




# Tear Trough Ligament Release and Autologous Fat Injection as a New Method for Tear Trough Deformity Correction

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## Abstract

**Background** Even though the tear trough (TT) deformity is only 2 cm in length, it can give a worn, even haggard appearance on the face. The authors developed a novel approach and presented findings from the clinical effect.

**Methods** Between February 2018 and January 2021, the medical records of patients treated with autologous fat injection for TT deformity were researched. The fat was placed under the orbicularis oculi muscle with a sharp cannula. During that period, the TT ligament was also released with the cannula. After the fat was injected entirely, we still needed to repeatedly puncture this ligament to release it until there was no puncture resistance. Improvement was evaluated by measuring patients' and investigators' global aesthetic improvement scale.

**Results** 152 of 173 patients completed the follow-up plan and were enrolled in this study. The most common complications reported were temporary swelling and lumpiness. At 1 month, 3 months, 6 months, 12 months, and 24 months, the satisfaction rate of patient self-assessment was 93.4%, 89.5%, 86.8%, 84.3%, and 82.4%, respectively. The Investigator Global Aesthetic Improvement Scale showed 94.1% of patients' improvement after one month, 83.6% after three months, 78.3% after six months, 75% after 12 months, and 71.8% after 24 months.

**Conclusion** Fat injection based on TT ligament release to correct TT deformity is a novel, easy and effective treatment that deserves to be further used.

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**Keywords** Tear trough · Fat injection · Deformity · Correction

## Introduction

The tear trough (TT) is defined by Flowers [1] as a deep groove that lies on the eyelid and cheek junction, extending inferolaterally from the medial canthus. Haddock [2] then pointed out that TT deformity arises when the groove creates an unsightly look. The concern of TT deformity is greatly amplified by its presence at the face's vision core. The most aggravating aspect is the difficulty of getting rid of it.

In theory, there are two treatment options: filling the groove or elevating the hollow. Excision, lower eyelid fat release, orbital fat repositioning, fat graft, alloplastic implants, and midface lifting are all surgical options, with orbital fat repositioning being the most popular [1, 3–5]. However, the expected and satisfying result does not always occur. As a result, the demand for less invasive, even non-injury techniques is growing. Hyaluronic acid (HA) gel fillers, fat graft injections, and other novel soft tissue fillers are becoming more common nonsurgical procedures [6–8]. Despite the autologous fat offering the advantages of non-immunogenicity and easy availability, as well as being rich in adipose-derived stem cells (ADSCs) [9], lumpiness still develops in the tear trough area when patients smile following fat injection.

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To address the issue of lumpiness induced by fat injection, we must first identify the source of TT deformity. Patients in the 20 to 30-year-old age range are affected by pre-existing maxillary bone hypoplasia and the steady loss of subcutaneous fat [10]. The descent of the malar fat pad may cause the orbital rim to become prominent. Furthermore, TT deformity may result from the loss of fat and osseous support in the TT, as well as herniation of the orbital fat above the trough. Moreover, there is a noticeable variation in skin thickness between the eyelid and cheek [3, 6, 11]. It's not difficult to notice that the explanations presented are imprecise and contradictory, resulting to doubt about the true anatomical cause of TT deformity. The existence of The TT ligament, discovered by Wong [12] was the true anatomic genesis of the TT deformity, providing us with novel therapeutic possibilities for eradicating the deformity with greater assurance.

We released the TT ligament while injecting autologous fat, which proved to be a safe and practical way in addressing the TT deformity. We here detailed our experience with TT ligament release in autologous fat injection to address TT deformity.

## Patients and Methods

### Patients

According to the medical records, 173 individuals with TT deformity undertook the procedure between February 2018 and January 2021. Patients with infections and previous filling or fat injection in the TT area are excluded from this study. Patients allergy to lidocaine and has a history of severe orbital prolapse or under-eye fluid were also excluded. Before therapy, all patients were photographed using regular digital camera in the identical settings. The grade of the TT deformity was made according to Barton's grading system (Table 1). This study was approved by the Institutional Review Board of The Plastic Surgery Hospital, Chinese Academy of Medical Sciences. Patients signed consent forms agreeing to their data being used and analyzed.

