Abstract

Background Fat-preserving lower blepharoplasty techniques and filling techniques using autologous or non-autologous materials are increasingly used to treat tear trough deformity. However, there has been no definitive comparison of the results of fat repositioning versus autologous fat grafting for this condition. The authors used statistical analysis to compare the results of the two methods.

Methods From October 2013 to September 2015, a total of 101 patients, aged 20–43 years, underwent fat repositioning or autologous fat grafting in our department. Group 1 (51 patients, 102 eyes) underwent intraorbital fat repositioning with septal reset by transconjunctival lower blepharoplasty. Group 2 (50 patients, 100 eyes) underwent autologous fat grafting by lipoinjection.

Results No significant complications occurred in any patient postoperatively. Four of 102 eyes in Group 1 and seven of 100 eyes in Group 2 had no improvement; the rest had different degrees of improvement. In Grade II and III deformities, fat repositioning resulted in significantly greater improvement of grade compared with autologous fat grafting. The surgical method of Group 1 resulted in better curative effects than that of Group 2.

Conclusion In patients with tear trough deformity and without obvious skin or orbicularis oculi muscle laxity, both fat repositioning and autologous fat grafting are acceptable for mild deformity. In patients with higher-grade deformities, fat repositioning produced superior results than autologous fat grafting.

Level of Evidence IV This journal requires that the authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors http://www.springer.com/00266.

Keywords Tear trough · Fat reposition · Autologous fat grafting · Transconjunctival route · Lower blepharoplasty

Introduction

Tear trough deformity is one of the noticeable signs of periorbital aging. The deformity is characterized by the “tear trough triad”: (1) fat herniation, (2) marked orbital rim depression, and (3) malar rim retrusion, producing a negative vector orbit [1]. Increasing the tissue volume in the infraorbital area is an effective method for rectifying the concave appearance of tear trough deformity. Techniques such as preserving and transposing orbital fat [2–6], autologous fat grafting [7], hyaluronic acid filling, filling with other semipermanent filler materials [8, 9], and periorbital skeletal augmentation [10] have been reported. For patients with minimal skin laxity, injection of hyaluronic acid is quick and easy. However, hyaluronic acid and other dermal fillers are expensive in China. Many patients are more willing to choose surgical treatment. Both fat repositioning and autologous fat grafting can achieve good aesthetic results, but a definitive comparison of the two methods is lacking. In this study, the authors used statistical analysis to compare the two methods using Barton’s grading system [1].
Patients and Methods

Ethical approval was given by the Ethics Committee at our institution. Patients who underwent fat-repositioning surgery or autologous fat grafting in our department from October 2013 to September 2015 with an effective follow-up time of at least 6 months were included. The mean follow-up period was approximately 11.5 months (range, 6–20 months). A total of 101 patients (seven men and 94 women) with a mean age of 32.5 years (range, 20–43 years) were included.

Patients who had tear trough deformity with small protrusions of the lower lid fat pad met the inclusion criteria. The lowest point of the tear trough was more than 5 mm below the infraorbital margin in eligible patients. Patients were excluded if they had obvious skin or orbicularis oculi muscle laxity or a history of any prior eyelid or periorbital surgery or dermal filler injection.

Preoperative and postoperative frontal photos were taken with a digital camera (SONY NEX-5 N) in the Frankfort horizontal plane. Photos were excluded if the patients showed a strained facial expression, skewed gaze, or head tilt. Two professional plastic surgeons evaluated the grade of tear trough deformity according to Barton's grading system [1] (Table 1). Because of facial asymmetry, patients can have different Barton’s grades in each eye; therefore, each eye was assessed independently. We evaluated a total of 202 eyes (101 patients) in this study.

The patients were divided into two groups. In Group 1, 51 patients (102 eyes) underwent intraorbital fat repositioning with septal reset in conjunction with lower blepharoplasty. In Group 2, 50 patients (100 eyes) underwent autologous fat grafting by lipoinjection to fill the tear trough.

