



Surgical Removal of Fat Nodules Formed in the Tear Trough After Autologous Fat Grafting

Zhengang Li¹ · Ziming Zhang² · Tao Ma³ · Jintian Hu⁴ · Lianji Xu³



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Abstract

Background Autologous fat grafting is a common treatment for tear trough deformities. This procedure involves a potential complication of fat nodule formation, leading to abnormal bulging of the lower eyelid. However, limited information exists about this complication, and an effective treatment is lacking. The present study aimed to present a novel surgical approach for the removal of fat nodules caused by autologous fat grafting in the tear trough.

Methods This retrospective study included 33 patients who underwent surgery for the removal of fat nodules formed after autologous fat grafting. The procedure was performed using a conjunctival approach, allowing exposure and removal of all fat nodules in the anterior septal space, with the method adapted according to the severity of the deformity.

Results A total of 66 eyelids were treated surgically, including 30 (45.45%) with mild nodular deformity, 23 (34.85%) with moderate nodular deformity, and 13 (10.70%) with severe nodular deformity. A second surgical

procedure was required on 3 eyelids (4.56%). The main complications of the surgery were conjunctival congestion (21.21%), and localized depression (18.18%), bruising (12.12%). Among the patients, 29 (87.88%) were satisfied and 4 (12.12%) were dissatisfied with the treatment results.

Conclusion Conjunctival approach surgery is an effective method of removing fat nodules formed after autologous fat grafting in the tear trough, with good results and high levels of patient satisfaction. This approach enables the effective management of a common complication of autologous fat grafting and may enable the wider application of autologous fat grafting in the periorbital region.

Level of Evidence III This journal requires that 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 www.springer.com/00266.

Keywords Conjunctival approach · Autologous fat grafting · Fat nodules · Tear trough

✉ Lianji Xu
lianjixu@163.com

¹ Plastic Surgery Department, Boai Hospital of Huanghua Development Zone, Cangzhou 061100, Hebei Province, China

² Department of Ear Reconstruction, Plastic Surgery Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100144, China

³ Department of Plastic and Reconstructive Surgery, Beijing Tongren Hospital, Capital Medical University, 1 Dongjiaominxiang Lane, Beijing 100730, China

⁴ Department of Cosmetic Injection Center, Plastic Surgery Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100144, China

Introduction

Tear trough deformity arises from weakened fibrous support structures, decreased muscle tone, lower eyelid swelling, and orbital fat bulging outwards due to weakness in the orbital septum [1]. The tear trough is anatomically located below the lower eyelid margin, in an arc from the medial canthus to the midpoint of the pupil. Advanced injection techniques, including autologous fat grafting and the injection of various filler materials, such as hyaluronic acid, poly-L-lactic acid, and hydroxyapatite, have been developed to treat tear trough deformities [2, 3]. Owing to the advantages of autologous fat grafting, including the

easy availability of and access to material and the lack of a rejection response, its application in the treatment of tear trough deformity has proven effective. However, this approach has been associated with adverse effects, such as the formation of fat nodules, fat migration, and fat necrosis, which have restricted its use [4].

In addition, little is known about the fat nodules caused by autologous fat grafting for the treatment of tear trough deformity, and an effective remedy for this complication is lacking. In this study, we aim to present a novel surgical approach for the removal of fat nodules caused by autologous fat grafting in the tear trough. We retrospectively analyzed data on 33 patients who developed fat nodules after tear trough autologous fat grafting and propose a surgical approach to treat this issue; good treatment results were obtained, and patient satisfaction was high throughout the follow-up period. In addition, we have a detailed grading of the nodules caused by the appearance of autologous fat grafting according to the severity of the patient's condition, providing us with a better understanding of this complication.

Patients and Methods

The study was conducted by the principles outlined in the Declaration of Helsinki and was approved by our institutional ethical review board. Written consent was obtained from the patients for the use and analysis of their data. We recorded the data of 33 patients who presented to our clinic after developing fat nodules following tear trough autologous fat grafting between December 2019 and December 2022; in total, 66 eyelids were treated. Data on patient sex, age, and treatment satisfaction were collected, as well as information on the number of surgeries performed and the surgical complications reported. Photographs were taken before and after treatment under standard positioning and illumination. The severity of the deformities was assessed and classified as shown in Fig. 1 and Table 1.