**Table 1** Barton's grading system

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

### Fat Harvesting

Patients in a standing position were used to mark the area of TT deformity and the most depressed position of TT (the connection of the TT ligament to the orbital rim) prior to surgery. Filling volume was estimated in advance based on the TT degree.

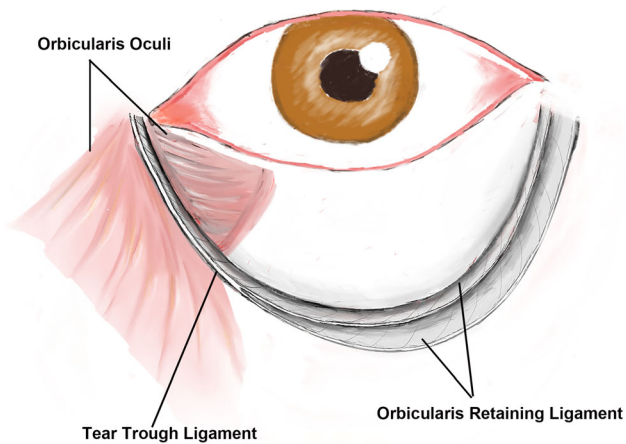
Fat was harvested from the thigh or lower abdomen, and the exact liposuction point was determined by the patient's desire and the surgeon's recommendations. We used a 26-gauge needle mounted on the 1-cc syringe to administer incision anesthetics to lessen the patients' discomfort during the procedure. An 18-gauge needle placed on a 10-cc syringe was then used to inject the swelling anesthetic solution of 0.06 percent lidocaine and 1:400000 adrenaline solution into the liposuction site through the prior injection point. The swelling pain could be minimized in this manner. The fat was then harvested using a 2-mm liposuction cannula with multiple sharp sides connected to a 10-cc syringe under manually-controlled negative pressure. Lipoaspirate was then centrifuged for 3 minutes with 2000r/min.

### Tear Trough Deformity Anatomy

The TT ligament, which originates from the maxilla and inserts into the TT's skin, was thought to be a real osteo-cutaneous ligament. The TT ligament ran from the insertion of the medial canthal tendon, immediately inferior to the anterior lacrimal crest, to the line of the medial pupil, where it was joined by the orbicularis retaining ligament. The TT ligament was incredibly robust and could not be readily torn down, despite its thin thickness of less than 0.5 mm (Fig. 1).

### Injection Technique

Before the injection procedure began, patients were asked to close their eyes, and local anesthesia was administered to the TT area. An 18-gauge needle perpendicular to the skin was used to pierce the lower eyelid skin and orbicularis oculi muscle. The entry location was around 5–8 mm

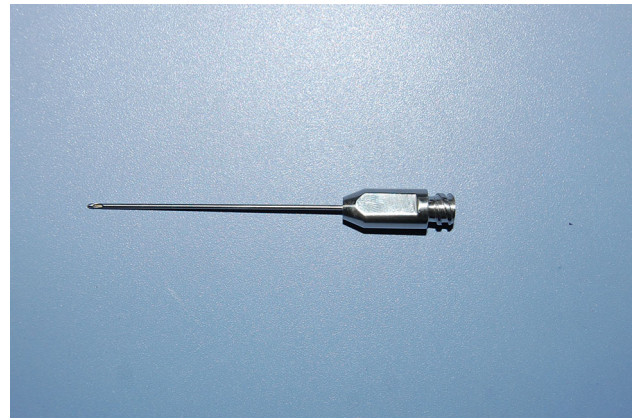


**Fig. 1** Illustration of TT ligament: the anatomical basis of TT deformity. TT ligament continues laterally as bilayered orbicularis retaining ligament

from the inferior palpebral edge, in the middle and outer one-third of the lower eyelid above the filling area (Fig. 2). The sharp 1.2 mm diameter cannula with a single hole at the end (Fig. 3) was then inserted. The goal area of filling was the preperiosteal tissues under the orbicularis oculi muscle. The cannula tip must pass through the TT ligament during the filling process (Fig. 4). The cannula was inserted perpendicular to the ligament and parallel to the bone plane. Because the TT ligament is blocked, there will be evident resistance when the cannula travels through it, and the performer will have a sense of breakthrough after the cannula passes through it. The cannula was gradually withdrawn while the fat was injected into the desired contour. Of note, the fat was injected near each position of the ligament only after that position's ligament had been released, not after the entire ligament was completely



