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Efficacy of Transconjunctival Tucking Surgery in Comparison With the Phenylephrine-test Positive and Negative Involutional Blepharoptosis Groups

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Background: This study aimed to determine whether there is a significant difference in the efficacy of transconjunctival tucking of the Müller muscle and levator aponeurosis in patients with involutional blepharoptosis who tested positive or negative on the phenylephrine test.

Methods: The analysis involved 64 eyes of 42 patients with levator muscle function of the upper eyelid of 8 mm or more and a margin reflex distance 1 (MRD-1) of less than 2 mm. Patients who tested positive and negative for 5% phenylephrine were allocated to group A (41 eyes of 26 patients) and group B (23 eyes of 16 patients), respectively. The efficacy of surgery (ΔMRD-1) was compared by subtracting preoperative MRD-1 from postoperative MRD-1. Multiple comparison tests were performed to evaluate changes in MRD-1 and ΔMRD-1 every 3 months from 3 to 12 months after transconjunctival tucking of the Müller muscle and levator aponeurosis.

Results: Regarding the mean ΔMRD-1 values at 3, 6, and 12 months postoperatively, the values at 6 and 12 months were significantly lower in group A than in group B, with 2.31, 1.98, and 1.81 mm, respectively, in group A and 2.73, 2.71, and 2.50 mm, in group B ($P = 0.03$ at 6 mo and $P = 0.041$ at 12 mo).

Conclusions: The efficacy of transconjunctival tucking of the Müller muscle and levator aponeurosis was greater in group B than in group A, and the results were more stable. This is an interesting finding when considering the successful mechanism in the present surgical method. *(Plast Reconstr Surg Glob Open 2025;13:e6902; doi: 10.1097/GOX.0000000000006902; Published online 16 July 2025.)*

INTRODUCTION

Surgical approaches for involutional blepharoptosis involve a transcutaneous method (external approach), in which surgery is performed from the skin side, and a transconjunctival method (internal approach), in which surgery is performed from the conjunctival side.[1] In Japan, percutaneous methods are commonly used; however, in Europe and the United States, many studies have reported the significance of the transconjunctival Müller muscle-conjunctival resection (MMCR).[2–4] In the case of involutional blepharoptosis, preservation of the levator muscle function of the upper eyelid is the most important indication. MMCR, which dissects the conjunctiva, is considered a highly invasive approach affecting the entire complex of the levator muscle of the upper eyelid.

Given the usefulness of minimally invasive surgery, we devised a transconjunctival tucking of the Müller muscle and levator aponeurosis (hereafter, "the present surgical method")[5] based on anatomical evidence.[6–8] We aimed to stabilize the postoperative course, increase the number of patients indicated for the present surgical method, and report its efficacy in severe patients (margin reflex distance 1 [MRD-1] < 1 mm). However, based on our experience, postoperative efficacy and durability may differ between patients who tested positive and negative for phenylephrine.

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The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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This study, which included patients who underwent the present surgical method and had comparable data, aimed to examine whether their postoperative efficacy differed between those who tested positive and negative for phenylephrine. Furthermore, we evaluated factors affecting postoperative efficacy.

PATIENTS AND METHODS

Patients

Among 152 eyes of 102 patients who underwent the present surgical method alone for involutional blepharoptosis between January 2018 and March 2022, this study included 64 eyes of 42 patients who had a preoperative MRD-1 of less than 2 mm, had a levator muscle function of the upper eyelid of 8 mm or more, and received examination every 3 months and were able to be followed up for at least 12 months after surgery. Preoperative age ranged from 36 to 88 years, with a mean age of 66.1 years. There were 10 men and 32 women, and 5 patients used anticoagulants. Written informed consent was obtained from all patients. Patients whose images appear in this publication provided additional written consent for publication. Patients with a history of neuro-ophthalmologic disease, strabismus, eye operation, and congenital blepharoptosis were excluded. Patients who have small tarsus and shallow conjunctival sacs were also excluded. The study was conducted as per the tenets of the Declaration of Helsinki and approved by the ethical review board of the Medical Corporation of Ogasawara Eye Clinic (approval number: 2401).