Surgical Technique

As most of the autologous fat grafts and the resulting the fat nodules were situated beneath the orbicularis oculi muscle, adhering closely to it, we opted for the transconjunctival approach. This choice aimed to delicately excise the fat nodules produced after the grafts were also located under the orbicularis oculi muscle while minimizing complications, such as orbicularis oculi muscle injuries and lower eyelid hollowing, due to incision of the orbicularis oculi muscle. The patient is in the supine position with eyes closed. After disinfection of the surgical area, local anesthesia was administered using lidocaine injection. After the

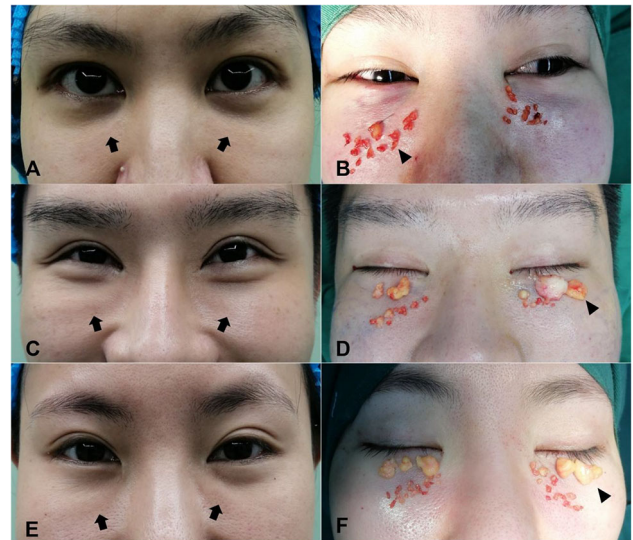


Fig. 1 The severity of the deformities. Mild deformity (A and B), Moderate deformity (C and D), Severe deformity (E and F). A Mild abnormal bulge as indicated by the arrows. B Granular fat nodules were removed intraoperatively as indicated by the arrowhead. C Localized significant bulge on smiling as indicated by the arrows. D Fat nodules were removed intraoperatively, with a lamellar nodule indicated by the arrowhead. E Obvious abnormal bulges visible at rest as indicated by the arrows. F Nodules were removed intraoperatively, with a large and deeply located example indicated by the arrowhead

completion of anesthesia was completed, the conjunctiva of the lower eyelid was exposed by holding the lid margin with forceps and gently turning it outward. A mid-conjunctival incision was made, approximately 1 cm in length, and scissors were introduced into the incision to access the anterior orbital septum, gently separating the tissue between the orbicularis oculi muscle and the orbital septum to determine the location of the fat graft. Subsequently, using a pulling hook, the lower eyelid was lifted downward and forward from the conjunctival incision to fully expose the fat nodule under the orbicularis oculi muscle. The fat nodules were then individually excised using hemostats and forceps in the direction of the orbicularis oculi muscle bundle texture. For mild deformities, we used forceps to carefully peel all fat nodules as they were few in number and in isolated granules under the orbicularis oculi muscle. For moderate nodules, the number of fat nodules under the orbicularis oculi muscle was high, appearing as strips wrapped by fibrous connective tissue. Therefore, we individually excised the fat nodules in the direction of the orbicularis oculi muscle texture until the striped structure disappeared. For severe nodules, the fat nodules were more numerous and larger in size, and most of them were in the form of clumps that formed extensive adhesions with the orbicularis oculi muscle. Thus, we exercised utmost care during the dissection process, and some of the patients required a second surgery (Fig. 2). Post-operative

Table 1 The severity of the deformities

	Visual diagnosis of nodules at rest	Visual diagnosis of nodules during smile	Palpation of nodules	Nodule morphology
Mild deformity	–	+	+	Nodules are granular in shape
Moderate deformity	+	+	+	Nodules are striated in shape
Severe deformity	+	+	+	Nodules are in the form of clusters

Fig. 2 Surgical procedure.