**Fig. 2** The sharp 1.2 mm diameter cannula was used for releasing the TT ligament. The entry point was at the middle and outer one-third of the lower eyelid above the filling area, about 5–8 mm from the inferior palpebral margin



**Fig. 3** A sharp 1.2 mm diameter cannula with a single hole at the end is used to release the TT deformity in the above-mentioned technique

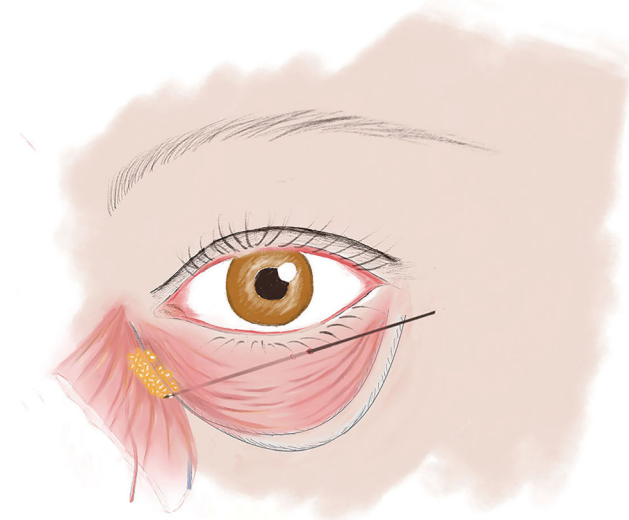
released. The cannula was still utilized to repeatedly puncture the TT ligament to relieve the remaining adhesion between the TT ligament and the orbital rim after the fat was injected. Each pass injection contained roughly 0.02 ml. The patient was discharged shortly after that.

After the operation, erythromycin ophthalmic ointment was applied to the lower eyelid, and the donor area was treated with a pressure dressing. Three months after therapy, all individuals were instructed to return to the outpatient department to assess for the clinical effect and engage in the routine follow-up.

### Evaluation of Results

The clinical improvement of the TT deformity was reviewed by a group of three plastic surgeons who were not participating in the study. Using the Investigator Global Aesthetic Improvement Scale (GAIS; 0–worse; 1–unchanged; 2–improved; 3–substantially improved; 4–greatly improved; 5–practically entire improvement), surgeons rated the effect depending on the standard photographs before and one month, 3 months, 6 months, 12 months and 24 months after the treatment.

Patients were asked to complete a satisfaction survey based on a questionnaire where they needed to rate their satisfaction level according to their treatment result (1–very dissatisfied, 2–dissatisfied, 3–satisfied, 4–very satisfied) at one month, 3 months, 6 months, 12 months and 24 months after the treatment. They also needed to determine whether this treatment was worth suggesting to other persons with TT deformity. Any complications arising from this treatment must also be recorded.



**Fig. 4** Illustrating the process of injecting the fat using the sharp cannula. The goal area of filling was the preperiosteal tissues under the orbicularis oculi muscle. The tip of the cannula must pass through the TT ligament during the filling process. The entry direction of the cannula was perpendicular to the ligament and parallel to the bone plane

### Statistical Analysis

The categorical variables were described using percentages while data used for comparison between two groups were analyzed by Kolmogorov–Smirnov test to determine if normality assumptions were fulfilled. Means and standard deviations (SD) were then applied to describe normally distributed quantitative variables. The satisfaction values between the two groups were compared with an independent t-test.