Methods

Accurate measurement of eyelid levator function is important for determining the surgical procedure. To measure upper eyelid function accurately, eyeglasses developed by us[9] were used in the present study. (See **Video 1 [online]**, which demonstrates eyeglasses designed to accurately measure upper eyelid function.) For evaluating surgical procedures in blepharoptosis, accurate and stable measurement of MRD-1 is quite important. We measured MRD-1 using a sophisticated method that adopts the application of second-generation swept-source anterior segment optical coherence tomography (Fig. 1).[10] Because preoperative MRD-1 varied from patient to patient, we calculated the surgical efficacy by subtracting preoperative MRD-1 from postoperative MRD-1 to objectively evaluate the efficacy of the present surgical method. The surgical efficacy was expressed as ΔMRD-1 and was compared between the groups.

All patients received a 5% phenylephrine (Neo-Synephrine, Kowa Pharmaceutical, Nagoya, Japan) test in both eyes, and patients with an elevation in MRD-1 of 1 mm or more, 20 minutes after the eye drop, were regarded as positive for the phenylephrine test. The number of patients who tested positive and negative for phenylephrine was 41 eyes from 26 patients and 23 eyes from 16 patients, respectively. The former patients were assigned to group A, and the latter to group B. When the surgical efficacy was defined as 2 mm or more in ΔMRD-1, survival analysis (Kaplan–Meier method) was performed on 42 eyes from 30 patients in both groups who could be followed up for 2 years postoperatively. This study adheres to the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Takeaways

Question: Is there a significant difference in the efficacy of transconjunctival tucking of the Müller muscle and levator aponeurosis in patients with involutional blepharoptosis who tested positive or negative for phenylephrine?

Findings: The present surgical method was stable and provided long-term relief in patients who tested negative for phenylephrine.

Meaning: The levator aponeurosis was shortened, and proprioceptive stimulation from the Müller muscle to the levator muscle is associated with the success of the present surgical method.

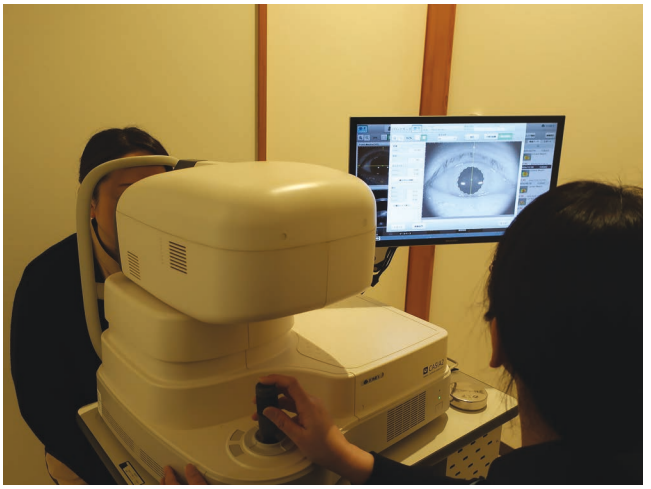

Fig. 1. MRD-1 measurement scene using anterior segment optical coherence tomography.

Surgical Technique

The outline of the presented surgical method is in the following order.[5] (1) The Müller muscle is exposed after the conjunctival fornix incision, and a 7-0 nylon thread with a double-armed needle (MANI3365) is passed through the tarsal side. (2) From this site, a thread is passed 5 mm through the underside of the tarsal plate and then exits again on the tarsal plate side. (3) From this point, the thread is rethreaded back to the site of the conjunctival incision in the conjunctival fornix. (4) At this site, a double-armed needle thread is used to pass the thread above the Müller muscle to a sufficient depth, including the posterior layer of the levator aponeurosis, so that both arms intersect. This surgical process for enhancing eyelid elevation is the most crucial part of the present improved technique. (5) After ligation and checking that the elevation of the eyelid is satisfactory, the suture is cut and the conjunctival incision site is closed by coagulation.

