Volume loss and muscular hyperactivity are two major components of the aging process that contribute to the formation of the folds and wrinkles. Tear trough deformity is one of the most difficult depressions to correct surgically. In traditional lower eyelid surgery, the focus is on removing tissue, with the philosophy being that facial aging is characterized by excess tissue. The fundamental cosmetic goal of this type of treatment is to improve the appearance of the midface while maintaining a natural position of the lower eyelid. Harmonious rejuvenation between the midface and lower lid relies on preserving the pretreatment shape of eyelids. Although there is a role for conservatively removing tissue in some patients, almost all patients can benefit from some filling with injectables because periorbital aging often involves soft tissue deflation.

The pathogenesis of aging in the lower eyelid is multifactorial and varies among patients. Periorbital age-related changes include crow’s feet and lower eyelid rhytides, scleral show, infraorbital hollowing, herniated fat pads, excess upper and lower lid skin, festoons, and eyelid hooding.

In addition, attenuation of the lateral canthal tendons results in loss of the youthful architecture of the eye, secondary to a decrease of the aesthetically-pleasing upward tilt.

Even as our understanding of these anatomical concepts has evolved, treatment of the tear trough has remained a challenge. Also known as the nasojugal groove, the tear trough is the natural depression extending inferolaterally from the medial canthus. It is bounded superiorly by the infraorbital fat protuberance. The inferior border is formed...
by the thick skin of the upper cheek with its abundant subcutaneous fat, suborbicularis oculi fat, and portions of the malar fat pad. In most individuals, the trough is deeper medially and more shallow laterally.7-9 Through aging, further loss of soft tissue and, importantly, a loss of osseous support also cause the tear trough to deepen further.5,10

Treatment options for the tear trough include alloplastic implants, release of the orbicularis oculi muscle origin, and transposition of pedicled orbital fat.7,8,10-12 More recently, there has been a movement toward focusing on volume loss in the treatment of facial aging. The surgical options for volume replacement have been limited; autogenous fat grafting requires harvesting and can be unpredictable, and the synthetic fillers that were previously available were either too permanent or too nonpermanent. The arrival of new fillers that are safe and predictable has provided a practical solution with which we may approach facial volume loss.10,13-16 We report our results with one such filler, the hyaluronic acid (HA) gel filler Restylane (Q-MED, Rio de Janeiro RJ, Brazil, and Medicis Aesthetics, Scottsdale, Arizona), for the treatment of tear troughs.

METHODS

A prospective clinical trial was conducted between June 2008 and December 2009 at Federal University of São Paulo. Twenty-five consecutive patients with tear trough deformities were recruited preoperatively through the Oculoplastic Surgery Service. All patients who agreed to participate signed a consent form approved by the Human Subjects Review Board at Federal University of São Paulo (UNIFESP/EPM). The patients were between 25 and 65 years old. Pretreatment evaluation included a thorough ophthalmologic history and review of any relevant medical conditions. Patients with a history of any treatments in the lower eyelid in the preceding two years were excluded from the study.

Hyaluronic Acid Gel Filler

HA is a molecule that naturally occurs in the extracellular matrix of many human tissues, including connective tissues, interstitial membranes, dermis, joints, and the vitreous body of the eye. HA is a glycosaminoglycan disaccharide composed of alternately repeating units of D-glucuronic acid and N-acetyl-D-glucosamine.17-19 Restylane, the brand of HA selected for this study, is a modified HA product. It is nonanimal derived, obtained by bacterial fermentation of Streptococcus strains (Streptococcus equi or Streptococcus zooepidemicus), and stabilized by a chemical crosslinking process. It has approximately 100,000 particles of gel per millimeter.14,17-19

Patient Preparation and Marking

Patients were advised to avoid medications that might interfere with platelet function for two weeks prior to treatment. Standard digital photographs were taken at all visits.

Immediately prior to injection, each patient’s makeup was removed, the skin was prepped with alcohol, and the morphology of the eyelids was studied. The area to be treated was marked, delimiting the lower and upper borders of the tear trough (Figure 1). As a precaution, the position of the lower bony orbital rim was also marked in most cases. The lower eyelid area was anesthetized by topical application of 2.5% lidocaine and 2.5% prilocaine cream. After 20 to 30 minutes, the ointment was removed with alcohol.

Injection Technique

The patient’s chair was reclined 30° from a sitting position and the patient’s head was firmly resting against a solid headrest. Under a bright overhead light, the injections were performed as described by Steinsapir and Steinsapir.20 Patients were permitted to close their eyes. The goal was to place aliquots of filler in the preperiosteal tissues immediately inferior to the orbital rim, which is free of significant vascular structures from the base of the anterior lacrimal crest to the lateral canthal tendon.20 The filler was introduced with a serial puncture technique through the 30-gauge needle supplied with the medication (Figure 2). Approximately 0.1 mL was injected at each pass. The needle was then withdrawn and the filler was molded to the desired contour. The deepest part of the medial tear trough was treated first and as the depression became less deep, parallel lines of filler were injected cephalad and caudal to the first injection until the entire area was corrected.