### Results

In total, 152 of 173 patients completed the follow-up plan, including 146 females (96.1%) and six males (3.9%). The average age of the patients was 29.3 years (range:19–56 years). Patients who were not included in this study were either lost to follow-up or declined to take part. The average time of follow-up was 23 months (range:6–40 months). A total of 152 patients were followed for more than six months, 108 for more than 12 months, and 85 patients for more than 24 months. A total of 1.2 ml(range:0.5–3.0ml) was placed beneath the TT. Furthermore, 120 out of 152 individuals received other cosmetic treatments at the same time (fat injection in other areas of the face, such as the forehead, temporal, nasolabial sulcus, and others). None of the patients received more than one-time fat injection during the follow-up period.

Before therapy, 152 patients (304 TTs) were recorded, with 92 TTs of Grade I, 164 TTs of Grade II, and 48 TTs of Grade III. Seventy-four of the 92 TTs classified as Grade I preoperatively developed into Grade 0, with the remaining 18 TTs unchanged. Eighty-four of the 164 TTs divided into Grade II improved to Grade 0, whereas 78 TTs developed into Grade I, and two remained unchanged. Twenty-six of the 48 TTs divided into Grade III developed into Grade 0, 14 TTs developed into Grade I, 7 TTs developed into Grade II, and one TT remained unchanged (Table 2).

All patients had transient swelling and redness around the TT postoperatively, which usually lasted 1–2 weeks but went away on their own. Only one patient (0.66%) suffered a persistent bruising around her right TT for three months. After four weeks of treatment, nodules formed on 10 TTs of 10 patients (6.58%), two of which only appeared when patients smiled and two of which only appeared when they were touched. The remaining six nodules were visible up close. The nodules were described by patients as being the size of soybeans. Eight of these patients recovered progressively over the next 3–6 months, while two others elected to have the nodules removed because they were concerned about nodules' presence. One patient (0.66%) developed an asymmetric TT deformity after treatment, but she was nevertheless pleased with the overall results due to the faded dark eye circle. Surprisingly, nearly 88.8% of patients said their dark eye circles had improved. Two patients (1.32%) complained of a hypertrophic scar at the liposuction site (lower abdomen), but no scar removal surgery was performed. Three patients (1.97%) had uneven surfaces after treatment. Between three and four months, three patients (1.97%) had retouch procedures. They were related to removing injected fat due to the evident nodule in two patients and injecting HA into the TT due to the faded therapeutic effect in one patient. During the follow-up period, severe side effects such as infection, embolism, and oil cysts, were not found (Table 3).

Patients were able to resume their regular work and make-up again within 1.7 weeks and 2.3 weeks after the treatment, respectively. The maximum recovery time for ordinary work and make-up was four and five weeks, respectively. Furthermore, 85.5 percent of patients thought it was worthwhile to recommend to other TT patients. Three classic examples of patients were depicted in Figs. 5 and 6.

In terms of patient satisfaction, a rating of more than two indicated satisfaction, while a score of less than three indicated discontent. At one month, 142 patients (93.4%) were satisfied, and ten patients (6.6%) were dissatisfied, according to patient self-assessment. 136 patients (89.5%) were satisfied after 3 months, while 16 patients (10.5%) were dissatisfied. At 6 months, 12 months, and 24 months, the satisfaction rate declined to 86.8% (132 patients),



**Table 2** Barton's grade of before and post-treatment

Preoperative grade,	No. (%)	Postoperative Grade			
		Grade 0, No (%)	Grade I, No (%)	Grade II, No (%)	Grade III, No (%)
Grade I	92 (30.3)	74 (24.3)	18 (5.9)	0 (0)	0 (0)
Grade II	164 (53.9)	84 (27.6)	78 (25.7)	2 (0.7)	0 (0)
Grade III	48 (15.8)	26 (8.6)	14 (4.6)	7 (2.3)	1 (0.3)
Total, No. (%)	304(100)	184 (60.5)	110 (36.2)	9 (3.0)	1 (0.3)

**Table 3** Postoperative Complications

Complications	No. of patients(%)
Swelling and redness	152(100)
Lumpiness	10(6.58)
Uneven surface	3(1.97)
Hypertrophic scar of the liposuction point	2(1.32)
Asymmetric tear trough deformity	1(0.66)
Bruising	1(0.66)