For details regarding the surgical technique, refer to Video 2 in the previous study.[5] (**See Video 2 [online]**, which demonstrates the surgical technique.) Moreover, a surgical animation is also available in Video 3. (**See Video 3 [online]**, which demonstrates the surgical technique in an animated format.) Figure 2 provides an overview of the final state of the surgical method.

Statistical Analysis

The age of the patients and measurement results are shown as mean ± SD. The Mann-Whitney test was used to measure the age and levator muscle function of the upper eyelid in group A and group B. The chi-square test was used for sex. The *t* test was used for preoperative MRD-1, MRD-1 at 12 months postoperatively, and the follow-up period. The *t* test was also used to examine whether there were significant differences in ΔMRD-1 at 3, 6, and 12 months postoperatively between group A and group B. Multiple comparison tests (Tukey–Kramer and Bonferroni methods) were used to assess changes in MRD-1 and ΔMRD-1 from 3 to 12 months postoperatively in each group. The methods used in the multiple comparison tests are described in the tables and graphs. Statistical significance was considered significant at a *P* value of less than 0.05. The Kaplan–Meier method was used to assess the survival rates of patients in group A and group B who were able to be followed up for 2 years postoperatively, and the log-rank test was used to examine the difference in survival rates between the groups.

RESULTS

Table 1 summarizes patients' data, measurement results, and statistical comparisons. The age of the patients in group B was slightly higher than in group A, and the number of women was significantly greater. Preoperative

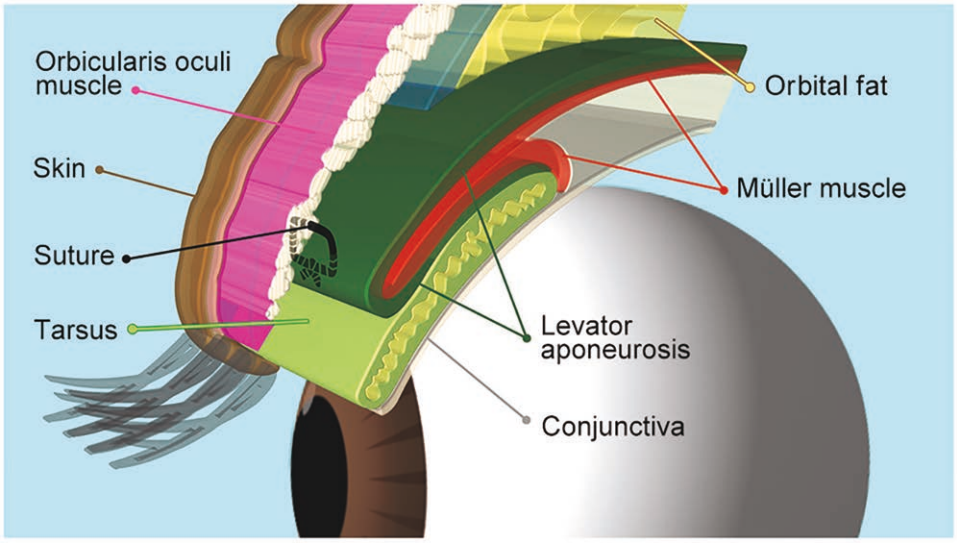

Fig. 2. Final state of the transconjunctival tucking of the Müller muscle and levator aponeurosis when a double-armed needle is threaded from the Müller muscle to the posterior layer of the levator aponeurosis.

Table 1. Summary of Cases, Test Results, and Comparative Statistics

	Total	Group A	Group B	*P* Group A Versus B
No. eyelids/patients	64/42	41/26	23/16	
Age (range), y	66.1 ± 11.04 (36–88)	63.3 ± 10.81 (36–84)	70.7 ± 9.80 (45–88)	0.052
Sex (F/M)	32/10	23/3	9/7	0.023*
Levator function preoperative, mm	11.00 ± 1.88	11.18 ± 2.00	10.65 ± 1.59	0.402
Preoperative MRD-1, mm	0.70 ± 0.80	0.90 ± 0.65	0.33 ± 0.90	0.005†
Postoperative 12-mo MRD-1, mm	2.75 ± 1.07	2.71 ± 1.02	2.83 ± 1.15	0.693
Postoperative 3-mo ΔMRD-1, mm	2.46 ± 1.01	2.31 ± 0.91	2.73 ± 1.13	0.113
Postoperative 6-mo ΔMRD-1, mm	2.24 ± 1.11	1.98 ± 0.80	2.71 ± 1.39	0.03†
Postoperative 12-mo ΔMRD-1, mm	2.06 ± 1.12	1.81 ± 0.84	2.50 ± 1.38	0.041†
Postoperative follow-up time (range), mo	19.50 ± 9.23 (12–44)	19.88 ± 10.40	18.88 ± 6.88	0.48
Longitudinal survival ratio (ΔMRD-1 ≥ 2 mm, 24 mo)	42 (56.1%)	25 (42.9%)	17 (72.8%)	0.032‡

