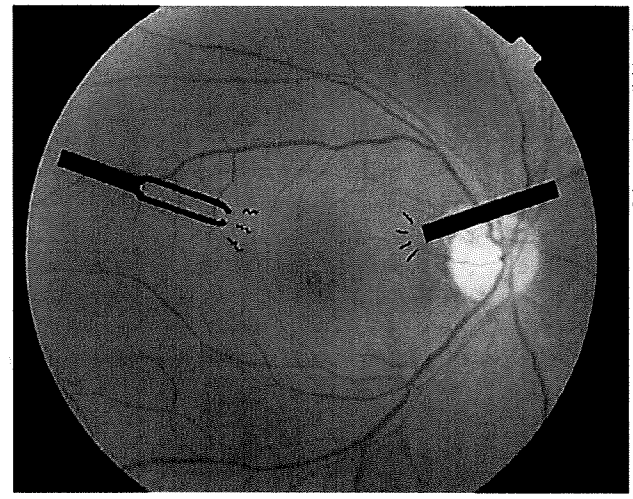
er, and the membrane seemed sticky. The tip of the stick picked up and held the membrane again and again.'

Another patient drew two stick-like objects on the fundus picture (fig. 2). This 56-year-old man underwent vitrectomy for macular hole in the right eye. He reported that a forceps-like instrument grasped a waste thread on the left side, and the tip of the stick-like instrument from right side looked bright. These two sticks seemed black as in a silhouette pattern. Both shafts were interrupted in the periphery.

A 55-year-old man underwent vitrectomy, phacoemulsification, and IOL implantation in the right eye uneventfully for vitreous hemorrhage associated with proliferative diabetic retinopathy. He reported his visual experience during surgery by drawing several sketches with very interesting descriptions.



Color version available online

Fig. 2. Sketch drawn by a 56-year-old man who underwent vitrectomy under retrobulbar anesthesia for a macular hole in the right eye showing the patient's experience during the internal limiting membrane peeling procedure. The patient reported that a forceps-like instrument coming from the left side grasped a waste thread, and the tip of a stick-like instrument from the right side looked like a light. These two sticks appeared black as on the silhouette picture. Both shafts were interrupted in the periphery.

Discussion

Our results demonstrated that a variety of visual sensations were experienced by approximately 90% of the patients with macular disease during vitreous surgery in spite of full pain control by retrobulbar anesthesia. These findings are in agreement with earlier reports on the visual sensations experienced during cataract or vitreous surgery under retrobulbar anesthesia [2, 4–7].

We found that more patients with macular disease tended to experience visual sensations during vitrectomy than patients with nonmacular disease. This may be because patients with macular disease had relatively better visual acuity and peripheral vision than patients with nonmacular disease. However, other factors such as age, gender, and amount of anesthesia, must also be considered. Other things that can influence the visual sensation during vitrectomy may be the temperature of the vitreous cavity-retina and intraocular pressure. Miyake and Horiguchi [9] used electroretinogram (ERG) during vitrectomy and showed reduced amplitude under high infusion pressure. They also showed that the lower temperature of the vitreous cavity-retina resulted in the enormous delay of implicit time of ERG. So it is expected that the patient's visual sensation would be influenced significantly, depending on the temperature of the retina and IOP.

One of the limitations of this study stemmed from patients' classification. We focused on the macular disease where only the central retina was involved and the peripheral and most of the retina was relatively intact since we had expected to be able to obtain more precise characteristics of the patients' visual sensation. But it was difficult to differentiate macular from diffuse retinal disease. The macula was not involved in part of the rhegmatogenous retinal detachment eyes, and in eyes with macular edema not only the macula but also wider retinal area might be involved. Though it is difficult, another investigation focusing on patients with macular intact disease such as asteroid hyalosis or peripheral retinal detachment would be helpful to assess the contribution of macular function on patients' visual perception during vitrectomy.

Intravitreal instruments were perceived by approximately 60.0% of our patients, and considering the high percentage of cataract patients reporting visual sensations, this relatively high percentage was not so surprising. However, the accuracy and precision of the descriptions was unexpected, although we have reported on one patient who not only described but also drew what he saw during vitrectomy with great accuracy [3]. These drawings illustrated how well the visual perception of the patient corresponded with the surgical procedures performed, even when they are not focused on the retina through the optical system of the eye.

Chung et al. [6] reported that some patients saw rectangular moving objects during cataract surgery. Khan

[10] suggested that the visual sensations during cataract surgery result from the images of intracameral instruments created by the posterior surface of the cornea acting as a concave mirror. The higher incidence of perceiving moving object during vitreous surgery than cataract surgery might be because the instruments are closer to the retina during vitrectomy, thus making them clearer and sharper. A significant correlation between the pre- or postoperative visual acuity and intraoperative visual sensations has been reported [4]. Patients who reported intraoperative sensation of light, colors, and moving objects, which are perceived mainly by the cone system, had significantly better postoperative visual acuity. This suggests that the intraoperative visual sensation is highly correlated with the macular function of the patient.

The basic mechanism for the visual sensations was suggested to be similar to that of other entoptic phenomena [11], e.g. vitreal floaters, perceived by patient with a posterior vitreous detachment. The closer the object is to the retina, the more exact will the shape and size of the shadow correspond to the actual shape and size of the object. This may explain why some of our patients reported that they saw a decrease in the thickness of the object in the center of the visual field when a cylindrical instrument was inserted into the vitreous (fig. 1). In addition, patients reported only one instrument on the left side of the visual field, and the shaft of the light pipe was not seen when a surgeon held an instrument (vitreous cutter, scissors, or forceps) with the right hand and a light pipe with the left hand. When the surgeon reversed the instrument and light pipe, patients reported the reverse perception. This can be interpreted as the shadow of the instrument but not of the endoillumination probe. Furthermore, when the illumination came from the operating microscope [8], the patient saw two rod-shaped structures entering the center of visual field from opposite sides (online suppl. table 2). This supports the idea that the patients saw the shadows of the instruments [4].

It is very interesting that some patients perceived blood as red, as has been reported earlier [1]. Because shadows are achromatic, the perception of red or any colored object is difficult. Furthermore, some patients were able to see the blades of the instruments (vitreous cutter or vitreous scissors) open and close inside the eye, and the aspiration of blood or vitreous gel with TA particles through a cannula or vitreous cutter just in front of the retina [1, 4]. Patients perceived very detailed images of the shape and movement of the tip of the instrument and their own tissue, i.e. membrane (fig. 1 and 2). These findings suggest the existence of a common mechanism other than just seeing a shadow, by which the retinal cone system perceives the intravitreal objects that are not focused on by the retina through the eye's optical system. Additional investigations are needed to determine the mechanism of these phenomena.

