



Repair Techniques for Failed Double-Eyelids Involving Restoration of Eyelid Anatomical Structure and Function

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Abstract

Background This study aimed to evaluate techniques for repairing previously failed double-eyelid surgeries based on different anatomical structure injuries.

Methods A total of 120 patients with failed double-eyelids in our hospital were enrolled and classified into four types according to their anatomical structure damage: type I, unsmooth radians of the double-eyelid line; type II, upper socket depression; type III, iatrogenic ptosis; and type IV, comprehensive damage. Accordingly, methods of restoration included orbital septum fat supplement, repair of levator palpebrae superioris, and treatment of scar. Post-operative follow-up time points were 1 week, 1 month, and 6 months. Outcome observations were binocular symmetry, fluency of double-eyelid, scar recovery, height and contour profile of the upper eyelid margin, and plumpness of the upper eyelid. The eyelid morphological score was evaluated using photographs of preoperative and 6-month postoperative data, and the effect of eyelid repair was evaluated objectively by statistical analysis.

Results At 1 month after surgery, the height of the upper palpebral margin was maintained in most patients and located at 1–2 mm below the superior limbus. At 6 months after surgery, most patients had better restorative effects. Comparison of mean eyelid morphological scores showed a statistically significant improvement following surgery ($P < 0.001$).

Conclusions The technique of restoring eyelid anatomical structure in failed double-eyelids not only recovered the normal function of injured eyelids but also produced satisfactory aesthetic effects.

Level of Evidence IV 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 Double-eyelids · Repair surgery · Ptosis · Socket · Fat transplantation · Anatomy

Introduction

It has been reported that 30–60% of Asians are characterized by a single eyelid [1]. The double-eyelid shape is considered a more attractive trait [2, 3]. Thus, double-eyelid surgery represents one of the most common cosmetic procedures in Asia [4]. Traditional double-eyelid surgery is performed by removing the orbicularis oculi muscle (OOM) and orbital septum fat (OSF) in large quantities [3, 5]. A cicatricial double-eyelid is subsequently formed by stable scar adhesion among the levator aponeurosis, tarsus, and skin. This process may result in serious damage to the eyelid anatomical structure and subsequent complications, such as concave scar around the double-eyelid line, eye socket depression, and iatrogenic ptosis. These complications lead to not only undesirable changes in appearance and functional damage but also psychological trauma to patients [6]. Therefore, it is necessary to perform effective repair as soon as possible. Moreover, failed double-eyelid surgery has been reported. Some studies have reported only one cause and treatment

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for the adverse symptoms after double-eyelid surgery, such as the report by Kim et al. [7], in which wide double-eyelids were corrected using wide dual-plane dissection. Martin [8] reported ptosis repair for aesthetic blepharoplasty. Park [9] reported the repair of eye socket depression by fat filling. Kim et al. [10] removed multilaminated septal structures and used grafting of preaponeurotic fat to repair unsatisfactory blepharoplasty. However, the causes of the failure of double-eyelid surgery are various and complicated [11]. Currently, there are no related reports, and classification of clinical manifestations and evaluation of causes are performed preoperatively. The anatomical structure of the injury is identified, and the corresponding repair methods are intraoperatively adopted so as to achieve anatomic repair.

This study aimed to evaluate techniques for repairing previously failed double-eyelid surgeries based on different anatomical structure injuries. A total of 120 cases of failed double-eyelid surgery were presented at our hospital. By systematically analyzing the causes of previous failures before repair surgery, we developed targeted remedies, for which we present the 6-month outcomes.

Materials and Methods

Ethics Statement

This retrospective, interventional, nonrandomized observational study was approved by the local ethics committee of our institution and performed in accordance with the regulations of good clinical practice. After a thorough explanation about the nature of the study, all patients agreed to participate and provided written informed consents to participate prior to study entry. Signed consent was obtained from patients for all clinical photographs that permit their identification and is archived by the authors. Furthermore, this study conformed to the ethical standards outlined in the Declaration of Helsinki, as amended in 2013.