The data of the results were analyzed with the Fisher exact two-tailed test or the rank-sum test. The preoperative grade of I should adopt the Fisher exact two-tailed test, and the rank-sum test was applied for the preoperative grade of II and III. A P value of <0.05 was considered significant. All analyses were performed with SAS (Statistics Analysis System, World Headquarters SAS Institute Inc.).

Surgical Techniques

In Group 1, local anesthetic containing 2 % lidocaine with 1:200,000 epinephrine was injected through the inferior fornix. A transconjunctival infraorbital nerve block was important to achieve adequate anesthesia. Through a transconjunctival approach, a transection incision was made between the lower edge of the tarsal plate and the conjunctival fornix. The separation was performed in the anterior orbital septum and posterior orbicularis oculi plane (Fig. 1a), with care taken not to damage the orbital septum to maintain an optimal surgical field. After reaching the arcus marginalis, the orbicularis retaining ligament was released. Blunt dissection with periosteal stripping was performed on the periosteal surface. The dissection was made approximately 5–8 mm below the inferior orbital rim (Fig. 1b). Next, the orbital septum was incised, and the medial, central, and lateral fat pads were pulled out to form the fat pedicle flaps (Fig. 1c). Approximately 3–5 mm below the inferior orbital rim, three-to-four 5-0 absorbable sutures anchored the middle of the fat pedicle with the lower edge of the orbital septum to the periosteal surface (Fig. 1d). The free end of pedicled fat was extended to over 5 mm below the infraorbital margin. The conjunctival incision did not require sutures. A schematic illustration is shown in Fig. 2.

In Group 2, the donor region of the inner thigh was infiltrated with tumescent 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 washed in normal saline and transferred into multiple 1-ml syringes. Using an 18-gauge needle, a small amount of fat was injected within the orbicularis muscle along the infraorbital rim (Fig. 3). 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 1.2–3.6 ml on each side. After deep fat filling, fat was injected into the superficial

<table>
<thead>
<tr>
<th>Grade</th>
<th>Anatomic analysis</th>
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<tr>
<td>0</td>
<td>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</td>
</tr>
<tr>
<td>I</td>
<td>Mild, subtle presence of a medial line or shadow; smooth lateral transition of lid-cheek junction</td>
</tr>
<tr>
<td>II</td>
<td>Moderate prominence of a visible demarcation of the lid-cheek junction, extending from medial to lateral</td>
</tr>
<tr>
<td>III</td>
<td>Severe demarcation of the orbit-cheek junction, with an obvious step between the orbit and the cheek</td>
</tr>
</tbody>
</table>

Reprinted with permission from Barton et al. [1]
layer if surface depression remained. Unilateral filling volume was not more than 0.5 ml in the superficial layer.

Results

In Group 1, 34 eyes were categorized as Grade I in preoperative evaluation. Thirty of these (88.2 %) improved from Grade I to 0; four (11.8 %) showed no improvement. Forty-four eyes were categorized as Grade II before surgery. Thirty-four of these (77.3 %) improved to Grade 0, 10 (22.7 %) improved to Grade I, and none showed no improvement. There were 24 eyes with preoperative Grade III. Seventeen of these (70.8 %) improved to Grade 0, seven (29.2 %) improved to Grade I, and none showed no improvement (Tables 2, 3, and 4).

In Group 2, 37 eyes were categorized as Grade I. Thirty-one of these (83.8 %) improved from Grade I to Grade 0 and six (16.2 %) showed no improvement. Among 39 eyes with a preoperative grade of II, 20 (51.3 %) improved to Grade 0, 18 (46.1 %) improved to Grade I, and one (2.6 %) showed no improvement. Among the 24 preoperative Grade III eyes, three (12.5 %) improved to Grade 0, 11 (45.8 %) improved to Grade I, 10 (41.7 %) improved to Grade II, and none showed no improvement (Tables 2, 3, and 4).