Acknowledgement

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Twenty-three gauge cannula system with microvitreoretinal blade trocar

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ABSTRACT

Aims To report on a 23-gauge cannula with a microvitreoretinal (MVR) blade trocar which improved wound closure after vitrectomy and reduced the incidence of postoperative hypotony.

Methods The resistance of inserting a 23-gauge MVR trocar-cannula through the porcine sclera was compared with that with the conventional 23-gauge trocar-cannula. The incidence of postoperative hypotony (intraocular pressure <6 mm Hg) was determined for 48 eyes that underwent vitrectomy with the 23-gauge MVR trocar-cannula and 30 eyes with the conventional 23-gauge trocar-cannula. The eyes were examined on postoperative days 1, 2 and 7. The closure of the sclerotomies was examined by optical coherence tomography in nine eyes in each group on postoperative days 1, 3 and 7, and 1 month.

Results The resistance of inserting the MVR trocar-cannula was lower than that with the conventional trocar-cannula. In patients, a transient hypotony was found at postoperative day 1 after the vitrectomy in two eyes (4%) with the MVR trocar-cannula, and in seven eyes (23%) with the conventional trocar-cannula (p=0.023). An unclosed incision was detected in nine sclerotomies (50%) with the MVR trocar-cannula and 16 sclerotomies (89%) with the conventional trocar-cannula (p=0.028) on postoperative day 1, and the incidence of an opened incision was also significantly higher with the conventional trocar-cannula on days 3 and 7 but not after 1 month (p=0.003, p=0.008, p=0.486, respectively).

Conclusion The MVR trocar-cannula leads to better postoperative wound closure and reduces the incidence of postoperative hypotony.

INTRODUCTION

Small-gauge vitrectomy instruments were developed to allow transconjunctival sutureless vitrectomy.[1] Although good results have been obtained with their use, hypotony, choroidal detachments and endophthalmitis have been reported as postoperative complications.[2] An oblique sclerotomy or an angled incision was reported to minimise the incidence of wound leakage when the 25-gauge system was used.[3 4] Histological analysis of the angled incisions made by 25-gauge and 23-gauge systems showed better wound closure than with straight incisions.[5] The better closure reduced the leakage of intraocular fluid and blocked the entry of India ink on the surface of the eye into the vitreous.[5]

Twenty-three-gauge vitrectomy, first described by Eckardt,[6] uses a slit-shaped blade that was similar to the microvitreoretinal (MVR) blade. The sclerotomy was made by inserting the blade at an angle of 30°C, and the blade was removed. The 23-gauge cannula with the inserter was then pushed through the sclerotomy into the vitreous. This two-step procedure had at least two disadvantages: the sclerotomy incision can be lost between the time of the incision and the insertion of the cannula, and the open incision between two-step procedure can enhance bacterial contamination, although it is influenced by the sterile condition of the surgical field.

In an earlier study, we described the advantages of incorporating an MVR trocar in the 25-gauge cannula system so that the incision of the sclera by the trocar and insertion of the cannula could be done as a one-step procedure.[7] This reduced the incidence of postoperative hypotony.[7]

We have applied this principle to the 25-gauge system and investigated whether this system will have a lower resistance during insertion, and whether this system will enhance the wound closure, thus preventing postoperative hypotony.

MATERIALS AND METHODS

The resistance of inserting the MVR blade trocar-cannula through the sclera was measured in four isolated porcine eyes by a TENSILON Universal Tensile Instrument (RTC-1250A, A&D Co., Tokyo). The sclera was excised, and a part of the sclera with a thickness of approximately 0.4 mm was used for the experiments. The resistance values obtained with the MVR blade trocar-cannula were compared with those obtained when a conventional solid-shafted 23-gauge trocar system (Alcon Laboratories, Fort Worth, Texas) was used (n=2).

To determine the effectiveness of the 23-gauge MVR trocar system in human eyes, vitrectomy was performed on 48 eyes with these instruments, and the results were compared with those obtained from 30 eyes that underwent vitrectomy with the standard 23-gauge trocar-cannula (Alcon Laboratories, Fort Worth, Texas). A gas tamponade was used in 15 eyes with the MVR trocar-cannula and 16 eyes with the conventional trocar-cannula. The eyes were followed for at least 3 months in both groups. All patients were fully informed about the procedures, and a signed written informed consent was obtained from all patients. The procedures conformed to the tenets of the Declaration of Helsinki and all federal laws.

To begin, the MVR blade trocar was pushed through the sclera at an angle of about 45°. This direction was parallel to the corneal limbus, and the direction was then changed so that the tip of the blade was directed to the centre of the globe. The standard 23-gauge trocar-cannula was inserted in the same fashion. At the end of the surgery, the cannula was removed, and the sclerotomy site was gently wiped with cotton swabs to close the

opening and was not sutured. Eyes that had sutures because of silicon oil tamponade or simultaneous placement of encircling buckle were excluded from the study. The intraocular pressure (IOP) was adjusted to be between 10 and 20 mm Hg by palpation by injecting balanced salt solution into the anterior chamber through a corneal paracentesis or gas into the vitreous cavity with a 30-gauge needle.

The selection of the patients was consecutive and not randomised, and the methodology was not masked. The IOPs were measured preoperatively and postoperatively on days 1, 2 and 7, and the incidence of hypotony (IOP <6 mm Hg) was determined. Eyes with previous vitrectomies were excluded. The sclerotomy incisions were examined by optical coherence tomography (OCT3, Carl Zeiss Meditec, Dublin, California). Eighteen sclerotomy ports were made on the temporal and nasal sides in nine eyes with the MVR blade trocar-cannula, and 18 corresponding sclerotomy ports were made in nine eyes with the conventional trocar-cannula. All of these sites were scanned with the OCT3 on days 1, 3 and 7, and 1 month postoperatively. The direction of the OCT scan was parallel to the corneal limbus, which was the same direction as the incision made by the trocar to create the sclerotomy. The number of eyes in each group that had open scleral wounds in the OCT images was determined. An open scleral wound was detected in the OCT3 image by the lack of signals within the sclera in the obliquely scanned images. Eyes with a postoperative IOP <6 mm Hg were excluded from the wound-scanning study.