If a bruise began to form, the needle was quickly withdrawn and gentle pressure was applied to the local area with a cotton tip applicator. If the needle was placed too superficially, visible lumps or wheals of the HA gel would
appear. It was also important to avoid depositing large volumes of the filler in one location. Rather, a gentle continuous pressure was applied to the syringe plunger after the needle touched the periosteal tissue and the syringe was slowly withdrawn, yielding multiple fine, vertically stacked deposits and a smooth three-dimensional contour.

At the conclusion of the procedure—which was determined by successful, artistic filling of the hollow contours—the injector performed a massage of the treated areas to mold to the desired contour. Immediately afterward, the patient was discharged. Posttreatment instructions permitted the patient to massage the treated areas if any irregularity in the contour was observed; patients were also instructed to place a cold compress on the eyelids for two days. Patients were allowed to apply makeup to conceal any bruising and no activity restrictions were imposed.

Follow-up

Each patient was scheduled to return to the office in seven days. At the first follow-up, the treated area was reevaluated. If required, a touch-up was performed at this visit. Any complications were recorded on a clinic-specific form, focusing on signs of infection and hematomas. Second and third follow-up visits were scheduled for one and three months posttreatment. A fourth follow-up was planned six months posttreatment and the final follow-up was arranged at one year.

Outcomes

To objectively assess the outcomes, a quantitative scale was applied to photographs of each patient at each visit, both pretreatment and follow-up (0 = best result; 3 = worst result). Two standardized digital photographs were taken of each patient in the frontal view: one with the eyes opened and one with the eyes closed. Each patient’s pre- and posttreatment photographs were reviewed by three independent surgeons who had not been involved in treatment. Photographs from some of the patients in this series are shown in Figures 3 to 6.

The data provided by the independent surgeons were pooled and means were used in all comparisons. The Mann-Whitney U-test was selected to assess the significance of the subjective aesthetic evaluation of the photographs. Statistical analysis was carried out with Statistical Package for Social Science (SPSS) version 16.0 for Mac (SPSS, Inc., an IBM Company, Chicago, Illinois). Differences were regarded as significant if if $p < 0.05$.

RESULTS

The mean (SD) age of the 25 patients in this study was 46.1 (8.8) years. All patients were women. The mean (SD) follow-up was 9.5 (2.3) months (minimum eight, maximum 15).

The total injection volume per side (baseline and touch-ups) needed to achieve correction of the tear trough was 0.54 (0.27) mL on the right side and 0.61 (0.30) mL on the left side. There was a broad range in the amount of product injected to correct the tear trough, spanning from 0.1 to 1.1 mL on the right side and 0.2 to 1.2 mL on the left side. Of the 25 patients, only two received a touch-up injection one week later.

Complications included some degree of bruising (52%; 13 patients), erythema (40%; 10 patients), and local swelling (8%; two patients). It should be noted that transient swelling in the lower eyelid is expected for one or two days. In one case, long-lasting swelling was related to bruising and did not resolve until the bruise disappeared.

The results of the independent outcomes analysis can be seen in Table 1. The mean pretreatment ranking was 1.92, with a standard deviation of 0.57; the mean (SD) posttreatment ranking was 0.80 (0.69), which represented a significant improvement in patient appearance. Most patients (22; 88%) demonstrated cosmetic improvement of the tear trough after the treatment with HA. Three patients showed no improvement; two of these had a pre-treatment grade of 2.0 and one had a grade of 3.0. Even these patients showed some visual improvement posttreatment, but not enough to grade them as better than their first score.

DISCUSSION

Flowers, who first defined the tear trough region, described it thus: “the deep groove that commonly occurs near the junction of the eyelid and the cheek is the most consistently ignored major deformity of the orbital region. With a characteristic length of but 2 cm, it extends downward and lateral from the inner canthus of the eye. . . . Whether
limited or extended, it gives the face a dissipated, unhealthy, and tired—even haggard—appearance.”

The cause of tear trough deformity is multifactorial and separating each entirely may be difficult. The main components of the tear trough are the hollow itself, the fat bulge just superior to it, and the very distinct change of skin quality, color, and thickness between the lid and the cheek.\textsuperscript{10,21} Recently, Haddock et al\textsuperscript{9} evaluated the anatomy underlying the tear trough and lid/cheek junction, observing that the main features responsible for these landmarks were atrophy of the skin and fat and bulging orbital fat. These authors observed that the deformity itself was unlikely to occur due to age-related descent of these structures because they are fixed to the bone.