There was no significant difference in postoperative improvement effect between the two surgical methods in patients with Grade I deformity (Table 2). In patients with Grade II and III deformities, fat repositioning resulted in significantly greater grade improvement, compared with autologous fat grafting ($P < 0.05$) (Tables 3 and 4).

No significant complications occurred postoperatively in any patient. None of the eyes in Group 1 and seven eyes in Group 2 had palpable subcutaneous induration. These cases
were treated with steroid injection at the time of follow-up examination, and resolved without long-term consequences. Unsatisfactory correction of the tear trough deformities or contour irregularities occurred in six eyes in Group 1 and in 15 eyes in Group 2. In these cases, revisions were performed as needed with transconjunctival excess fat excision or percutaneous lipoinjection. There were six eyes with postoperative skin laxity or wrinkles in Group 1; there were no cases of postoperative laxity or wrinkles in Group 2. Edema or ecchymosis occurred in 22 eyes in Group 1 and in 13 eyes in Group 2 (Table 5).

**Patient 1**

A 22-year-old female patient presented with tear trough deformity with protrusion of orbital fat. We performed a transconjunctival lower blepharoplasty combining fat repositioning and septal reset. Significant improvement was achieved postoperatively. The deformity improved from preoperative Grade II to postoperative Grade 0 (Fig. 4).

**Patient 2**

A 31-year-old female patient presented with a primary complaint of tear trough deformity. We performed autologous fat grafting by lipoinjection. The deformity improved from preoperative Grade II to postoperative Grade 0 (Fig. 5).

**Patient 3**

A 28-year-old female patient with different grades of tear trough deformity in each eye underwent fat repositioning. The left side improved from preoperative Grade II to postoperative Grade 0; the right side improved from preoperative Grade III to postoperative Grade 0 (Fig. 6).

**Table 2**  Efficacy comparison of two types of operation in treating preoperative Grade I deformity

<table>
<thead>
<tr>
<th>Group</th>
<th>Postoperative Barton’s grades</th>
<th>Total number (%)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Grade 0 number (%)</td>
<td>Grade I number (%)</td>
</tr>
<tr>
<td>Group 1</td>
<td>30 (88.2 %)</td>
<td>4 (11.8 %)</td>
</tr>
<tr>
<td>Group 2</td>
<td>31 (83.8 %)</td>
<td>6 (16.2 %)</td>
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Fisher exact two-tailed test, $P = 0.7373 > 0.05$

**Table 3**  Efficacy comparison of two types of operation in treating preoperative Grade II deformity

<table>
<thead>
<tr>
<th>Group</th>
<th>Postoperative Barton’s grades</th>
<th>Total number (%)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Grade 0 number (%)</td>
<td>Grade I number (%)</td>
</tr>
<tr>
<td>Group 1</td>
<td>34 (77.3 %)</td>
<td>10 (22.7 %)</td>
</tr>
<tr>
<td>Group 2</td>
<td>20 (51.3 %)</td>
<td>18 (46.1 %)</td>
</tr>
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Rank-sum test, $P = 0.0142 < 0.05$
A 29-year-old female patient with tear trough deformity and hypertrophy of the orbicularis oculi muscle underwent autologous fat grafting. The deformity improved from preoperative Grade II to postoperative Grade 0 (Fig. 7).

**Patient 4**

A 29-year-old female patient with tear trough deformity and hypertrophy of the orbicularis oculi muscle underwent autologous fat grafting. The deformity improved from preoperative Grade II to postoperative Grade 0 (Fig. 7).