RESULTS

Insertion resistance of trocar-cannulas

The trocar-cannula with a MVR blade trocar is shown in figure 1A. The width of the MVR blade was 0.65 mm, and the inner and outer diameters of the cannula were 0.66 mm and 0.77 mm, respectively. The tip of the cannula was sharpened to decrease the inserting resistance (figure 1A) compared with that of the conventional trocar-cannula (figure 1B). The inserting resistance of the MVR blade trocar-cannula though the porcine sclera had two peaks as the trocar and cannula passed through the sclera. The force was 0.24 N at 4.6 mm and 1.72 N at 6.7 mm. The values were lower than that with the conventional trocar-cannula: 0.51 N at 4.8 mm and 2.16 N at 6.9 mm (figure 2).

Incidence of postoperative hypotony

The MVR blade trocar could be easily inserted through the sclera, and the cannula could be orientated so that it could be inserted into the middle of the vitreous. All of the incisions were angled (figure 1C,D), and the cannula was not retracted from the sclerotomy during the surgery. The sclerotomy was not sutured at the completion of the surgery in both groups.

The sclerotomies after vitrectomy with the MVR blade trocar-cannula were observed to be linear-shaped, and those with the conventional trocar-cannula were V-shaped according to the shape of the tip of the trocar, even with the angle incisions (figure 1E,F). The mean preoperative IOP in the eyes on which the MVR blade trocar-cannula was used was 12.7±3.8 mm Hg, and the mean postoperative IOPs were 13.1±5.0 mm Hg on day 1, 13.5±4.9 on day 2 and 13.0±3.3 on day 7. The postoperative IOPs were not significantly different from the preoperative IOPs ($p=0.891$, 0.078 and 0.074, respectively; Wilcoxon signed rank test). The mean preoperative IOP in the eyes that had vitrectomy with the conventional trocar-cannula was 12.8±5.8 mm Hg, and the postoperative IOPs were 9.9±6.2 mm Hg on day 1, 12.8±5.3 on day 2 and 13.1±3.1 on day 7. The IOP was significantly lower only on postoperative day 1 ($p=0.019$, 0.945 and 0.722, respectively; Wilcoxon signed rank test).

A temporary hypotony was found in two eyes (4%) on the day after vitrectomy in eyes that had vitrectomy with the MVR blade trocar-cannula, but the IOP returned to normal levels on the second day (table 1). A temporary hypotony was found in seven eyes (23%) on postoperative day 1 in eyes that had vitrectomy with the conventional trocar-cannula. The higher number of eyes with hypotony with the conventional trocar-cannula instrument group was significant ($p=0.023$, Fisher exact probability test). However, only three eyes remained hypotonic on the second day (0/48 eyes vs 3/30 eyes; $p=0.105$). The incidence of hypotony in the eyes without a gas tamponade was also significantly higher in eyes that had the conventional trocar-cannular vitrectomy (6% vs 36%; $p=0.018$), but was not in the eyes with a gas tamponade (0% vs 13%; $p=0.484$). Two eyes developed uveitis after vitrectomy with the MVR blade trocar-cannula system, and two eyes developed proliferative vitreoretinopathy after vitrectomy with the conventional trocar-cannula system. However, these four eyes did not develop postoperative hypotony, as was expected for these postoperative complications. The incidence of hypotony in eyes with an epiretinal membrane (none had gas tamponade) was 0% (0/15 eyes) in the MVR trocar-cannula group, which was lower than that of 22% (2/9 eyes) in the conventional trocar-cannula group ($p=0.130$). The incidence of hypotony in the MVR trocar-cannula was lower than that of the conventional trocar-cannula group in eyes with a macular hole (0/5 eyes, 1/3 eyes; $p=0.375$), proliferative diabetic retinopathy (0/16 eyes, 2/9 eyes; $p=0.120$) and retinal detachment (0/8 eyes, 1/5 eyes; $p=0.385$).

None of the eyes in both groups had a leakage of intraocular fluid (positive for Seidel test), postoperative endophthalmitis, retinal detachment or suprachoroidal infusion.

Incidence of wound closure determined by OCT3

Open sclera wounds were observed on postoperative day 1 in nine ports after vitrectomy with the MVR blade trocar-cannula system and in 16 ports after vitrectomy with the conventional trocar-cannula system (figure 3). The lower incidence of open wounds with the MVR blade trocar-cannula was significant ($p=0.028$, Fisher exact probability test, table 2). Signals were not always detected at the sclerotomy sites because of subconjunctival haemorrhage or chemosis, but the signals became clearer on postoperative days 3 and 7. The significantly lower incidence of open wounds in the eyes that had undergone vitrectomy with the MVR trocar-cannula was still present on postoperative days 3 and 7 but not at 1 month ($p=0.008$, $p=0.008$, $p=0.486$, respectively).

In the conventional trocar-cannula vitrectomy group, the internal sites of the incisions were seen to be open with closure of the external sites, 'internal open,' in two eyes 1 month after the surgery. A gape in the incision at the external entry site with closure of the internal site, 'external open,' was seen in one eye of the conventional group at postoperative 1 month, although the IOP was in the normal range, and all these three eyes were classified as closed wounds.

DISCUSSION

The advantages of micro-incision vitrectomy surgery (MIVS) including 25-gauge and 23-gauge vitrectomy are the faster recovery, less invasiveness and reduction in surgery induced astigmatism.[8 9] The 23-gauge vitrectomy system creates a larger sclerotomy than the 25-gauge vitrectomy system, but the system also has similar advantages over the 20-gauge system in