Indications

Between October 2016 and April 2018, we recruited 120 patients with different types of failed double-eyelids in our hospital. The photographs of patients in a primary gaze without eyebrow lifting were collected before surgery. Based on past surgical history, ophthalmic examination, and data from photographs, an accurate evaluation and prediction was achieved according to the condition of upper eyelid anatomical structure, such as orbicularis, orbital fat, or palpebralis. There were four types of damage: type I, unsmooth radians of the double-eyelid line; type II,

upper socket depression; type III, iatrogenic ptosis; and type IV, comprehensive damage (including two or more of the above). There were no primary cases. Congenital ptosis was excluded from this study. The natural conditions and preoperative examination results of patients are summarized in Table 1.

Surgical Technique

Fat Block Preparation

Fat block extraction: In patients with eye socket depression, we prepared the fat mass for autologous transplantation in advance according to the preoperative assessment and prejudgment of orbital fat loss. Fat block extraction was performed by one doctor almost simultaneously with eyelid repair performed by another doctor. The adipose tissue for conventional transplantation was obtained from the periumbilical tissue using the following methods: The abdomen was routinely disinfected, followed by local infiltration anesthesia on the left or right side of the umbilical cord. A skin incision (approximately 8 mm) was created along the umbilical fossa. Subcutaneous tissue was separated, and the adipose layer was exposed. Two whole fat masses (approximately 1.5 mm³) were obtained and placed in saline as reserves. The incision was sutured discontinuously using 5-0 nylon thread and pressure dressing.

Design of Double-Eyelid Incision

The design of double-eyelid height and radians was based on patients' needs and current conditions and in accordance with the Asian double-eyelid aesthetic index [12]; that is, the distance from the upper eyelid margin to the upper eyelid should be approximately 5–8 mm. The primary and secondary considerations were ensuring an ideal double-eyelid shape and removing the primary incision scar, respectively. If the skin was abundant, the original scar was removed by double-eyelid design.

Surgical Procedures of Repair

(1) The surgery was performed under local anesthesia (mixture of 0.5% lidocaine and 1:200,000 epinephrine) with patients in a supine position. (2) Scar adhesion release: Skin incision was performed along a predesigned double-eyelid line. The scar adhesion was loosened completely according to the anatomical level. To avoid secondary damage, attention was paid to protect the fascia anterior to the tarsal plate and levator aponeurosis. (3) Repair of injured levator palpebrae superioris (LPS): The levator aponeurosis was exposed, and the extent and location of injury to the muscle were evaluated. If the

Table 1 Preoperative data of patients

Types of anatomical structure damage	No. of patients				
	Sex		Total (%)	Age (mean)	Number of double-eyelid surgeries (mean)
	Men	Women			
I	2	6	8 (7%)	24.5	1.7
II	0	12	12 (12%)	28.4	1.6
III	6	11	17 (14%)	32.3	2.7
IV	3	80	83 (69%)	34.1	3.1
Total	11	109	120	–	–

Type I, unsmooth radians of the double-eyelid line; type II, upper socket depression; type III, iatrogenic ptosis; type IV, comprehensive damage (including two or more of the above)

aponeurosis of LPS was broken at the upper edge of the tarsal plate, the fracture site was sutured to the attachment point with 6-0 nylon thread. If it was lacerated, the damage site was repaired carefully with a 6-0 absorbable line. The strengthening and shortening of LPS was also necessary when it was thin or fibrotic, affecting its function. The standard of restoration was the upper eyelid margin radian and height to achieve satisfactory results. (4) Supplement of socket depression: The eye socket depression could be filled with the prepared periumbilical fat, which was trimmed according to the missing amount. The transplanted fat mass was laid flat on the surface of LPS and fixed between the upper margin of the tarsus and residual orbital septum with 6-0 absorbable line. (5) Repair of the pretarsal orbicularis muscle: If there was further loss of the pretarsal orbicularis muscle, “U flap” transposition of the OOM of the anterior orbital septum was performed. If there was insufficient OOM, a moderate dermis was cut from the periumbilical space and fixed on the anterior surface of tarsal plate with 6-0 absorbable line. (6) Double-eyelid formation: The OOM between the upper and lower lip of the double-eyelid was sutured with 6-0 absorbable line at internal, medial, and lateral sites, and a small amount of pretarsal tissue at these sites was carried respectively. The purpose of this procedure was to ensure anatomical restoration of the OOM with stable double-eyelid formation. Discontinuous suture of the skin incision was performed with 7-0 mousse line, and a small amount of pretarsal tissue was carried to form smooth double-eyelid radians (Fig. 1).