Lambros\textsuperscript{5} demonstrated that the lid/cheek junction was, in fact, stable over time and that the perception of descent was attributable to age-related tissue contrasts and not actual movement. He also showed that skin atrophy led to darkening of the preseptal skin, causing an increase in contrast and therefore an accentuated lid/cheek junction. Much of the apparent descent is therefore owed to herniation of the orbital fat following orbital septum and preseptal orbicularis oculi muscle attenuation.\textsuperscript{22}

Injectable dermal fillers are rapidly challenging and complementing the market share of more invasive cosmetic surgical procedures. Dermal fillers have different tissue compatibility characteristics that determine their suitability. Thus, no single filler is “ideal” for all applications, but certain desirable filler qualities are generally accepted. For instance, fillers should be safe and effective, biocompatible, nonimmunogenic, easily obtainable, nonreabsorbable, low in cost, easily stored, and easy to remove or

**Figure 3.** (A) This 45-year-old woman presented for treatment of her tear trough region. Independent evaluators gave this patient a pretreatment grade of 1 (on a scale of 0-3, with 0 being best). (B) Eighteen months after treatment with hyaluronic acid filler Restylane through a serial puncture technique.

**Figure 4.** (A) This 60-year-old woman presented for treatment of her tear trough region. Independent evaluators gave this patient a pretreatment grade of 3 (on a scale of 0-3, with 0 being best). The patient also had xanthelasma on both upper eyelids and had been treated with trichloroacetic acid (TCA) peel. (B) Seven months after treatment with hyaluronic acid filler Restylane through a serial puncture technique. The xanthelasma required surgical intervention.
reverse if necessary. As the search for an ideal filler material continues, HA products have gained popularity because of their numerous advantages.

A number of investigators have explored the efficacy of crosslinked stabilized nonanimal HA filler to treat the tear trough. Kane described his personal method, in which he places HA (Restylane) between the skin and the orbicularis oculi muscle. Goldberg and Fiaschetti demonstrated a method in which they place multiple threads of HA (Restylane) under the orbicularis oculi muscle. Lambros discussed his experience of treating the tear trough with HA placed in the orbicularis oculi muscle and at the periosteum. Steinsapir and Steinsapir reported a two-year experience treating the nasojugal groove (tear trough) with Restylane through a deep-fill method. All of these methods require considerable experience to achieve an acceptable result. The superficial method can easily produce skin irregularities, whereas the deep-fill method places a premium on the skin, maximizing tissue coverage and minimizing the risk of intravascular injection. We prefer to inject HA gel filler in the preperiosteal tissues, as described. With experience, there appear to be some

Figure 5. (A) This 25-year-old woman presented for treatment of her tear trough region. Independent evaluators gave this patient a pretreatment grade of 1 (on a scale of 0-3, with 0 being best); note the dark circles under her eyes. (B) Eight months after treatment with hyaluronic acid filler Restylane through a serial puncture technique. The patient demonstrated improvement not only in her tear trough region, but also in the dark circles under her eyes. She was given a posttreatment grade of 0.

Figure 6. (A) This 56-year-old woman presented for treatment of her tear trough region. Independent evaluators gave this patient a pretreatment grade of 2 (on a scale of 0-3, with 0 being best). (B) Seven months after treatment with hyaluronic acid filler Restylane through a serial puncture technique, the patient showed improvement in the tear trough region and the eyelid-cheek groove, but only moderate improvement in the periorbital area. She would still benefit from surgical treatment (blepharoplasty).
Even though HA gel filler does not address the root causes of the tear trough, it certainly can improve it without surgery. Specifically, treating this area with fillers has the following benefits: injection is relatively easy to perform, there is a high degree of patient satisfaction, most complications are self-limiting and can be easily treated, and in the event of an unsatisfactory effect, the material can be dissolved away. Of course, there are some disadvantages in that the treatment is not permanent and there are no associated improvements in the lower eyelid. In patients with large fat pads, only moderate improvement is possible with filler treatment, so they are not ideal candidates. Patients with excess skin on lower eyelids would also not experience the benefit that could be obtained with surgery. Some patients with lower eyelid hyperpigmentation (dark circles) may experience improvement in their appearance after the treatment, but this cannot be guaranteed.

Despite promising results, our study is limited by its small sample size and short follow-up period. In the future, a prospective research study with a large sample size, patients serving as their own controls, and a longer follow-up of at least three years should be undertaken. We also did not apply a scale for evaluating the treating physician and patient satisfaction scores; this would have been of additional benefit to the study. We elected to engage only independent surgeons based on the ideas purported by (among others) Kosowski et al.,28 who reported that valid, reliable, and responsive instruments designed to measure patient-reported outcomes following surgical and nonsurgical facial rejuvenation are still lacking. It is likely that patient satisfaction is multifactorial, encompassing not only objectively-rated aesthetic ideals, but also subjective perceptions, motivations, and expectations. In the future, more research is needed to evaluate the effects of different cosmetic procedures on individuals’ self-esteem, self-image, quality of life, and confidence.29

**CONCLUSIONS**

In this series of 25 patients treated with HA fillers for tear trough deformity, some degree of posttreatment improvement was noted in all cases and all patients subjectively reported being very satisfied with their results. In properly-selected candidates, this nonsurgical cosmetic intervention can be an excellent alternative or complement to surgical treatment of the nasojugal area.

**Disclosures**

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