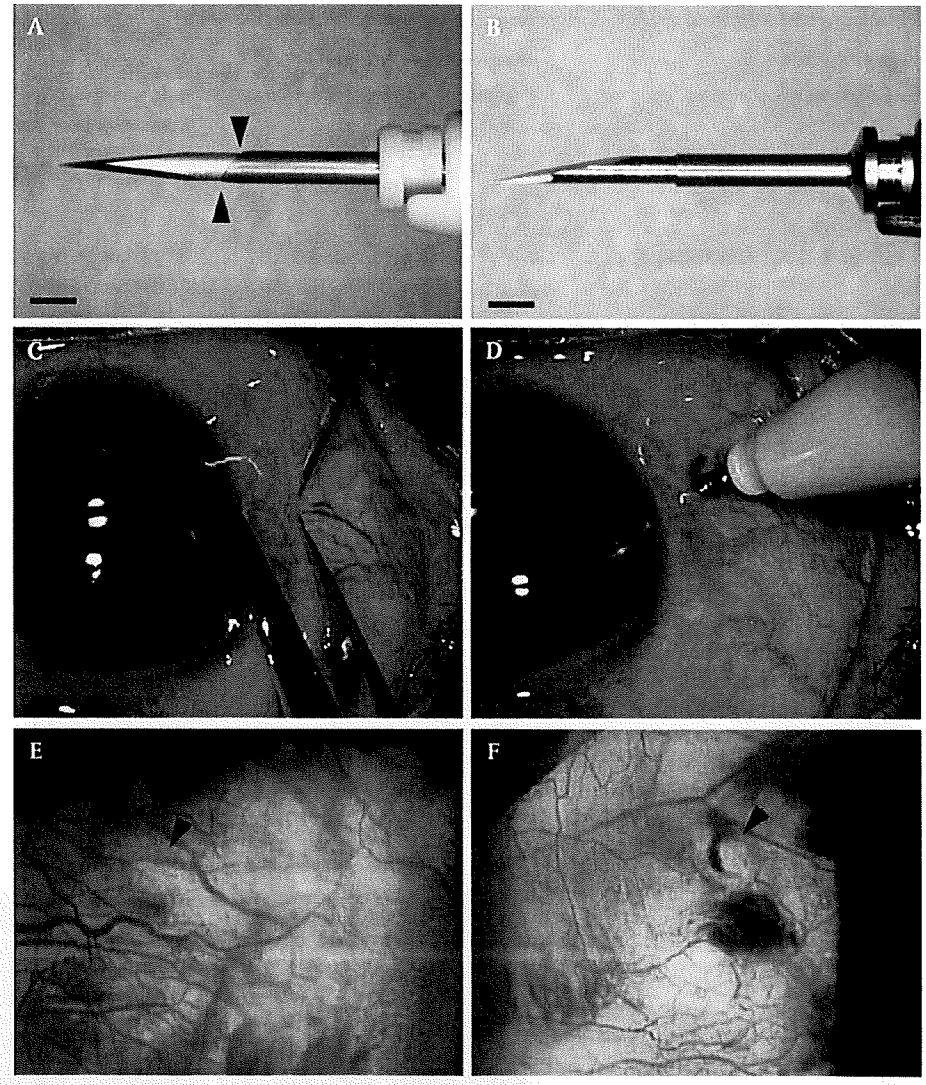

Figure 1 Microphotographs and intraoperative and postoperative photographs of the microvitreoretinal (MVR) trocar-cannula. (A) Side view of the MVR trocar-cannula; (B) side view of the conventional trocar-cannula (Alcon; bar: 0.5 mm). The tip of the cannula was sharpened to decrease the inserting resistance (A: arrowheads). (C) The head of the MVR blade trocar can be seen as it penetrates the globe at a 45° angle and parallel to the corneal limbus. (D) The direction of the trocar is turned to the vertical direction. (E) The sclerotomies after vitrectomy with the MVR blade trocar-cannula after linear-shaped (arrowhead) on the postoperative day 1. (F) The sclerotomies after vitrectomy with the conventional trocar-cannula is V-shaped (arrowhead) on the postoperative day 1.

postoperative astigmatism and faster visual recovery. Vitrectomy with 23-gauge instruments is safe and effective for surgeries for a macular hole, epiretinal membrane and other posterior segment surgeries.[8–11]

In a multicentre retrospective study, the intraoperative and postoperative complications of vitreal surgery for various posterior segment diseases were reported to be rare with the 23-gauge system, and the recovery time was significantly shorter.[12] A postoperative transient hypotony was the most common complication observed and was resolved without intervention by 1 week after the surgery.[12] A prospective randomised trial comparing 23-gauge and 20-gauge vitrectomy also showed that retinal manipulation and overall surgical damage did not differ significantly with the two systems, although the 23-gauge group had a shorter time for wound construction but a longer vitrectomy time.[13] However, a significantly higher number of patients reported less pain during the conjunctival injection and less pain during the early postoperative period in the 23-gauge MIVS group.[13,14]

A higher incidence of postoperative endophthalmitis has been reported after 25-gauge vitrectomy than after 20-gauge vitrectomy.[15,16] In those studies, vertical incisions were performed in 0–27% of the subjects to create sclerotomy, but a more recent

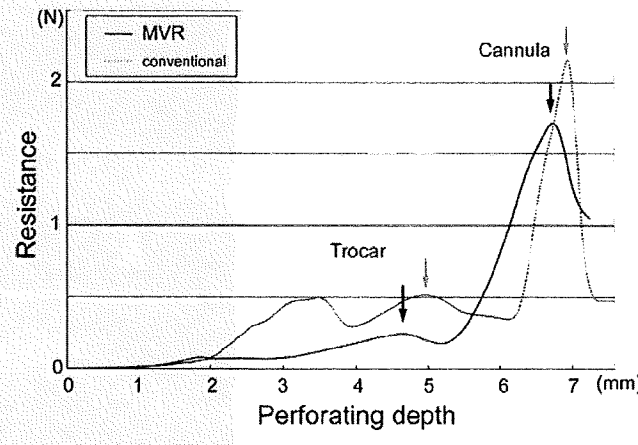

Figure 2 Resistance of insertion of each trocar-cannula through the sclera of an isolated porcine eye. The resistance of insertion of the microvitreoretinal trocar-cannula ('MVR') blade trocar-cannula was less than that of the conventional trocar-cannula ('conventional') when the trocar and the cannula were pushed through the sclera, as indicated by black arrows (MVR) and grey arrows (conventional).

Table 1 Comparison of the 23-gauge microvitreoretinal trocar-cannula vitrectomy and the conventional 23-gauge vitrectomy

Surgical procedure	Total eyes with postop hypotony	Procedure details (eyes) with postop hypotony	Surgical indications (N)
23-Gauge microvitreoretinal trocar-cannula vitrectomy	2/48 (4%)*	No exchange: 2/33 (6%)†	Epiretinal membrane: 15
		Gas exchange: 0/15 (0%)‡	Macular hole: 5
		Cataract surgery: 2/23 (8%)§	Proliferative diabetic retinopathy: 16
		Vitrectomy alone: 0/25 (0%)¶	Retinal detachment: 8
			Uveitis: 2
			Vitreous opacity: 1
Conventional 23-gauge trocar-cannula vitrectomy	7/30 (23%)*	No exchange: 5/14 (36%)†	Epiretinal membrane: 9
		Gas exchange: 2/16 (13%)‡	Macular hole: 3
		Cataract surgery: 3/17 (18%)§	Proliferative diabetic retinopathy: 9
		Vitrectomy alone: 2/13 (15%)¶	Retinal detachment: 5
			Diabetic macular oedema: 1
			Proliferative vitreoretinopathy: 2