A Selection of retroconjunctival approach. **B** Freeing the anterior orbital septum and exposing the fatty nodule. **C** Removal of the fatty nodule



instructions included immediate post-operative icing, no massage or severe rubbing of the lower eyelid area, and no other precautions beyond that.

Photographs were taken immediately after completion of the surgery, with the patients in the same position. All patients were followed up for 6 months. Photographs were taken at each visit, and patient satisfaction, the occurrence of adverse events, and the follow-up time were recorded to evaluate the outcomes of this surgical modality.

Table 2 Patient characteristics

Characteristic	Value
Sex, patient <i>n</i> (%)	
Male	2 (6.06%)
Female	31 (93.94%)
Age (years), mean (range)	28.7 (25–32)
Severity of deformity, eyelid <i>n</i> (%)	
Mild	30 (45.45%)
Moderate	23 (34.85%)
Severe	13 (10.70%)
Number of surgeries, eyelid <i>n</i> (%)	
1	63 (95.44%)
2	3 (4.56%)
Follow-up time (months), median (range)	15 (6–36)

Results

The patient characteristics are presented in Table 2. A total of 33 patients were included in this study, of whom two (6.06%) were male and 31 (93.94%) were female. The mean patient age was 28.7 (range, 25–32) years. Autologous fat grafting was performed on a total of 66 eyelids, of which 30 (45.45%), 23 (34.85%), and 13 (10.70%) had mild, moderate, and severe deformities, respectively. Three eyelids (4.56%) all with severe deformities continued to have nodules after one treatment and thus underwent two surgical treatments.

Patient satisfaction and the reported side effects of the surgery are presented in Table 3. The 33 patients who underwent surgical treatment were monitored over a median follow-up period of 15 months. Among all patients, 29 (87.88%) were satisfied and 4 (12.12%) were dissatisfied with the outcome of the treatment. Patient dissatisfaction may be due to repeat surgeries, as three of the four dissatisfied patients required a second procedure. The main

Table 3 Patient satisfaction and adverse events

Post-operative outcome	Value
Patient satisfaction, patient <i>n</i> (%)	
Satisfied	29 (87.88%)
Dissatisfied	4 (12.12%)
Adverse events, eyelid <i>n</i> (%)	
Bruising	36 (54.54%)
Localized depression	12 (18.18%)
Conjunctival congestion	14 (21.21%)

complications of the surgical procedure included conjunctival congestion, bruising, and localized depression. Most adverse effects did not require special treatment and disappeared upon absorption of the surgical edema. Further details on two representative surgical cases, along with images, are provided below.

Case 1 A 28-year-old female presented with mild deformity of the right eyelid and severe deformity of the left eyelid due to fat nodule formation. After one surgical treatment, the bulge at the lower eyelid disappeared and smiling no longer resulted in a localized bulge. The patient was very satisfied with the results of the treatment. We followed up on this patient for 6 months and she maintained a flat lower eyelid area without any abnormalities (Fig. 3).

Case 2 A 30-year-old female patient presented with mild deformity of the right eyelid, with a localized bump visible when smiling. This patient underwent one surgical treatment and was followed up for 6 months. She was satisfied with the results of the treatment, as the abnormal bulge of the lower eyelid disappeared and flattened out locally after surgery (Fig. 4).

Discussion

The rejuvenation of the lower eyelids is extremely challenging. The tear trough is located in an arcuate line extending from the inner corner of the eye to the midpoint of the pupil just below the lid margin of the lower eyelid. Tear trough deformities are depressions in the tear trough region, which often manifest as dark circles under the eyes, causing the appearance of age and fatigue [5, 6]. Tear trough deformity is associated with a number of factors, including collapse of the bony structures of the face with age, decrease in soft tissue volume, weakened orbital septum and ligamentous structures, and herniation of the periorbital fat through the flaccid orbicularis oculi muscle, collectively deepening the depressions in the tear trough region [5].