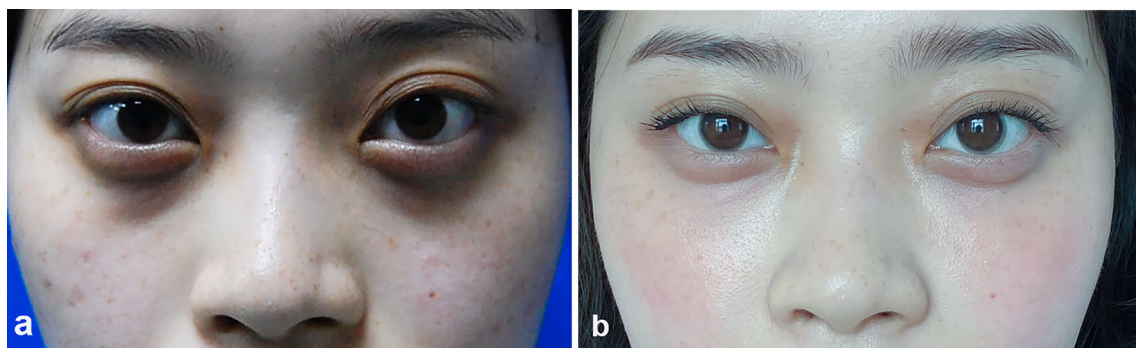
84.3% (91 patients), and 82.4% (70 patients), respectively (Fig. 7).

A grade of more than one on the Investigator Global Aesthetic Improvement Scale indicated improvement. Evaluation team found 94.1 percent improvement in TT deformity after one month, 83.6 percent improvement after three months, 78.3 percent improvement after six months, 75 percent improvement after 12 months, and 71.8% improvement after 24 months. After the treatment, 81 patients (75%) demonstrated improvement that lasted up to 12 months. The improvements of 21 patients (24.7%) went back to the baseline at 24 months (Fig. 8).

Additionally, to find out if there is any connection between liposuction site and satisfaction rate, we compared