**Discussion**

Tear trough deformity is a noticeable sign of periorbital aging. 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

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**Table 4** Efficacy comparison of two types of operation in treating preoperative Grade III deformity

<table>
<thead>
<tr>
<th>Group</th>
<th>Postoperative Barton’s grades</th>
<th>Total number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grade 0 number (%)</td>
<td>Grade I number (%)</td>
</tr>
<tr>
<td>Group 1</td>
<td>17 (70.8 %)</td>
<td>7 (29.2 %)</td>
</tr>
<tr>
<td>Group 2</td>
<td>3 (12.5 %)</td>
<td>11 (45.8 %)</td>
</tr>
</tbody>
</table>

Rank-sum test, $P < 0.001$

**Table 5** Postoperative complications

<table>
<thead>
<tr>
<th></th>
<th>Group 1 (102 eyes) number (%)</th>
<th>Group 2 (100 eyes) number (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pulpable subcutaneous induration</td>
<td>0 (0)</td>
<td>7 (7.0)</td>
</tr>
<tr>
<td>Unsatisfactory correction or contour irregularity</td>
<td>6 (5.9)</td>
<td>15 (15.0)</td>
</tr>
<tr>
<td>Skin laxity or wrinkles</td>
<td>6 (5.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Edema or ecchymosis (&gt;2 weeks)</td>
<td>22 (21.6)</td>
<td>13 (13.0)</td>
</tr>
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**Fig. 4** A 22-year-old female patient with improvement from Grade II to 0 after a transconjunctival lower blepharoplasty combining fat repositioning and septal reset

**Fig. 5** A 31-year-old female patient with improvement from Grade II to 0 after autologous fat grafting by lipoinjection
orbicularis retaining ligament, and malar retrusion from decreased prezygomatic fat [1, 11–14]. For patients with minimal skin laxity, injection of hyaluronic acid is quick and easy. However, hyaluronic acid and other dermal fillers are expensive in China. Many patients are more willing to choose surgical treatment of tear trough deformity.

Conventional lower blepharoplasty techniques with the removal of intraorbital fat are still widely performed to correct tear trough deformity. However, these techniques tend to make the depression below the lower eyelid more obvious. Because fat excision cannot sufficiently rectify contour irregularities, fat-preserving and fat-repositioning techniques have been proposed. Fat repositioning was first introduced by Loeb [2]. The method was further adapted by Hamra [3], who performed “arcus marginalis release and fat preservation” in his midface rejuvenation. Then Hamra [11] reported his method, by resetting the orbital septum along with the fat at the anterior surface of the orbital rim, the integrity of the septal partition is restored. The vascularized fat volume is delivered to the malar depression. The release of the orbicularis retaining ligament as part of redraping the ptotic orbicularis completes the correction [1]. The newer technique was developed by Liapakis [15], using the method of fat redraping and lateral “eye lift.” All these methods use the transcutaneous approach. The transconjunctival approach was reported by Goldberg [4], who described fixing the pedicled orbital fat in the subperiosteal plane. Kawamoto [5] reported his method of transconjunctival submuscular reposition of pedicled fat. Mohadjer [6] performed lower eyelid blepharoplasty with fat repositioning in an intrasuborbicularis oculi fat dissection plane via a transconjunctival incision.

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. As an ideal autologous filler material, autologous fat has been widely used in facial rejuvenation. It is relatively safe, nonimmunogenic, readily available, easily obtainable, and reproducible [16]. Autologous fat grafting can be performed by lipoinjection. The utilization of sharp needles contributes to precise placement of fat in superficial planes. Although lipoinjection can be performed safely with a sharp needle [17, 18], many surgeons still prefer using a blunt cannula to reduce the risk of vascular complications. Fat grafting can also be performed with lower eyelid blepharoplasty, by placing fat within the orbicularis muscle, slightly caudal to the infraorbital rim directly [19]. Direct fat grafting is performed via a transcutaneous approach. Compared with open approaches, the lipoinjection technique reduces the possibility of fat migration [20].