*p=0.023;†p=0.018;‡p=0.484;§p=0.634;¶p=0.111.
The statistics were to compare the distribution of the procedure details between the two groups. With significant p values, we assume that the procedure details are not balanced (Fisher exact probability test).

study with angled incisions reported no significant difference in the incidence of postoperative endophthalmitis between 25-gauge MIVS and 20-gauge vitrectomy.[17] Histological analysis of cadaver or animal eyes showed that angled incision led to a better wound closure then vertical incisions.[18 19]

However, the transient postoperative hypotony after MIVS may allow entry of ocular surface fluid that increases the risk of bacterial contamination and endophthalmitis.[18 20–22] Because the conventional solid shaft-type torcar-cannula creates a V-shaped sclerotomy, the angled incision with a bevel-side down insertion has been suggested to lead to a better sealing of the wound.[4] Thus, we hypothesised that a slit-shaped incision with less resistance of insertion would lead to a better self-sealing wound.[7 23] We found less resistance of the MVR trocar-cannula in a porcine sclera and a lower incidence of postoperative hypotony in the MVR torcar-cannula group. We also found opened scleral ports even 1 month after surgery with the conventional solid shaft-type trocar-cannula system. This was probably because the V-shaped scleral tunnel would offer an easier passage of vitreous into the scleral tunnel. The opened

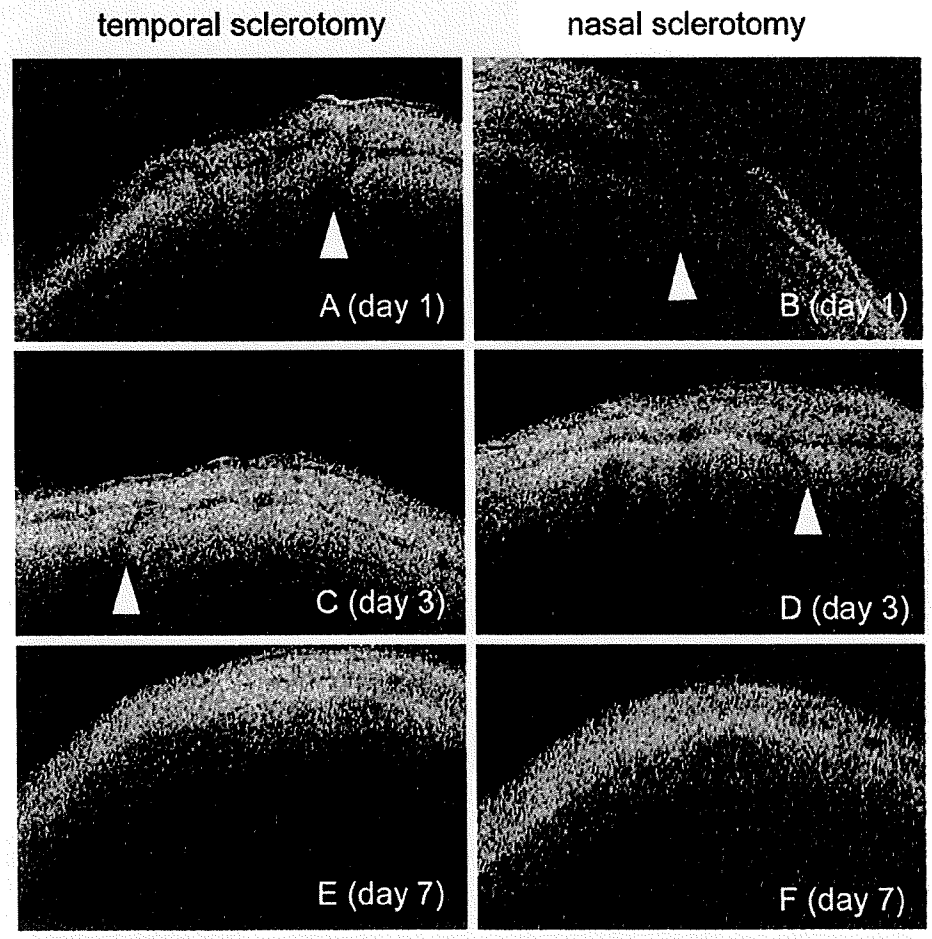

Figure 3 Optical coherence tomography images of temporal and nasal sclerotomies. The absence of scleral signals (white arrowheads) in the eyes that were operated on with the microvitreoretinal trocar-cannula can be seen on each side of the sclerotomy on postoperative days 1 and 3, but not on postoperative day 7.

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Table 2 Incidence of absence of signals of oblique scleral wounds

	Scleral ports	Day 1	Day 3	Day 7	1 month
Microvitreoretinal trocar-cannula	Temporal (n=9)	6	3	0	0
	Nasal (n=9)	3	1	0	0
Conventional trocar-cannula	Temporal (n=9)	9	9	6	2
	Nasal (n=9)	7	5	1	0
p Value		0.028	0.003	0.008	0.486

wound was observed as an empty, non-reflective space in the OCT images. Nagpal described a significant amount of vitreous blocking the inner lip of the sclerotomy ports of 25-gauge conventional systems that was detected by endoscopy in uncomplicated cases of vitreous haemorrhage due to diabetic retinopathy.[24]

OCT examinations of the anterior segment showed an occasional opened external incision at the entry site on postoperative days 1 and 8 in the eyes after 25-gauge conventional vitrectomy without postoperative hypotony.[25] OCT has the advantage as a non-contact examination to evaluate postoperative surgical wounds compared with high-frequency ultrasound biomicroscopy which requires direct contact with the wound surface. We used an OCT with a shorter wavelength light source with lower penetrating power through the sclera, and we found a significantly better wound closure with an MVR blade torocar-cannula system from an earlier postoperative period, although we examined only a limited number of cases. The evaluation of wound closure in sclerotomy with OCT may have a disadvantage by mistaking haemorrhage or fibrin within the gap of the scleral wound as a wound closure. However, none of the eyes were misclassified as having wound closure after the absorption of haemorrhage or fibrin. In addition, we did not find any choroidal detachments as has been reported as a complication of 25-gauge vitrectomy.[25]

We conclude that this new trocar-cannula is effective in obtaining better wound closure, and the incidence of postoperative hypotony was significantly lower. However, more cases are needed to determine the value of this surgical instrument.