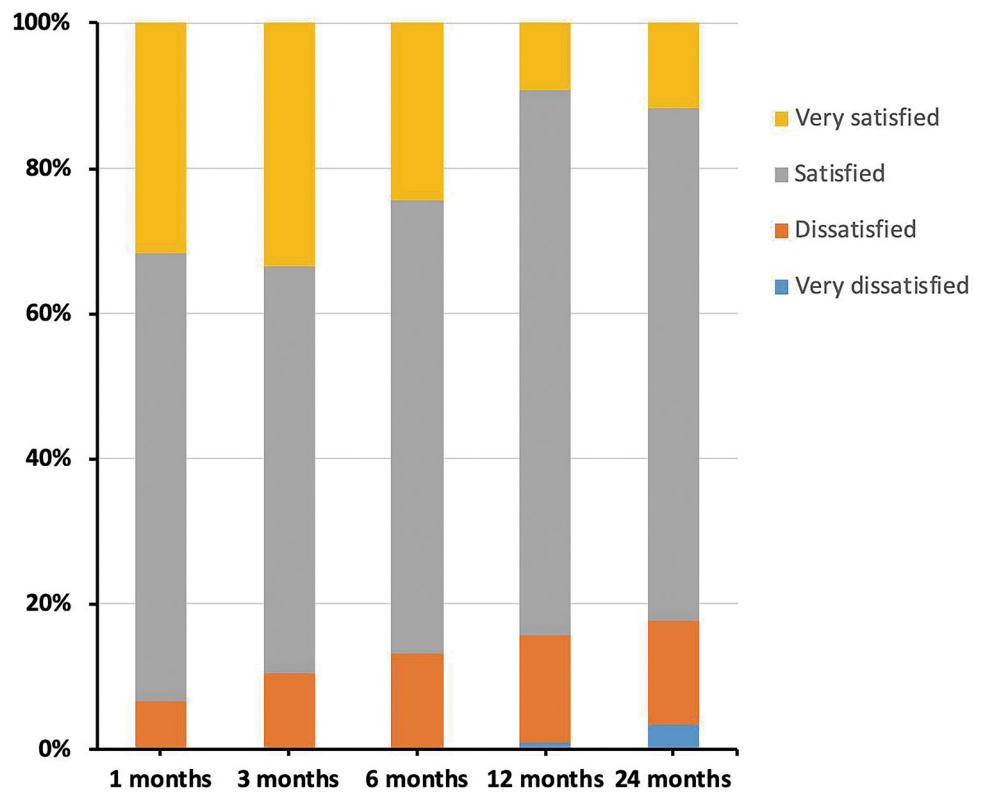


**Fig. 5** A 27-year-old female with TT deformity underwent the fat injection and TT ligament release. Image **a** Preoperative. **b** 3 months postoperative. **c** 18 months postoperative. The injection volume was 2 ml on each side of the TT

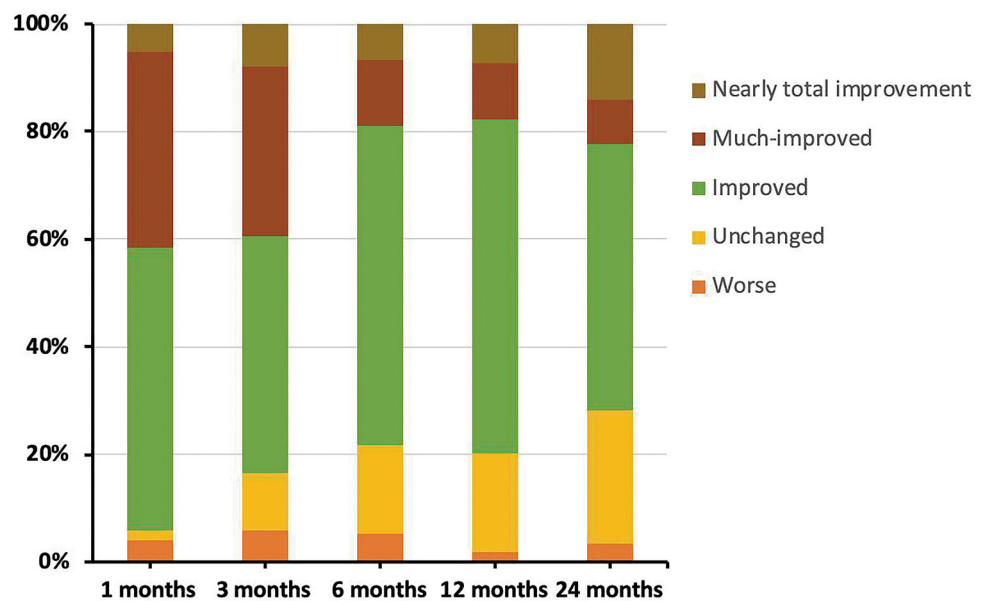


**Fig. 6** A 29-year-old female underwent fat injection and TT ligament release to correct the TT deformity. Image **a** Preoperative. **b** 24 months postoperative. The injection volume was 2.5 ml on each side of the tear trough

**Fig. 7** Patients' Subject Global Aesthetic Improvement Scale at different time



**Fig. 8** Investigator Global Aesthetic Improvement Scale at different time



the satisfaction results of the lower abdomen liposuction group ( $n=79$ ) and thigh liposuction group ( $n=73$ ) at six months post-operation. Results showed that there was no significant difference in the satisfaction between the abdomen liposuction group (mean: 3.14; SD: 0.66) and the thigh liposuction group (mean: 3.25; SD:0.66) ( $p > 0.05$ ).

### Discussion

There are numerous options for treating TT deformity. In clinical applications, soft tissue filler injection for TT deformity treatment is more popular than surgical operations. Biocompatibility, ease of use, low cost, and a long-

lasting effect are all desirable attributes in soft tissue fillers. Although HA injections are commonly utilized, when given too superficially, they might create a bluish discoloration under the skin. Furthermore, the role of PRP (Platelet-rich Plasma) in reducing dark circles and TT deformity has been established, which is due to its high platelet concentration [13]. However, because there are few reports at this time, the long-term clinical effect needs to be confirmed. Understanding the periorbital cosmetic abnormalities as well as the real cause of the TT deformity is critical to its correction. Despite the numerous theories concerning the reason, none of the existing treatment methods are based on these speculative hypotheses, which is an important point that is often overlooked. The TT's anatomical finding prompted us to come up with new ways to restore the TT's youth.

