneva) and a reinforced a 25G × 38 mm cannula microcannula. Also, local anesthesia was applied.

Group B (n = 44) underwent a periorbital treatment with a lipofilling. Also, a general sedaction and local anesthesia was applied.

The grade of tear trough deformity was evaluated according to Barton grading system (Table 1).[7] Because of facial asymmetry, patients can have different Barton grades in each eye; therefore, each eye was assessed independently.

Operative Technique

For Group A, our technique recommended for filling tear trough and palpebromalar groove would be the use of a 25G × 38 mm cannula. The cannula is inserted through a puncture hole made with a 23G needle into the skin.

For Group B, the donor region of the inner thigh was infiltrated with Klein solution (500 mL normal saline, 1 mL 2% lidocaine, 1 mL 0.1% epinephrine). After adequate anesthesia, an adequate amount of subcutaneous fat was harvested from the donor region. The harvested fat was centrifuged (3000 rpm for 3 minutes) and transferred into multiple 1-mL syringes. Using an 18-gauge microcannula, a small amount of fat was injected along the infraorbital rim.

FIGURE 2. (A) Preoperative picture of a patient with Grade 2 deformity treated with lipofilling. (B) Preoperative marking. (C) Result 6 mo after treatment.

TABLE 1. Barton Grading System

Grade	Anatomic Analysis
Grade 0	Absence of medial or lateral lines demarcating the arcus marginalis or the orbital rim, and a smooth youthful contour without a transition zone at the orbit-cheek junction
Grade 1	Mild, subtle presence of a medial line or shadow; smooth lateral transition of lid-cheek junction
Grade 2	Moderate prominence of a visible demarcation of the lid-cheek junction, extending from medial to lateral
Grade 3	Severe demarcation of the orbit-cheek junction, with an obvious step between the orbit and the cheek

For both groups, the entry point of the cannula is located at the intersection between the line passing through the external canthus and the line marked by the tear trough. From this point of entry, both the tear trough and the palpebromalar groove can be filled. After introducing the cannula, resistance to the passage of the cannula should be noted; the cannula should pass through this resistant layer until it reaches the safe supraperiosteal layer. Once the cannula has been inserted into the deep layer, it should be moved medially, injecting small amounts in a fan shape, in the retro-tracing technique. From the same entry point, the cannula is removed and inserted laterally at supraperiosteal level to fill the palpebromalar groove in a similar way.

For patients treated with HA filler it is not advisable to inject more than 0.5 mL per side in the same session; and it is preferable to repeat the treatment after 1 month if more volume is needed.

For patients treated with autologous for lipofilling, the injection volume depended on the depth of the tear trough, with a goal of injecting until the tear trough deformity had been corrected and appeared slightly bulging. The deep layer was injected first, generally with 1 to 2.5 mL on each side.

RESULTS

In Group A, 42 eyes were categorized as Grade 1 in preoperative evaluation. One-month follow-up, 95.2% of these improved to Grade 0; 4.8% showed no improvement. Thirty-two eyes were categorized as Grade 2 before surgery, 1-mouth follow-up, 56.2% of these improved to Grade 0, 31.7% improved to Grade 1, and 3.1% showed no improvement. There were 30 eyes with preoperative Grade 3, 1-mouth follow-up, 66.7% of these improved to Grade 0, 33.3% improved to Grade 1, and none showed no improvement. All patients who have not seen improvements underwent further treatment correct the tear trough deformity with HA.

In Group B, 22 eyes were categorized as Grade 1, 1 mouth after treatment all patients improved from Grade 1 to Grade 0. Among 30 eyes with a preoperative grade of 2, 1 month after treatment 83.3% improved to Grade 0, 26.7% improved to Grade 1, and none showed no improvement. Among the 36 preoperative Grade 3 eyes, 94.4% improved to Grade 0, 5.6% improved to Grade 1, and none showed no improvement. None of the patients treated with lipofilling needed to undergo a second correction of the deformity.

Six months after treatment, all patients of both groups are well corrected and with stable results. One year after treatment, while patients treated with HA start having a regression of correction, all patients of group treated with lipofilling keep a stable result.

In patients with Grade 1, 2, and 3 deformities, lipofilling resulted in significantly greater grade improvement, compared with HA filling. In fact, even if the esthetic result may be comparable, the correction degree is most powerful and enduring when it comes with lipofilling. No significant complications occurred postoperatively in any patient. None of the eyes in both groups had palpable subcutaneous induration.

Unsatisfactory correction of the tear trough deformities occurred in 3 eyes in Group A and none in Group B. In these patients, revisions were performed as needed with HA filling.

Edema or ecchymosis occurred only in 4 patients in Group A and in 6 patients in Group B.