Postoperative Care

Intermittent ice deposition was applied on the surgical eyelid within 24 h after surgery. Surgical dressing was changed on day 2, and the suture was removed on day 7 after surgery.

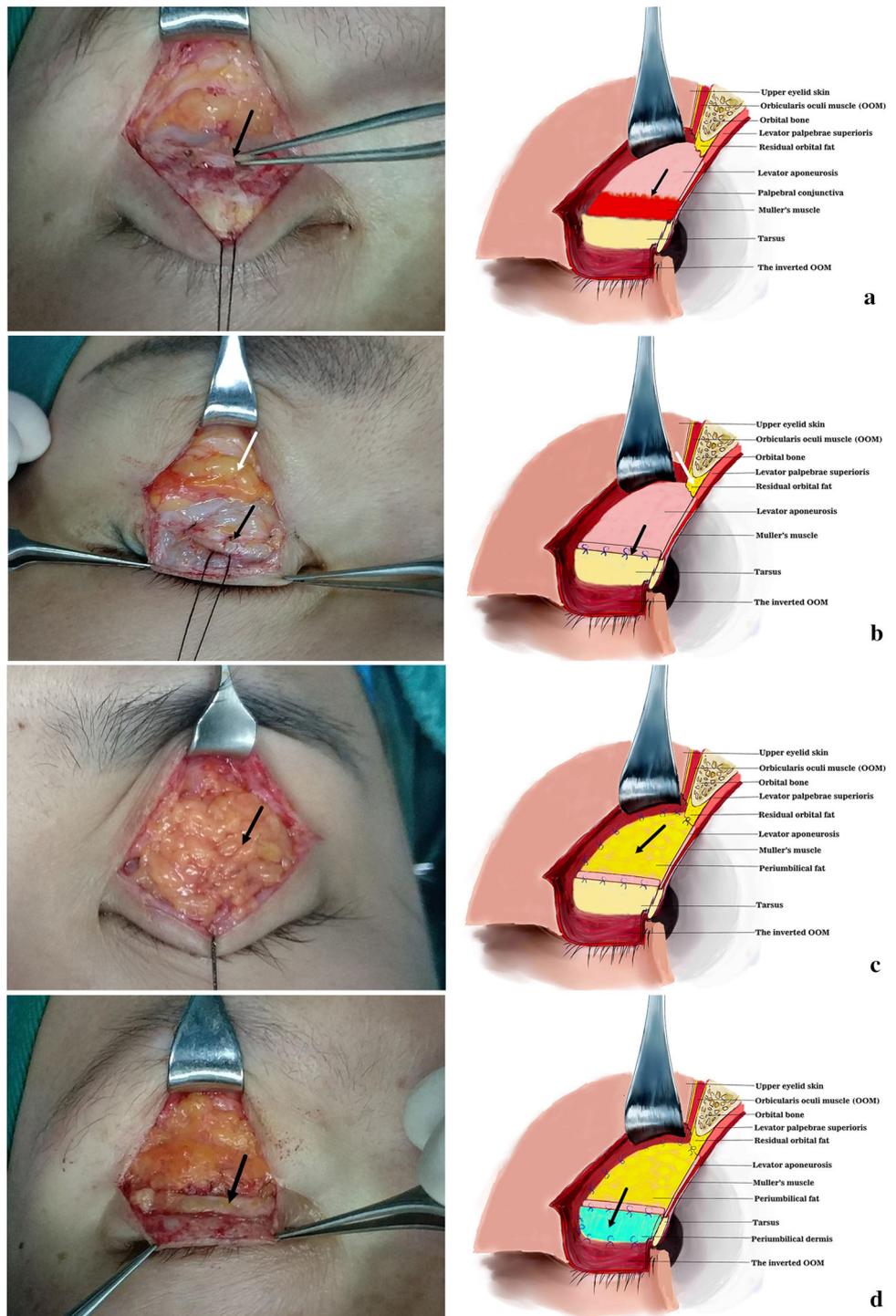
Postoperative Evaluation of Efficacy

Patients were followed up at 1 week, 1 month, and 6 months after surgery. Standard photographs of open eyes were collected. The following outcomes were evaluated by three experienced plastic surgeons: (1) score according to the double-eyelid shape, including three aspects: bilateral double-eyelid symmetry, double-eyelid radian fluency, and the degree of scar; (2) score according to the distance between highest point of the upper orbital margin and lowest point of the upper eye socket (Table 2) [9]; (3) score according to the height of upper eyelid margin below the superior limbus and its radian [13–16]. The scores before and at 6 months after surgery were summarized in MS Excel 2016 and analyzed using SPSS 24.0 (IBM, Armonk, NY).

Results

At 1 week after surgery, the eyelids of type I and III patients were slightly swollen, and the degree of swelling was slightly higher in type II and IV patients. At 1 month after surgery, type I patients had better recovery with respect to double-eyelid fluency, height of eyelid margin, and binocular symmetry. Type II patients had full sockets; the height of the upper palpebral margin was located at approximately 2 mm below the corneal limbus, and the fluency of double-eyelids was good. All type III patients except for two with blepharomarginal height (sublimbal, 2 mm) showed good results with respect to the height of upper eyelid margin, fullness of eye socket, and shape of double-eyelid. All type IV patients had good socket fullness. Except for eight patients with blepharomarginal height (sublimbal, 2–3 mm), others had good height of the eyelid edge and double-eyelid shape. At 6 months after surgery, the recovery of type I patients was stable. One type II patient had slight plumpness of the upper eye socket

Fig. 1 Main procedures and corresponding schematics of surgical processes for the repair of failed double-eyelids. The left figure shows the surgical procedure, whereas the right figure shows the corresponding schematic diagram. **a** The levator aponeurosis breaks from the upper edge of the tarsal plate. The black arrow indicates the fracture in the levator aponeurosis. **b** Repair of the injured levator aponeurosis: The black arrow indicates that the fracture site was sutured to the attachment point, whereas the white arrow shows the fracture in the residual orbital fat, which is pulled out