The TT ligament has never been discovered before until Wong [12] discovered it by not adopting the layer-by-layer dissection anatomical method. The TT ligament is an actual osteocutaneous ligament that arises from the maxilla and attaches firmly to the skin around the TT. The orbicularis retaining ligament was known to be responsible for the palpebromalar groove [14, 15]. What's more, the TT ligament continues laterally as the orbicularis retaining ligament, confirming the TT ligament's tethering effect in connecting the medial suborbital skin to the maxilla. According to these supports, the critical clinical implications of TT ligament are understandable for correcting TT deformity.

Even though advances in fat injection have allowed for fine-tuning techniques over the last two decades, the issue of overfilling has remained unaddressed. The situation has been exacerbated by TT's minor deformity. Patients frequently complained of lumpiness and fibrous nodules caused by grafted fat following fat injection to repair TT deformity [16]. In our experience, lumpiness was more likely to develop when we merely injected fat into the TT area without releasing the TT ligament. Based on our experience and the anatomic reason for the TT deformity, we released the TT ligament with a sharp cannula. Overall, autologous fat injection combined with TT ligament release is a safe way to correct TT deformity with a low risk of nodules. The TT ligament's release disrupted the natural adherence of the medial suborbital skin to the maxilla. Significant elevation of the injected fat produced by a smile will not be prohibited. As a result, when patients smile, a complete release of the TT ligament can avoid the accumulation of filled fat and lumpiness formation (Fig. 9).

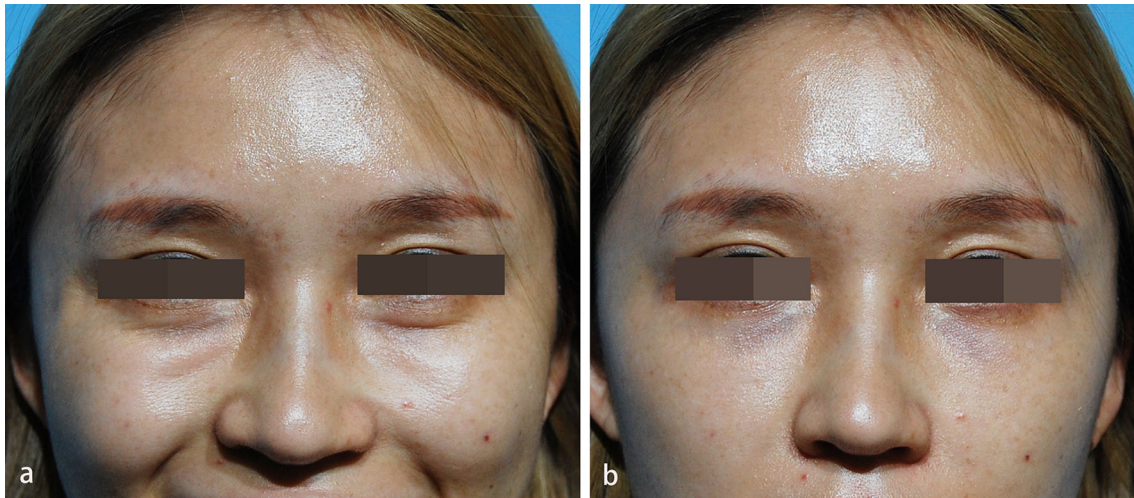
With an understanding of anatomical evolution and their treatment obstacles, our goal was not a single fat injection, but the complete release of the TT ligament. As this septum-like ligament was extremely strong, a sharp cannula was required to completely release it. We did not choose to

release TT ligament with sharp cannula first and then inject fat with a blunt cannula because we believe that releasing the whole ligament before injecting fat will create a cavity in the tear trough area, which can easily lead to fat storage. Hence, we decided to release the ligament and inject fat at the same time, limiting us to only using a sharp needle. When puncturing the TT ligament with the sharp cannula, the performer would feel a strong sense of breakthrough. Unlike us, Anido [17] held that a slight difficulty in passing should be noted as the orbitomalar ligament should not be crossed. However, we no longer need to avoid the TT ligament because of this anatomical discovery. Graf, who repositioned the orbicularis oculi muscle to fill the trough, shared a similar views regarding the TT ligament [18].