According to our statistical analysis, orbital fat repositioning produced better results than autologous fat grafting, especially in patients with higher-grade deformities. There are several reasons why orbital fat repositioning is better than autologous fat grafting. First, Wong et al. [21]
confirmed the role of the tear trough ligament—an osteocutaneous ligament at the tear trough that spreads to the orbicularis retaining ligament discovered by Muzaffar [12]—as the main factor in tear trough deformity. The distance from the tear trough ligament to the infraorbital rim is approximately 4–8 mm (average, 5 mm). It is essential to completely release the tear trough ligament to eliminate the tear trough [21]. Lipoinjection does not disrupt the tear trough ligament. Improper placement, above or directly into the tear trough, can increase the tethering effect of the dermal insertions of the ligament and worsen the tear trough deformity [20]. Second, fat grafting has an unpredictable resorption rate [22]. To offset postoperative fat resorption, excess correction of 30–40 % can be performed [23]. However, it remains difficult to estimate the percentage of fat that will remain viable. Patients with higher-grade deformities often require several procedures.

Additionally, fat grafting may carry a higher risk of permanent contour irregularities resulting from subcutaneous induration or firmness that requires surgical intervention to correct [22]. Fortunately, in our study, the seven cases of palpable subcutaneous induration after autologous fat grafting were temporary. These cases were treated with steroid injections. We used a low-dose injection of Diprospan (Compound Betamethasone Injection, Schering-Plough Labo N.V.). Each subcutaneous induration was injected with 0.05–0.1 ml of the steroid, once per month, generally repeated 3 to 4 times. All induration cases resolved without long-term consequences.

The authors prefer the method of orbital fat repositioning with septal reset through a transconjunctival approach. In this surgical technique, the septum and the periosteum still provide support for the underlying fat, and the pressure on the orbital septum from the redraping orbital fat is decreased. Hamra [11] proposed the method of septal reset and performed repositioning of the orbital fat by pulling down the septum along with the underlying fat. By maintaining the length of the septum and spreading it inferiorly, the reset septum was fixed within 5 mm of the infraorbital margin. Also, repositioning with septal reset via a transconjunctival approach resulted in better postoperative improvement compared to redraping of pedicled fat [24]. In our opinion, to fill the tear trough effectively, the orbital fat can be extended more than 5 mm below the infraorbital rim. If the separating range is limited to less than 10 mm below the infraorbital rim, the risk of damaging surrounding nerves is significantly decreased [25]. We use Coated Vicryl Plus Antibacterial Suture (Ethicon, Inc.) internally, so that suture removal is not necessary. Long-term maintenance of buried sutures can provide stability for the repositioned fat, and this suture material persists for a relatively long time before absorption. Considering that the periosteum is a firm and minimally elastic membrane, the surgical difficulty can be reduced by performing dissection on the peristomal surface [5]. Placing anchoring sutures to the posterior orbicularis oculi and supraperiostral plane can better fix the orbital fat in its exact position and rehabilitate the soft tissues as far as possible. The repositioned fat receives adequate blood supply from the abundant vascularity of the supraperiostral plane, possibly reducing fat resorption and providing a longer-lasting effect.

Orbital fat repositioning has a higher possibility of causing persistent edema or ecchymosis than autologous fat grafting. For edema or ecchymosis within the first 2 weeks, we do not normally pursue treatment. However, for cases lasting more than 2 weeks, we advise patients to apply local hot compresses and we prescribe oral medication to reduce the swelling. The longest duration of edema we encountered was 8 weeks, with eventual recovery. Three of 51 patients (six eyes) in Group 1 had worsening of lower eyelid skin sagging. This increased sagging might have occurred because these patients already had mild laxity of the lower lid skin before operation, especially in older patients. Although the patients in our study were relatively young, ranging in age from 20 to 43 years (mean, 32.5 years), we cannot completely eliminate the impact of aging, such as skin or orbicularis oculi muscle laxity. Therefore, we think that we can further modify the procedure using a transcutaneous approach for patients with skin laxity.

**Conclusion**

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

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References