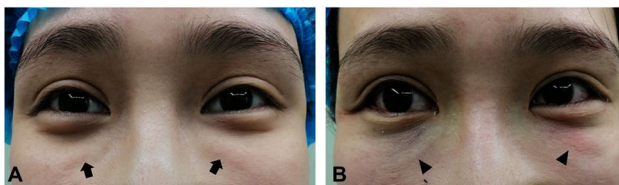


Fig. 3 Case 1, a 28-year-old female undergoing removal of fat nodules caused by autologous fat grafting. **A** Preoperatively, the patient had a severe deformity of the left lower eyelid and a left-sided mild deformity of the right lower eyelid, as indicated by the arrows. **B** Postoperatively, there was a significant improvement in the bilateral deformity, as indicated by the arrowheads

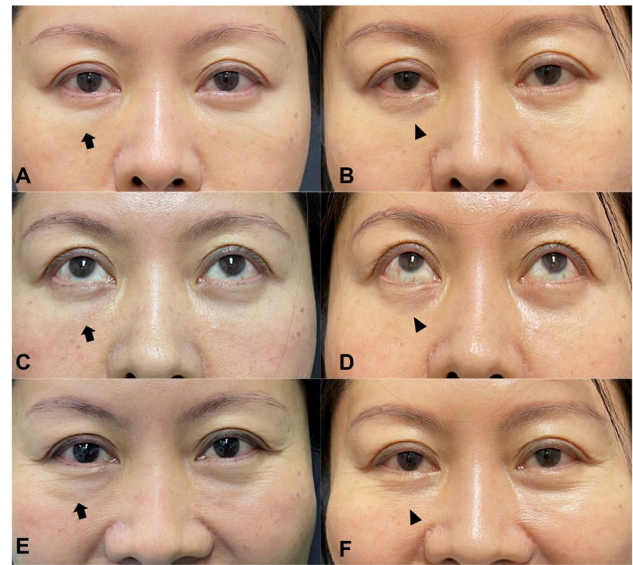


Fig. 4 Case 2, a 30-year-old female undergoing removal of fat nodules caused by autologous fat grafting. Images were captured in plano view (**A** and **B**), supraoptic view (**C** and **D**), and when smiling (**E** and **F**). Photographs were taken preoperatively (**A**, **C**, and **E**) and 6 months postoperatively (**B**, **D**, and **F**). Abnormal bumps are indicated by the arrows and the disappearance of these bumps is indicated by the arrowheads

A variety of surgical and nonsurgical methods can be used to address tear trough deformities, with injections of filler materials becoming increasingly popular owing to their less invasive nature, good results, and fewer side effects. Autologous fat grafting techniques have improved since the procedure was first proposed by Neuber in 1893, and after being popularized by Coleman, becoming an important method of facial rejuvenation [7–9]. The advantages of autologous fat grafting for the treatment of tear trough deformities lie in the use of fat as a filler material, which is richer and more durable than other chemicals used. Moreover, as it is obtained from the patient, it is non-immunogenic; thus, it will not undergo rejection and has a higher potential for persistence [4, 10]. However, due to the specific anatomy of the eyelid region, autologous fat grafting can still induce adverse events, including volume under- or overcorrection, edema, bruising, fat migration, formation of fat nodules, and, rarely, severe complications such as blindness and stroke [10–12].

Lower eyelid fat nodule formation is often associated with overcorrection of tear trough autologous fat grafting, resulting from excessive injection dose or superficial injection site [13, 14]. However, limited knowledge and treatment options are available for this complication. In the present study, we graded the severity of the nodules based on the patient's clinical presentation. Our aim was to diagnose the nodules, estimate in advance the amount to be removed, treat all fat nodules thoroughly, eliminate the

bulge in the lower eyelid area, and flatten the lower eyelid. To treat this complication, we chose a conjunctival approach to the procedure (Video). The choice of a conjunctival approach allows the surgical incision to be skillfully masked and avoids disrupting the aesthetic features of the periorbital region. In addition, the conjunctival approach allows us to more easily access the anterior orbital space between the orbital septum and the orbicularis oculi muscle, which is the most common area for autologous fat grafting to produce fat nodules. Moreover, it allows us to fully expose the fat nodules wrapped around the deeper surface of the orbicularis oculi muscle, enabling the easy removal of all fat nodules. An important advantage of this surgical approach over the transcutaneous approach is that it avoids damage to the orbicularis oculi muscle due to incision of the orbicularis oculi muscle, which can lead to lower eyelid depression (Fig. 5). For mild and moderate malformations, all fat nodules can usually be completely removed in a single operation; for some severe moderate and severe malformations with a large number of fat nodules and a wide distribution of fat nodules, there may be residual fat nodules after the operation, which may require a second operation.