of the orbit with fixation of the levator aponeurosis. **c** Supplement of socket depression: The periumbilical fat mass is laid flat on the surface of the levator palpebrae superioris. The black arrow shows the fixed periumbilical fat. **d** Repair of the pretarsal orbicularis muscle: The “U flap” transposition of the orbicularis oculi muscle or moderate dermis cut from the periumbilical space was fixed on the anterior surface of the tarsal plate. The black arrow shows the fracture in the periumbilical dermis



with a preoperative score of -3 , and one type III patient had slightly lower upper eyelid margin with a preoperative score of -2 . Four type IV patients with a preoperative ptosis score of -3 had poor upper eyelid margin height, and three with preoperative score of -3 for upper eyelid socket depression had poor plumpness of the upper eye socket. The remaining patients had normal upper eyelid

margin height and full eyelid sockets, and the double-eyelid radians were smooth with symmetrical eyelids (Figs. 2, 3, 4, and 5).

Postoperative improvement was assessed by calculating the difference (delta) between pre- and postoperative scores (double-eyelid shape, upper eyelid height, and extent of depression). The Q–Q diagram shows that all data

Table 2 Codes of the eyelid morphological score

Score	Double-eyelid shape	Extent of depression (sunken index)	Upper eyelid height
0	Double-eyelid line symmetry and fluency, without sunken scar	Full and moderate	Normal upper eyelid height of 1–2.0 mm below the superior limbus
– 1	Double-eyelid line asymmetry but fluency, without sunken scar	A sinking depth of 0.5 cm or less and slight depression	Upper eyelid height of 4.0 mm or less below the superior limbus
– 2	Double-eyelid line asymmetry and no fluency, without sunken scar	A sinking depth of 0.5–1 cm, with a prominent depressed area	Upper eyelid height of 4.0–6 mm below the superior limbus
– 3	Double-eyelid line asymmetry and no fluency, with sunken scar	A sinking depth of 1 cm or more	Upper eyelid height of 6 mm or more below the superior limbus



Fig. 2 A 26-year-old woman complained of failed eyelids (type II, upper socket depression) for 8 months after the second double-eyelid surgery. She underwent double-eyelid incision redesign and periumbilical fat supplement. **a** Preoperative photograph; **b** postoperative photograph at 6 months after surgery, showing full eyelid, normal eyelid margin, and symmetrical eyes

were normally distributed. The operative effect based on paired *t* test of delta in each scoring category was remarkable, and all results were statistically significant ($P < 0.001$) (Table 3).