*Statistical significance was determined using the chi-square test.
†Statistical significance was determined using the *t* test.
‡Statistical significance was determined using the log-rank test.

MRD-1 was significantly smaller in group B than in group A. No significant differences were found in preoperative levator function, with favorable results in both groups. Figure 3 shows changes in MRD-1 in group A and group B before surgery and at 3, 6, and 12 months postoperatively. Although MRD-1 tended to decrease in group A during the specified period, no significant differences were observed in MRD-1 in either group.

Figure 4 shows ΔMRD-1 in group A and group B. The multiple comparison tests of changes in ΔMRD-1 at 3, 6, and 12 months postoperatively showed significant differences at 3 and 12 months in group A ($P < 0.05$); however, such significant differences were not found at 3, 6, and 12 months postoperatively in group B. A *t* test was used to analyze changes in ΔMRD-1 in group A and group B every 3 months (from 3 to 12 mo postoperatively). The results showed that

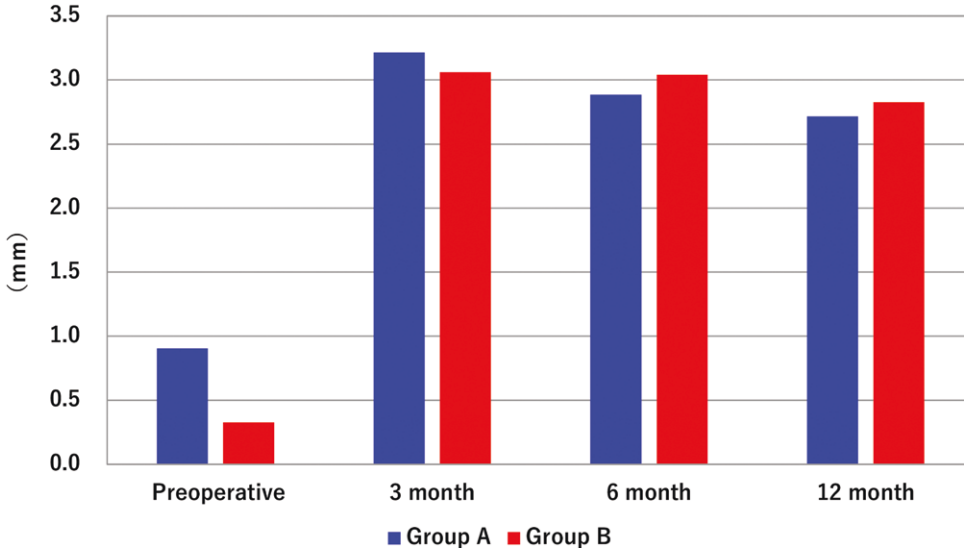

Fig. 3. Changes in MRD-1 before surgery and every 3 months in group A and group B. The results were analyzed using the Scheffe *F* test in group A and the Tukey–Kramer method in group B. No significant differences were found in changes in MRD-1 at 3 and 6 months postoperatively, 3 and 12 months postoperatively, and 6 and 12 months postoperatively.