Of these, fat nodules tend to cause patient dissatisfaction, as they typically present as a palpable and abnormal bulge in the lower eyelid, which is usually exacerbated by smiling. All patients included in this study presented with fat nodules and requested further treatment. We identified three main reasons for the appearance of this deformity. First, the grafting position is too shallow, and the grafts are displaced with the surge of the facial muscles. Second, the fat particles do not “seed” uniformly after grafting, but instead cluster together to form fat nodules. Third, injecting a large volume of fat leads to large local nodules or even hard lumps, which are especially visible when smiling. The mechanism underlying fat nodule production is mainly due to the unpredictable number of fat grafts that survive, resulting in contour irregularities and under-correction. To counteract fat absorption, the surgeon injects additional fat, leading to overcorrection and causing the production of fat nodules and lumps that are abnormally raised [15]. Moreover, the grafted adipose tissue requires diffused plasma to

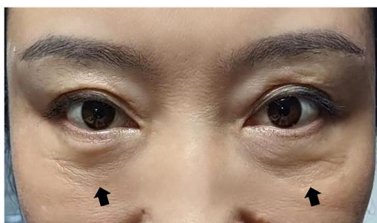


Fig. 5 Orbicularis oculi muscle injury due to percutaneous access surgery. Indentation due to orbicularis oculi muscle injury at the arrows

provide nutrients until new capillaries are formed. The presence of excessive grafted adipose can lead to necrosis of distant adipose tissues, as they fail to obtain nutrients. The dead adipocytes will be then phagocytosed by macrophages and replaced by scar tissue and oil cysts, resulting in the production of fat nodules that lead to contour irregularities [15, 16]. To minimize the production of fat nodules after autologous fat grafting in the lower eyelid, fat can be injected using a microdroplet technique, with fat particles up to 2 mm in diameter, using a blunt cannula to inject small portions of fat (no more than 0.05 cm³ at a time) placed in the lower eyelid area in a total volume of 1–3 mL, preventing overcorrection [13, 17]. In addition, precise surgical design and safe surgical procedures can largely minimize autologous fat grafting complications through proper patient assessment [14, 18].

This study had some limitations. First, our sample size was small, and we lacked specificity in grading the severity of fat nodules. Therefore, further accumulation of samples is required to summarize the characteristics of fat nodules of different severities and improve the grading system. Second, this study was retrospective without control, and some patient data were lost during the follow-up. Thus, prospective studies designed to explore the therapeutic effect of this procedure are required. Finally, more studies are still required to elucidate the mechanism of fat nodule production. Despite these limitations, we demonstrated that this surgical approach has favorable outcomes and patient satisfaction through the follow-up of 33 cases. During the procedure, we considered the periorbital aesthetic features and sought a balance between removing the grafted fat and maintaining the flatness of the lower eyelid, avoiding the appearance of lower eyelid depressions after stripping the fat nodules. At follow-up, we observed that all patients had a flatter lower eyelid area with no lower eyelid depression compared to the preoperative period, and the appearance of the periorbital region was significantly improved. In addition, the procedure was minimally invasive, safe, and had fewer complications. Surgical complications include conjunctival congestion, localized depression and bruising, which usually disappear on their own without treatment. Therefore, this procedure can serve as a good alternative for the treatment of fat nodules due to autologous fat grafting in the tear trough and can effectively address the complications caused by autologous fat grafting, making the autologous fat grafting technique more widely used.