Discussion

Eyelids, which are at the center of the face, play an important role not only in appearance but also in protecting the eyeball because of their complete structure and physiological function. The functional structures of the upper eyelids closely related to the double-eyelids include the LPS, OSF, OOM, and nerves and lymphatics. The main



Fig. 3 A 32-year-old woman complained of failed eyelids (type III, iatrogenic ptosis) for 9 months after the third double-eyelid surgery. She underwent double-eyelid incision redesign and levator aponeurosis repair. **a** Preoperative photograph; **b** postoperative photograph at 6 months after surgery, showing full eyelid, normal eyelid margin, and symmetrical eyes

function of the levator aponeurosis may be to elevate the eyelid margin [17]. The presence of adipose tissue in the orbital septum promotes sliding between the LPS and OOM, supports the upper eyelid shape, and keeps the upper eyelids younger [18, 19]. On the one hand, this physiological contraction of the pretarsal orbicularis muscle can close the eyelid to the surface of the eyeball; on the other hand, it can extrude the tarsus and promote the release of lipids from the tarsal gland. Furthermore, nerves and lymphatics are present in the pretarsal orbicularis muscle [8, 20–22]. However, in traditional double-eyelid surgery, a large number of pretarsal orbicularis muscles and OSF are removed, and the levator aponeurosis is damaged. Injury to these structures results in many morphological and

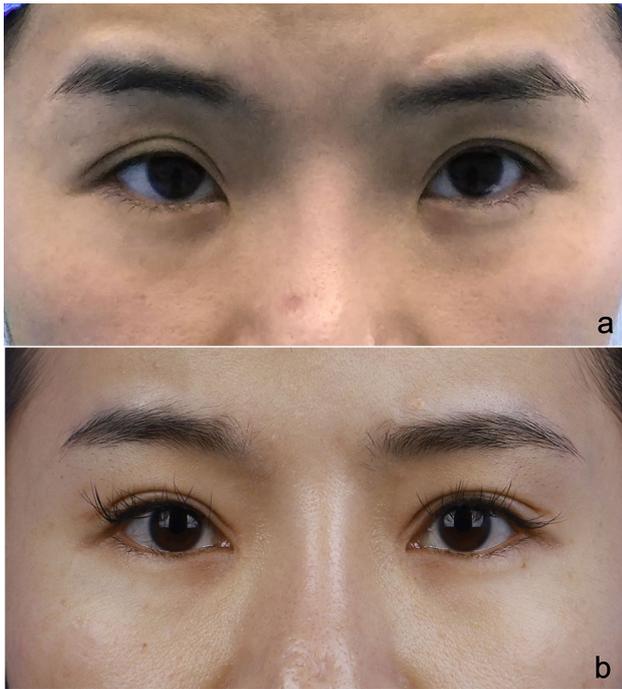


Fig. 4 A 29-year-old woman complained of failed eyelids (type IV, comprehensive damage) for 7 months after the second double-eyelid surgery. She underwent double-eyelid incision redesign, periumbilical fat supplement, and levator aponeurosis repair. **a** Preoperative photograph; **b** postoperative photograph at 6 months after surgery, showing full eyelid, normal eyelid margin, and symmetrical eyes



Fig. 5 A 49-year-old woman complained of failed eyelids (type IV, comprehensive damage) for 14 months after the second double-eyelid surgery. She underwent double-eyelid incision redesign, periumbilical fat supplement, and levator aponeurosis repair. **a** Preoperative photograph; **b** postoperative photograph at 6 months after surgery, showing full eyelid, normal eyelid margin, and symmetrical eyes

functional problems, such as sunken scars near the double-eyelid incision, iatrogenic ptosis, sunken eye socket, dry eyes after surgery, and numbness and persistent swelling of soft tissue in the lower lip below the incision [23].