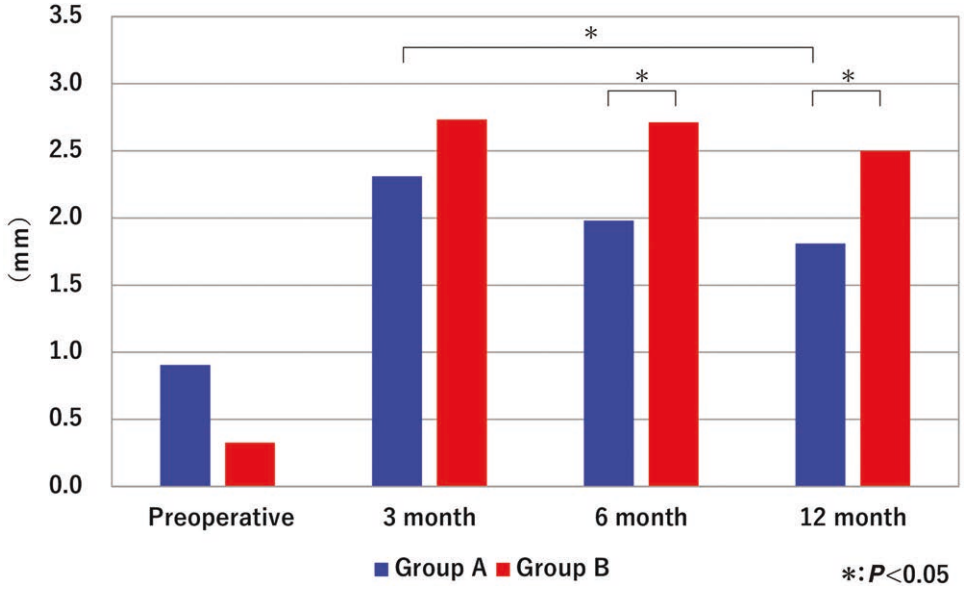

Fig. 4. Changes in ΔMRD-1 preoperatively and at 3, 6, and 12 months postoperatively. The results were analyzed using the Tukey–Kramer method in group A and the Bonferroni method in group B. Significant differences were found at 3 and 12 months postoperatively in group A. No significant differences were found at 3, 6, and 12 months postoperatively in group B. *T* tests were performed to compare group A and group B at 3, 6, and 12 months postoperatively; ΔMRD-1 was significantly smaller in group A than in group B at 6 and 12 months postoperatively ($P = 0.03$ at 6 mo, $P = 0.041$ at 12 mo).

changes in ΔMRD-1 tended to be smaller at 3 months postoperatively in group A than in group B. Furthermore, changes in ΔMRD-1 were significantly smaller at 6 and 12 months postoperatively in group A than in group B. The Kaplan–Meier method was used to examine the survival rate of patients who could be followed up for 2 years postoperatively. When ΔMRD-1 was set at 2 mm or more, there were significant differences in the survival rate, with 42.9% in group A and 72.8% in group B ($P = 0.032$) (Fig. 5).

Regarding postoperative complications, none of the patients experienced lagophthalmos due to overcorrection. Mild corneal erosion was observed in about 5% (8 eyes), but it was cured within 1 week with eye drops. Black eye hemorrhage was rarely observed, even in patients taking anticoagulants, and none of the patients experienced hemorrhage that persisted for more than 1 week.

DISCUSSION

The following are the important points for a more objective evaluation of surgical procedures for blepharoptosis: the efficacy of surgery, including MRD-1, should be assessed accurately; patients must be followed up for long periods without dropout; and errors in pre- and postoperative laboratory data should be minimized. Although the sample size in this study was not large, the accuracy of the measurement of levator muscle function of the upper eyelid was high,[9] and MRD-1 was measured every 3 months postoperatively in all patients using a method that minimizes errors,[10] indicating that the results of this study were highly reliable. A representative clinical case is shown (Figs. 6, 7).