Traditional filling points are rather varied. To allow the needle to travel in all directions, a single entry point is used, which is commonly situated on a line drawn vertically [17, 19]. Apart from that, the area 2 cm inferolateral to the lateral can thus is also a choice to inject HA into the TT ligament differently [20]. The above options, however, fell short of our requirement to release the TT ligament. For one thing, the TT ligament is almost parallel to the entry point 2 cm inferolateral to the lateral can thus. For another, the nose would block the injection and there is a larger risk of eyeball damage, thus, the option below the eyes is also not an option. We chose the outer third of the lower eyelid to inject because it corresponds to the necessity for multiple orientations to release the TT ligament in our experience.

We believe that the reported 6.6 percent of the patients' dissatisfaction was caused by early complications, mainly lumpiness or bruising. The patients' satisfaction rate decreased over time, consistent with the investigator's observation. The authors believe this might be attributable to the self-absorption of the injected fat. Even though one year after the treatment, the satisfaction rate dropped to 84.3%, the result was still relatively satisfying compared to HA injection, which is known to be absorbed within one year [17]. Moreover, given the greater reduction in patient satisfaction at two years, retreatment should be considered two years following the procedure to maintain a long-lasting benefit.

To realize safe and successful injection, the vascular anatomy below TT structure must be taken into account. The infraorbital artery and angular artery are the main vascular that must be kept in mind during the injection. The former arises from the infraorbital foramen, lying on the vertical line of the medial margin, slightly less than a fingerbreadth below the orbital margin [15]. Hence, deep and direct injections into this area should be avoided in favor of lateral injections. The angular artery is a branch of the facial artery that extends over the inner can thus of the eye and into the dermis [22]. The angular artery is the most



**Fig. 9** A 28-year-old female had a complication of lumpiness on the TT after she only underwent the fat injection to correct the tear trough deformity without releasing TT ligament. Obvious lumpiness only

appeared when she smiled. This set of pictures was taken two years after the surgery. a: Lumpiness appeared when she smiled. b: Lumpiness disappeared when she doesn't smile

crucial structure to consider because of its anatomical proximity to the injection zone [23].

Because the TT ligament is sandwiched between the beginnings of the palpebral and orbital sections of the orbicularis oculi, the danger of injuring these vessels during our injection is low. The angular artery runs outside the orbital position of the orbicularis oculi, which means the angular artery is medial to the area where the ligament needs release. Subconjunctival hemorrhage has been reported after HA injection for cheeks and TT deformity, and the needle injuring the angular artery seems to be the plausible explanation [24]. To avoid damaging the angular artery, recall that when the cannula penetrates the ligament, there is an evident sense of breakthrough, which could serve as a reminder. Periosteum has been seen as a safe area for injection with hardly any vessels running over it [22].

The limitation of this technique is that it is better suited to severe TT deformity, as modest TT deformity requires more precise volume injections, and fat injections can lead to excessive injections. Another limitation that cannot be overlooked is the unpredictability of fat injection results. Too much injection can cause nodules, and when the injection volume is medium, the correction effect may be limited due to partial fat absorption. The drawback of this procedure is that the clinical effect fades over time, and patients may require additional treatment.

## Conclusion

The author has innovatively created a new technique to correct TT deformity with fat injection on the basis of TT ligament release, which could yield a smooth and lower eyelid contour. Overall, disturbing complications were uncommon, and the downtime was short. We believe our method is an ideal resolve for TT deformity because we dealt with its confirmed etiology.

## Declarations

**Conflict of interest** The authors declare that they have no conflicts of interest to disclose.

**Ethical Approval** All procedures performed in the study 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. This study was approved by the ethics committee of our hospital.

**Informed Consent** Informed consent was obtained from the patients to publish the images.

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