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Contributors MI was involved in the management, analysis, interpretation and preparation of the data. MI, KS and AH were involved in the interpretation and preparation of the manuscript.

Competing interests None.

Patient consent Obtained.

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Dehiscence of levator aponeurosis in ptosis after sub-Tenon injection of triamcinolone acetonide

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ABSTRACT • RÉSUMÉ

Objective: To report the incidence, intraoperative findings, and surgical outcome of secondary ptosis that developed after a sub-Tenon injection of triamcinolone acetonide (TA).

Study Design: Retrospective, cross-sectional study.

Participants: One hundred forty-seven cases with a total of 286 sub-Tenon TA injections.

Methods: The medical records of 163 eyes of 147 cases treated with a sub-Tenon injection of 10 mg or 20 mg TA were reviewed. The incidence of secondary ptosis (palpebral fissure >2 mm narrower than that of the fellow eye) after a sub-Tenon TA injection was determined. The preoperative levator function and margin reflex distance (MRD) of the affected eyes, and the intraoperative findings in eyes that underwent reconstructive surgery, were evaluated.

Results: Eight eyes (5%) developed secondary ptosis after the injection and 6 eyes were treated by reconstructive surgery. The preoperative levator function of the affected eyes did not differ from that of the fellow eyes. Intraoperatively, no septal disruption or fat herniation was noted, but an aponeurotic disinsertion was identified and repaired with an advancement of the leading edge to the anterior tarsal plate. The surgery led to satisfactory results, with improvement of the MRD from −1.3 (SD 1.5) mm preoperatively to 2.3 (SD 0.5) mm postoperatively ($p = 0.027$). Additional sub-Tenon TA injections were required in 2 eyes after eyelid surgery but the ptosis did not worsen.

Conclusions: A sub-Tenon TA injection can occasionally cause ptosis by inducing a disinsertion of the levator aponeurosis. However, surgical reconstruction can lead to successful resolution of the ptosis.

Objet : Compte-rendu de l'incidence, des données peropératoires et du résultat chirurgical de la ptose secondaire qui s'est développée après injection sous-ténonienne d'acétonide de triamconolone (AT).

Nature : Étude rétrospective transversale.

Participants : Cent quarante-sept cas avec un total de 286 injections sous-ténoniennes d'AT.

Méthodes : Les fiches médicales de 163 yeux de 147 cas traités par injection sous-ténoniennes de 10 ou 20 mg d'AT ont été examinées. L'on a déterminé l'incidence de la ptose (fissure palpébrale plus étroite de >2 mm que celle de l'autre œil) secondaire à l'injection sous-ténonienne d'AT. On a aussi évalué la fonction releveuse préopératoire, la distance entre la marge palpébrale et le reflet cornéen (MPRC) des yeux affectés et les données peropératoires des yeux qui ont subi une chirurgie reconstructive.

Résultats : Huit yeux (5 %) ont développé une ptose secondaire après l'injection et 6 yeux ont été traités par chirurgie reconstructive. La fonction leveuse préopératoire des yeux affectés n'a pas différé de celle des autres yeux. Pendant l'opération, on n'a pas noté de disruption septale ni d'hernie de tissu adipeux mais une désinsertion aponévrotique a été décelée et réparée avec avancement de la bordure principale sur le plateau tarsien antérieur. La chirurgie a donné des résultats satisfaisants, avec amélioration de la MPRC de −1,3 (ÉT 1,5) mm avant l'opération à 2,3 (ÉT 0,5) mm après l'opération ($p = 0,027$). D'autres injections sous-ténoniennes d'AT ont été requises dans 2 yeux après la chirurgie de la paupière mais la ptose ne s'est pas aggravée.

Conclusions : Une injection sous-ténonienne d'AT peut parfois causer une ptose par induction d'une désinsertion de l'apronévrose releveuse. Toutefois, la reconstruction chirurgicale peut entraîner la résolution de la ptose.

Triamcinolone acetonide (TA) is a long-acting steroid that has been used widely in the orthopedic field.[1,2] In the ophthalmic field, eyelid hemangiomas and chalazions have been treated by subcutaneous injection of TA.[3,4] Recently, an intravitreal or sub-Tenon injection of TA has been shown to be efficacious for retinal vascular occlusions,[5] age-related macular degeneration,[6,7] and diabetic macular edema.[8,9]

An increase in the intraocular pressure and a progression of a cataract are well-known side effects of systemic or topical steroids. Such side effects have also been reported after a sub-Tenon TA injection.[10,11] In addition, secondary ptosis after a sub-Tenon TA injection has been described.[10-12] The presence of inflammatory lymphocytic infiltration at the site of injection suggested an inflammatory response causing the absorbance of orbital fat or dysfunction of the extraocular muscles, including the levator muscle.[12] However, we have described the presence of dehiscence of the levator aponeurosis in the intraoperative findings of eyes

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with subsequent ptosis after a sub-Tenon injection of TA.[3]

We reviewed the incidence of ptosis after a sub-Tenon TA injection performed for different vitreoretinal pathologies. Eyelid plastic surgery was performed successfully for the secondary ptosis, and we discuss the possible pathogenesis of the secondary ptosis by evaluating the intraoperative and clinical findings.

Methods

Subjects and methods

The medical records of 163 eyes of 147 cases that had a total of 286 sub-Tenon TA injections between 2005 and 2007 for retinal vascular occlusion, age-related macular degeneration, diabetic macular edema, or idiopathic choroidal neovascularization were reviewed. A ptosis was considered to be present when the palpebral fissure was >2 mm narrower than that of the fellow eye at the primary eye position. The patients who had myopathic, congenital, or senile ptosis before the TA injection, and those who had a history of contact lens use, were excluded.

Eight eyelids of 8 patients developed a ptosis after the sub-Tenon injection of TA, and none recovered in the following 6 months. Six of 8 patients underwent lid plastic surgery, whereas the other patients did not wish any surgery and were followed for the original disease. Two of the 6 patients required additional sub-Tenon injections of TA after lid plastic surgery.