At present, many doctors do not have a strong appreciation of the upper eyelid anatomy, leading to frequent double-eyelid surgery failures. It mainly manifests in indented scars around the double-eyelid line, an unsmooth double-eyelid line, bilateral asymmetric double-eyelid line, upper socket depression, and iatrogenic ptosis. The failure of double-eyelid surgery may be caused by unilateral anatomical damage or multiple causes. Our clinical data showed that 83/120 patients (69%) had comprehensive damage caused by multiple factors, including simultaneous damage to the OOM, OSF, and LPS. The following specific factors were analyzed: (1) Unfluency of the double-eyelid: There are three main factors affecting this—namely the design of the double-eyelid line; injury to the levator aponeurosis during double-eyelid surgery, which leads to imbalance of the force point of LPS at the position of the tarsal plate, resulting in unfluency of the double-eyelid curve; and the removal of OSF during double-eyelid surgery, resulting in uneven distribution, or scar adhesion and pulling between the lower lip skin of double-eyelid and LPS, causing the double-eyelid radiants to be unsmooth; (2) the indented scar around double-eyelid: The two main causes are: poor alignment of sutures of OOM at the incision and extensive removal of OOM around the incision resulting in uneven subcutaneous scars near the double-eyelid line; (3) eye socket depression: One factor affecting this is excessive removal of OSF. OSF not only promotes the sliding of the LPS and OOM and maintains the upper eyelid shape but also keeps the upper eyelids younger. Extensive removal of OSF causes upper eyelid skin relaxation and upper eye socket depression, as well as functional problems in LPS. The second reason is the tear between the levator aponeurosis and tarsal plate during surgery, moving the origin of force of LPS backwards, thus pulling the fat of the orbital septum backward, even into the orbit, manifesting as a sunken eye socket; (4) iatrogenic ptosis is mainly caused by the following three factors: First, the wide design of double-eyelid line or excessive removal of OSF causes the skin at the lower lip of the double-eyelid to directly attach to the levator aponeurosis, leading to excessive depth of the double-eyelid and limiting LPS movement, causing iatrogenic ptosis. Second, injury to the fascia anterior to the tarsal plate during double-eyelid surgery results in the detachment of the levator aponeurosis from the upper border of the tarsal plate, which weakens the function of the LPS and causes iatrogenic ptosis. Third, injury to the LPS itself, bleeding from the LPS, and postoperative fibrosis also directly affect its function.

Table 3 Comparison of pre- and postoperative mean eyelid morphological scores in all patients

	Preoperative mean eyelid morphological score (\pm SD)	Postoperative mean eyelid morphological score (\pm SD)	<i>P</i>	Mean delta (preoperative-postoperative)
Double-eyelid shape	- 1.8167 (\pm 1.17383)	- 0.0417 (\pm 0.20066)	< 0.001	- 1.77500
Upper eyelid height	- 1.2000 (\pm 0.94913)	- 0.0417 (\pm 0.20066)	< 0.001	- 1.15833
Extent of depression	- 1.4583 (\pm 1.24277)	- 0.0333 (\pm 0.18026)	< 0.001	- 1.42500

SD, standard abbreviation

Based on the above causes, the targeted double-eyelid repair method was selected. The main principles of repair surgery and their advantages are as follows: (1) First, whether the current amount of upper eyelid skin is adequate was determined; if there was redundant skin, the original double-eyelid line scar was removed. If it was insufficient, the incision was redesigned according to the need of surgery and the original scar was ignored. This principle not only avoids the problem of skin insufficiency in the upper eyelid due to scar removal, but also ensures the ideal double-eyelid shape. Other serious complications such as incomplete closure of eyelids are also avoided. (2) Fine release separation of scar adhesion. First, the anatomical layer of the tissue was found and separated, especially the functional structures such as LPS, to avoid secondary injury to the levator aponeurosis. In the process of separation, tissue bleeding needs to be strictly controlled simultaneously, to prevent interference of swelling with surgery and intraoperative judgment. (3) Repair technique of LPS. According to preoperative evaluation and intraoperative exploration, the cause of LPS injury was judged and repaired. If the location of damage to levator aponeurosis was at the attachment point of the upper edge of the tarsal plate, the LPS was resuscitated and fixed at the corresponding position. If it was a failed double-eyelid caused by the high adhesion between the skin, OOM, and levator aponeurosis, sufficient separation of levator aponeurosis from the surrounding tissue and reduction in the resistance of movement were necessary. If the muscle strength of the LPS was weakened or if fibrosis occurred because of direct injury, it was necessary to cut off the levator aponeurosis and shorten it appropriately to achieve a satisfying curvature and height of the palpebral margin. (4) The principle of correcting the socket depression is to supply the missing OSF. The prepared periumbilical fat mass needs to be trimmed according to the missing amount and spread between the LPS and OOM. The fat mass was fixed between the upper edge of the tarsal plate and the residual orbital fascia of the upper eyelid, and attention was paid to the leveling and stabilization of fat. The excessive