Conclusion

The formation of fat nodules is an important complication of autologous fat grafting, disrupting the aesthetic features of the lower eyelid and affecting the outcome of tear trough

autologous fat grafting. The deformity caused can be graded according to severity; these different grades are caused by different types of fat nodules. A conjunctival approach surgery is an effective way to remove fat nodules due to tear trough autologous fat grafting, with good outcomes and high levels of patient satisfaction. The dissemination of this surgical approach, which allows the effective management of a common complication of autologous fat grafting, may enable the wider application of autologous fat grafting in the periorbital region.

Authors' Contributions ZL and ZZ contributed equally to this work. LX developed the idea and provided the data for the study. ZL and ZZ analyzed the data and wrote the paper. Other co-authors collect literature and polish the paper.

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Declarations

Conflict of interest The authors have no financial interest to declare in relation to the content of this article.

Human and Animal Rights The ethical principles outlined in the Declaration of Helsinki were followed.

Patient Consent on File Consent for the publication of recognizable patient photographs or other identifiable material was obtained by the authors and included at the time of article submission to the journal stating that the patients gave consent with the understanding that this information may be publicly available.

References

- Coban I, Derin O, Sirinturk S, Pinar Y, Govsa F (2023) Anatomical basis for the lower eyelid rejuvenation. *Aesthet Plast Surg* 47:1059–1066
- Lipp M, Weiss E (2019) Nonsurgical treatments for infraorbital rejuvenation: a review. *Dermatol Surg* 45:700–710
- Attenello NH, Maas CS (2015) Injectable fillers: review of material and properties. *Facial Plast Surg* 31(1):29–34
- Roh MR, Kim TK, Chung KY (2009) Treatment of infraorbital dark circles by autologous fat transplantation: a pilot study. *Br J Dermatol* 160:1022–1025
- Stutman RL, Codner MA (2012) Tear trough deformity: review of anatomy and treatment options. *Aesthet Surg J* 32:426–440
- Corduff N (2020) An alternative periorbital treatment option using calcium hydroxyapatite for hyperpigmentation associated with the tear trough deformity. *Plast Reconstr Surg Glob Open* 8:e2633
- Coleman SR (2008) Long-term survival of fat transplants: controlled demonstrations. *Aesthet Plast Surg* 44:1268–1272
- Shue S, Kurlander DE, Guyuron B (2018) Fat injection: a systematic review of injection volumes by facial subunit. *Aesthet Plast Surg* 42:1261–1270
- Billings E Jr, May JW Jr (1989) Historical review and present status of free fat graft autotransplantation in plastic and reconstructive surgery. *Plast Reconstr Surg* 83:368–381
- Ciuci PM, Obagi S (2008) Rejuvenation of the periorbital complex with autologous fat transfer: current therapy. *J Oral Maxillofac Surg* 66:1686–1693
- Feinendegen DL, Baumgartner RW, Vuadens P et al (1998) Autologous fat injection for soft tissue augmentation in the face: a safe procedure. *Aesthet Plast Surg* 22:163–167
- Yoon SS, Chang DI, Chung KC (2003) Acute fatal stroke immediately following autologous fat injection into the face. *Neurology* 61:1151–1152
- Lam SM, Glasgold RA, Glasgold MJ (2008) Limitations, complications, and long-term sequelae of fat transfer. *Facial Plast Surg Clin North Am* 16:391–399
- Maamari RN, Massry GG, Holds JB (2019) Complications associated with fat grafting to the lower eyelid. *Facial Plast Surg Clin North Am* 27:435–441
- Cuzalina A, Guerrero AV (2018) Complications in fat grafting. *Atlas Oral Maxillofac Surg Clin North Am* 26:77–80
- Mashiko T, Yoshimura K (2015) How does fat survive and remodel after grafting. *Clin Plast Surg* 42:181–190
- Kranendonk S, Obagi S (2007) Autologous fat transfer for periorbital rejuvenation: indications, technique, and complications. *Dermatol Surg* 33:572–578
- Bellini E, Grieco MP, Raposio E (2017) The science behind autologous fat grafting. *Ann Med Surg (Lond)* 24:65–73

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