Procedures for sub-Tenon TA injection

Written informed consent was obtained from all patients after a full explanation of the purpose and possible complications of the sub-Tenon TA injection. Institutional approval was also obtained for this retrospective clinical review. Ten milligrams (0.25 mL) or 20 mg (0.5 mL) of TA (Kenacort-A, 40 mg/mL; Bristol Myers KK, Tokyo, Japan) was aspirated into a 1 mL syringe and the supernatant was removed after the crystals of TA had settled on the bottom to reduce the volume of crystals to 0.1 mL or 0.2 mL, respectively. After several drops of 4% lidocaine, an eye speculum was gently inserted, and the patient was asked to look inferonasally to reveal the superotemporal bulbar conjunctiva. A 26-gauge needle was inserted superotemporally into the sub-Tenon space, gently moving the tip of the needle to avoid ocular penetration; the triamcinolone crystals were then located superotemporally. The tip of the needle was not very sharp, similar to the needle attached to a tuberculin syringe.

Surgical technique of plastic surgery

The plastic surgery procedures were performed under an operating microscope by the transcutaneous approach after subcutaneous injection of 2% lidocaine. The levator aponeurosis was bluntly exposed and a disinsertion of the aponeurosis was revealed. The aponeurotic disinsertion was repaired by an advancement of the leading edge to the anterior tarsal plate without advancing Müller muscle or tucking the levator muscle. The height of the lid was adjusted intraoperatively with the patient's cooperation.

Results

Preoperative evaluations and intraoperative findings

The incidence of ptosis after sub-Tenon injection of TA was 4.9% (8 of 163 eyes), and the incidence was significantly higher in the eyes of women (7/68 eyes; 10.3%) than those of men (1/79 eyes; 1.3%) ($p = 0.025$, Fisher exact probability test). None of 30 eyes developed symptomatic ptosis after bilateral sub-Tenon TA injection.

In the 8 eyes that developed ptosis, the sub-Tenon TA injection had been performed for age-related macular degeneration in 3 eyes, central retinal vein occlusion in 2 eyes, and branch retinal vein occlusion in 3 eyes (Table 1). The number of injections was 4 in 1 eye, 3 in 1 eye, 2 in 2 eyes, and 1 in 4 eyes. The total volume of injected TA before symptomatic ptosis was 40 mg in 1 eye, 30 mg in 1 eye, 20 mg in 2 eyes, and 10 mg in 3 eyes. The period from the initial sub-Tenon TA injection to the symptomatic ptosis varied from 6 to 24 months (16.8 [SD 5.6] months). Preoperative evaluations showed that the ocular movements were full and orbital fat prolapse or exophthalmos was not observed in any of the eyes. The levator function in the affected eye was 12.0 (SD 1.4) mm, which was not significantly different from that in the fellow eye of 12.5 (SD 1.4) mm ($p = 0.689$, Mann Whitney U test, $n = 6$) (Table 2), although the margin reflex distance (MRD) in the affected eye was −1.1 (SD 1.6) mm, which was significantly lower than that of the fellow eye of 1.8 (SD 0.9) mm ($p = 0.002$, Mann-Whitney U test, $n = 8$) (Table 2).

Table 1—Cases of secondary ptosis after sub-Tenon injection of triamcinolone acetonide

Case	Eye	Sex	Age	Disease	TA injections, *n* (mg)	Ocular history	Preop period* (mo)	Eye movement	Orbital fat prolapse
1	L	F	56	CRVO	4 (40)	t-PA, Vx	14	Full	None
2	L	F	73	CRVO	3 (30)	t-PA, PC	18	Full	None
3	L	F	65	AMD	2 (30)	PDT	9	Full	None
4	R	F	85	AMD	1 (20)	PDT	19	Full	None
5	L	F	88	AMD	2 (40)	PDT	24	Full	None
6	L	F	75	BRVO	1 (10)	Vx	8	Full	None
7	L	F	56	BRVO	1 (10)	Vx	6	Full	None
8	L	M	69	BRVO	2 (20)	Vx	7	Full	None

*Preop period is the period during which the symptomatic ptosis developed from the initial sub-Tenon TA injection

Note: TA triamcinolone acetonide; *n* (mg) total numbers and total milligrams of injections; Preop, preoperative; mo, month; L, left; F, female; CRVO, central retinal vein occlusion; t-PA, intravitreal injection of tissue plasminogen activator; Vx vitrectomy; PC photocoagulation; AMD age-related macular degeneration; PDT photodynamic therapy; R right; BRVO, branch retinal vein occlusion; M, male.

Intraoperatively, no septal disruption or fat herniation was noted, although an aponeurotic disinsertion from the tarsal plate was identified, and anatomical defects of the macrostructure of the Müller muscle were not found. These findings were similar to the findings seen in aponeurotic ptosis (Table 2, Fig. 1).

Postoperative outcomes

The levator function in the affected eye that had a plastic surgery was 12.0 (SD 1.6) mm preoperatively and 12.3 (SD 1.3) mm postoperatively (p = 0.885, Mann Whitney U test, n = 4), and that in the fellow eye was 12.5 (SD 1.7) mm preoperatively and 12.5 (SD 1.7) mm postoperatively ($p > 0.999$, n = 4).

The MRD in the affected eye was −1.3 (SD 1.5) mm preoperatively, which was significantly improved to 2.3 (SD 0.5) mm postoperatively (p = 0.027, Wilcoxon's signed-rank test, n = 6), whereas that in the fellow eye was 2.0 (SD 0.6) mm preoperatively and 2.3 (SD 0.5) mm postoperatively (p = 0.423, Mann Whitney U test, Fig. 2).

The ptosis did not recur in the 6 eyes that underwent reconstructive surgery in a mean postoperative period of 11.8 months. During this period, additional sub-Tenon TA injections were performed in 2 eyes (cases 2 and 3) because of a recurrence of macular edema with visual deterioration. The macular edema was resolved, and visual improvement was achieved after the reinjection. The ptosis did not worsen in either eye during the 9 months after the last injection. The surgical effect of lid surgery persisted even after additional injection. All the patients were satisfied with the outcome of the surgery.

Conclusions

Complications after posterior sub-Tenon TA injection are not rare (e.g., blepharoptosis has been reported in 4% to 15% of cases).[10,11] TA injection can also cause an increase in the orbital fat volume through a mechanism related to lipomatosis. Gupta et al.[14] reported 5 cases of proptosis after retrobulbar TA injection, and all cases demonstrated increased retrobulbar fat and increased fat in the inferior aspect of the orbit, but without fibrosis and granulomatous inflammation. They hypothesized that the lipomatosis may cause the ptosis through a mass effect. Glucocorticoids have been shown to cause hypertrophy of retroperitoneal adipose tissue in adult rats.[15]

On the other hand, TA injections can also cause local fat atrophy.[16–20] In particular, periorbital steroid injections have been reported to result in subcutaneous lipoatrophy.[16–18] The amount of TA we injected, 10 to 20 mg, was lower than the 40 mg used in previous studies,[10,11] which may explain why there was no orbital fat prolapse in our series.