burden of LPS was avoided. This method can correct the sunken eye socket, prevent scar adhesion between the injured anatomical structures, and promote sliding between LPS and OOM. These factors ensure fluidity of the double-eyelid radians and avoid nodule formation due to injection of granular fat [9, 24]. (5) OOM repair. If there was substantial loss of OOM anterior to the tarsal plate, we used the U-shaped flap of the OOM of the anterior orbital septum or the periumbilical dermis tissue to fill in the missing OOM, ensuring that the lower lip of the double-eyelid was full and flat. This not only ensured the fullness and smoothness of the lower lip of the double-eyelid but also improved the skin state at the lower lip of the double-eyelid, relieving the scar in and around the double-eyelid incision. The ectropion of the lower lip of the double-eyelid caused by scar contracture can also be corrected.

Different changes occurred in different stages during the recovery process. The upper eyelid was slightly swollen at 1 week after surgery; hence, it was impossible to make accurate morphological judgments. Type I patients recovered well at 1 month after surgery and remained stable at 6 months. The last surgery had little tissue damage; thus, the repair was relatively simple, and the success rate was the highest in these patients. In type II patients, the eyelid was full, and the height of palpebral margin was lower or slightly lower than the normal range at 1 month after surgery. At 6 months, one patient with a preoperative score of - 3 had a slightly worse degree of fullness in the upper eye socket, but the height of the upper eyelid margin was completely normal. The underlying reason may be that the fat graft was in the unstable absorbing phase at 1 month after transplantation. At the same time, because the slightly inflated fat compressed the LPS, the height of the upper palpebral margin was low but within the normal range at 1 month after surgery. Although the transplanted fat was partially absorbed and the situation was stable at 6 months, the LPS compression was eliminated by swollen fat, and the upper palpebral margin was completely restored to normal height. At 1 month after surgery, two type III patients had under correction of the upper eyelid margin:

one recovered eventually, but one still had under correction at 6 months. The reason is that the LPS injury was serious preoperatively, and muscle function may not have completely recovered at 1 month or that there was under correction in the surgery itself, so the patient with injury to the muscle itself recovered. However, under correction due to the surgery itself prevented achievement of normal state in the end. Type IV patients had a slightly bloated upper eyelid at 1 month after surgery, and eight of them had height problems of the palpebral margin. At 6 months after surgery, three patients with severe eye socket depression before surgery had a slightly sunken eyelid, and four patients with prior severe injury to the LPS had poor upper eyelid edge height. The underlying reason was that the fat was still swollen at 1 month after surgery. When the absorption of transplanted fat was stable at 6 months, the situation of supplement insufficiency emerged. At 1 month after surgery, the LPS function was impaired owing to the compression of transplanted fat, but the function of LPS recovered after 6 months. Only type IV patients with injury to the LPS itself and with insufficient correction of surgery had problems related to the palpebral edge height. Despite the high success rate, this surgical technique still requires further improvement, and experience needs to be gained, such as in mastering the amount of transplanted fat. In addition, experience in the repair of injured LPS should be generated.

Conclusion

The repair techniques for failed double-eyelid are based on the principle of anatomical structure reduction. This procedure can not only restore the normal function of eyelids to the maximum extent, but also form a beautiful double-eyelid. This method ensures smooth double-eyelid radiants, moderately full upper orbital fossa, normal corneal exposure, and lighter severe eyelid scars and makes the eyes look conscious and natural.

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Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

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