DISCUSSION

Tear trough deformity is a noticeable sign of periorbital aging. To understand the tear trough, it is important to review factors contributing to facial aging. There are multiple purported causes of facial aging, but the current consensus opinion on the changes that occur with facial aging focus on volume loss (bone and fat atrophy), skin changes including loss of dermal collagen, and finally, laxity of the orbitomalar ligament and the submuscular aponeurotic system. Formation of the tear trough deformity results from herniation of orbital fat, atrophy of the skin and subcutaneous fat, laxity of the orbicularis muscle and the orbicularis retaining ligament, and malar retrusion from decreased prezygomatic fat.[8–11]

For patients with tear trough deformity and without obvious laxity of the lower lid skin, increasing tissue volume in the infraorbital area is an effective method for rectifying the concave appearance. For these patients with minimal skin laxity, injection of HA or autologous fat is the ideal treatment to correct these deformities

Many authors have described their own technique for treating this anatomic area. Some have used a "serial puncture" technique,[12–14] whereas others have used a "parallel threads" approach.[15,16]

In our opinion, it is recommendable to make a supraperiosteal injection, because it is an avascular space, to reduce the risk of compression of lymphatic vessels, lymphedema, ecchymosis, visible material, and embolism, as mentioned previously.

Several factors leading to the appearance of malar lymphedema after filler injection. A surface injection in the septum malaris increases its impermeability, and may compress the lymphatic vessels causing malar edema. Excessive volumes put pressure directly on the lymphatic vessels if the material is injected either superficially or deep in the septum malaris, to avoid it, injection of small bolus of product prevents the appearance of lymphedema and nodules. The nodules in this region are more visible and palpable because the skin of the lower eyelid is extremely thin, so it is important to prevent their appearance. Moreover, it is not advisable to vigorously massage the area after injection because massaging can move the filler superficially through the needle tracts and lead to inappropriate placement of the product even though it was initially injected correctly.

Correct patient selection is also important. Patients with previous malar bags, a history of malar edema after excessive intake of salt or alcohol or when getting up in the morning, are patients with diminished lymphatic transport capacity so they are more at risk of presenting malar lymphedema after treatment. Patients suspected of being at greater risk of lymphatic insufficiency in this region should not be candidates for treatment. Nevertheless, if the decision is taken to treat these patients, the safest approach would be to perform the procedure with a small volume of product and in various sessions to avoid saturating lymphatic transport capacity due to lymphatic vessel compression.

It is also necessary to choose the right products, which must offer low elasticity and be resorbable, such as HA with low cross-linkage or semi cross-linked, or collagen. Permanent products must be avoided in this region because they increase the risk of complications such as granulomas, product migration, chronic reaction to a foreign body, and visible or palpable material.

Hyaluronic acid because is an important component of the extracellular matrix and anionic polysaccharide that depicts various mechanical and biochemical functions of the human body. It naturally and substantially stabilizes and organizes the extracellular matrix and contributes to cell proliferation and differentiation. Moreover, HA is responsible for vascular integrity, which might help prevent clinical complications after it is injected into the periorbital area.[15,17–21]. Hyaluronic acid is a quick and easy option; however, it may be insufficient to complete resolution of the problem. Autologous fat has already been widely used in facial rejuvenation, and considered as the ideal autologous filler material, because it is relatively safe, nonimmunogenic, readily available, easily obtainable, and reproducible.[22] Autologous fat grafting can be performed by lipoinjection. Unlike synthetic fillers, autologous fat has the ability to change in structure with the patient's physiologic changes, and adverse reactions are extremely uncommon. Local improvements in skin quality and in dark circles[23] at the graft location are another benefit of lipofilling and may add to satisfaction with the postoperative result.

The lipofilling technique is still often plagued with uncertainties about its longevity and the unpredictability of fat cell survival.[24,25] Postoperative graft atrophy has been reported in literature[25,26]; in our study, there was no need for secondary lipofilling during the period of investigation furthermore centrifugation before injection improves reproducibility and allows for better pretreatment quantification of the volumes needed for injection.

The utilization of sharp needles contributes to precise placement of fat in superficial planes. Although lipoinjection can be performed safely with a sharp needle,[27,28] many surgeons still prefer using a blunt cannula. The choice between cannula or needle depends on the physician preference, but generally less bruising and ecchymosis occur with cannula. Bruising may also cause lymphatic vessel compression and greater risk of edema, so the technique should be as atraumatic as possible. Cannula also minimizes the risk of intravascular injection and embolism. It is also advisable not to inject medially in the inner canthus to avoid lesions to the angular vessels.

Whenever the purpose of treatment is to restore volume in the midface together with treatment of the tear trough, it is recommendable to start by treating the midface. With aging, facial fat compartments atrophy and lower migration of facial fat occurs, increasing the distance between the eyelid and cheek fat compartments, leading to the appearance of the tear trough. Restoring volume in the midface rejuvenates the face and reduces the distance between the eyelid and cheek fat compartments, thus partially correcting the tear trough reducing the amount of product required to treat tear troughs, and also related risk of complications.[28]

Tear trough treatment shows satisfying and efficient results with few complications.

The anatomic features of the tear trough make it a particularly delicate area when injecting fillers. The injection technique must be based on good anatomic knowledge of the region, a refined and atraumatic technique with supraperiosteal injection of resorbable or autologous materials, in moderate volumes and adequate selection of patients.

In patients with tear trough deformity and without obvious skin or OO muscle laxity, both HA and autologous fat grafting can produce good results. Both procedures are acceptable for mild deformity but, for patients with higher-grade deformities, autologous fat grafting produced better results than HA filler.

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