However, other studies have reported ptosis and orbital fat prolapse after posterior sub-Tenon TA injection.[12] A recruitment of inflammatory histocytes with phagocytosed materials in the pathological sections obtained from the biopsy of the herniated orbital fat in patients with orbital fat

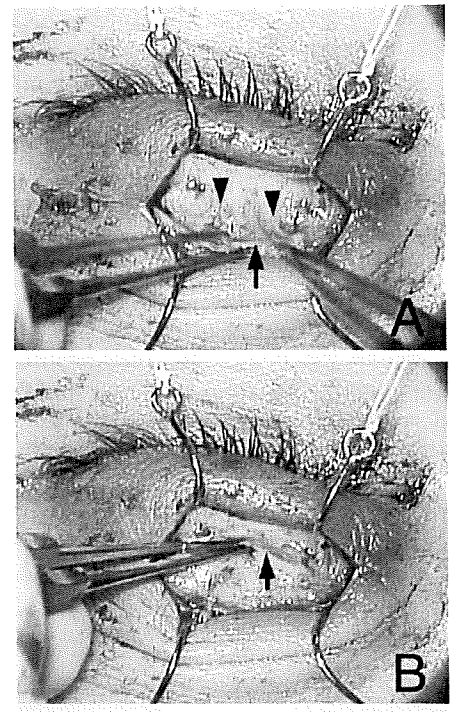

Fig. 1—Intraoperative photograph through the operating microscope of case 1. (A) Müller muscle (arrowheads) is seen at the upper rim of the tarsus. The adjunction of aponeurosis (arrow) is deviated superiorly to the attached location of Müller muscle. (B) The levator aponeurosis (arrow) is separated and sutured onto the tarsal plate.

Table 2—Intraoperative findings and postoperative outcome of secondary ptosis

				Preop MRD (mm)		Postop MRD (mm)		Preop levator function (mm)		Postop levator function (mm)		
Case	Eye	Dehiscence of LA	Intraop fat atrophy	Right	Left	Right	Left	Right	Left	Right	Left	Postop period* (month)
1	L		—	3	1	3	3	15	14	15	14	20
2	L		—	2	2	2	2	11	10	11	11	12
3	L		—	2	3	2	2	12	12	12	12	9
4	R		—	0	2	2	2	12	12	12	12	3
5	L		—	2	2	2	2	—	—	—	—	3
6	L		—	1	2	3	3	—	—	16	15	24
7	L	Not done	Not done	0	2	Not done	—	12	11	Not done	—	—
8	R	Not done	Not done	1	2	Not done	—	13	13	Not done	—	—

*Postop period is the follow-up period after the plastic surgery.
Note: LA, levator aponeurosis; Intraop, intraoperative; Preop, preoperative; MRD, margin reflex distance; Postop, postoperative; L, left; R, right.

prolapse and ptosis 2 weeks after their last sub-Tenon TA injection has been described.[11] The researchers concluded that a low-grade inflammation developed after a local TA injection, and this was the cause of the eyelid abnormalities such as rarefaction of the orbital septum, frail deconstruction of the levator muscle, and dehiscence of levator aponeurosis.[12] However, the levator function in their report was described as being as normal as that of the fellow eye.[12] In our cases, the levator muscle was not affected by the sub-Tenon TA injection because the levator function was well preserved preoperatively and postoperatively, which is compatible with the description by Dal Canto et al.[12] The intraoperative findings indicated that the vascular connective tissue surrounding the insertion appeared flimsy, without any atrophy of the muscle, which was consistent with that of aponeurotic ptosis. Local injections of TA into rabbit Achilles tendons have been described as weakening tendons, which decreased failure stress both within the tendon substance and in the space between the heel bones (retrocalcaneal bursa).[21] Histopathologic analysis of rabbit levator muscle and aponeurosis after sub-Tenon's triamcinolone injection revealed no significant histopathologic atrophy or increase in the inflammation between experimental and control groups.[22] These results indicate that dehiscence of levator aponeurosis most likely caused the ptosis after TA injection. In addition, our results show a higher incidence of ptosis after TA injection in the female population. The secondary ptosis after TA injection may relate to the female sex hormone; this issue must also be investigated.

We used a lid speculum, which has been shown to cause ptosis after cataract extraction. The mechanical stretching of the lid by the lid speculum while the eye was infraducted can result in postoperative ptosis, which is caused by levator aponeurosis dehiscence.[23,24] The relatively long delay of several months from the injection of TA to the identification of ptosis in our cases supports the concept of an aponeurotic weakening from the steroid rather than a mechanical effect of the speculum. Excellent surgical outcome using conjunctival-Müllerectomy ptosis repair or external levator advancement with debulking of the enlarged and herniated orbital fat component has been described, although the researchers did not present any details of the surgeries.[12] However, the Müller muscle was found intraoperatively to be intact in our patients, and excellent surgical outcome was achieved by fixating the levator aponeurosis to the original position without any advancement. Thus, these results may prove the hypothesis by Dal Canto et al.[12] regarding the presence of dehiscence of levator aponeurosis, although their surgical method of conjunctival Müllerectomy was different from their hypothesis.

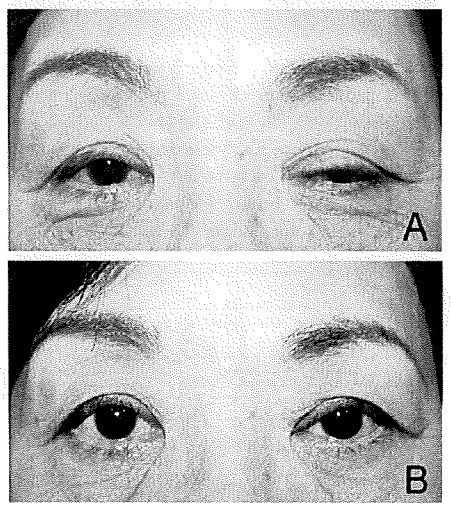

Fig. 2—Preoperative (upper) and postoperative (lower) photograph of case 1 showing a recovery of the ptosis after the lid plastic surgery.

In conclusion, ptosis may occasionally develop after a sub-Tenon TA injection, which should be related to patients as a possible side effect of TA injection. Our results showed that ptosis after sub-Tenon TA injections can be treated successfully by a conventional method, as used for aponeurotic ptosis.

The authors have no proprietary or commercial interest in any materials discussed in this article.

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