This study showed that there was no significant decrease in MRD-1 at 3 months interval from 3 to 12 months after surgery in group A or group B (Fig. 3); however, when

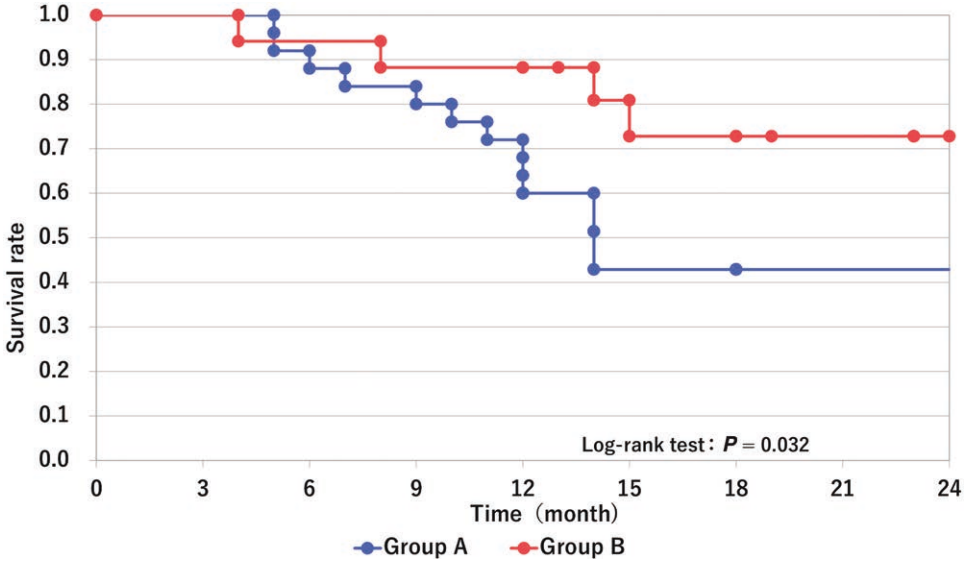

Fig. 5. Changes in ΔMRD-1 preoperatively and at 3, 6, and 12 months postoperatively. Survival analysis using the Kaplan–Meier method was performed on patients who can be followed up for 2 years postoperatively. When ΔMRD-1 was set at 2 mm or more, the survival rate was 42.9% in group A and 72.8% in group B ($P = 0.032$).

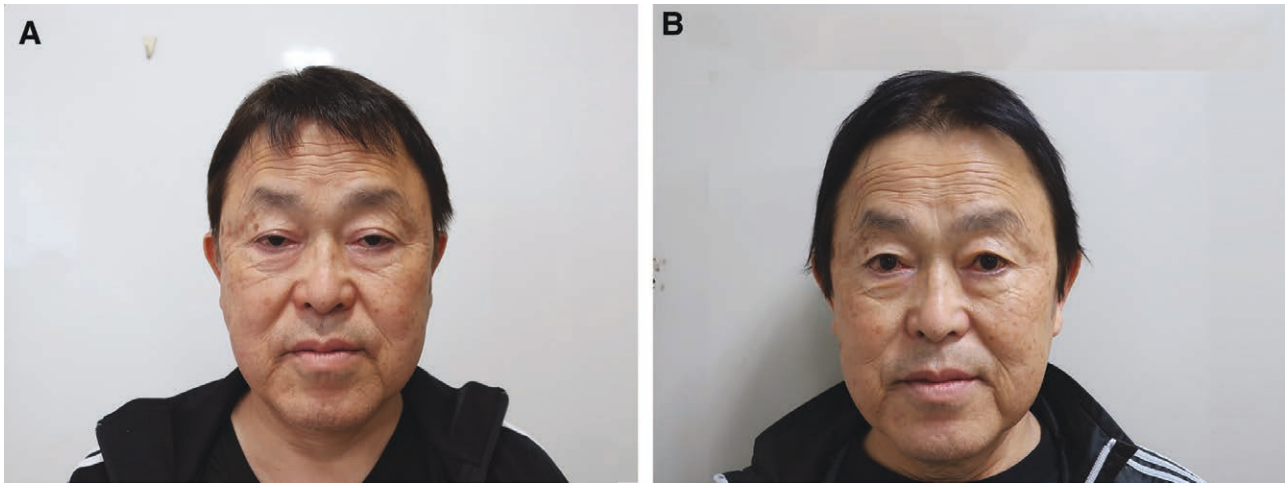

Fig. 6. A representative case by the present surgical method. Photographs of a 66-year-old male phenylephrine-test-negative patient with severe blepharoptosis, shown before (A) and 2 years after surgery (B).

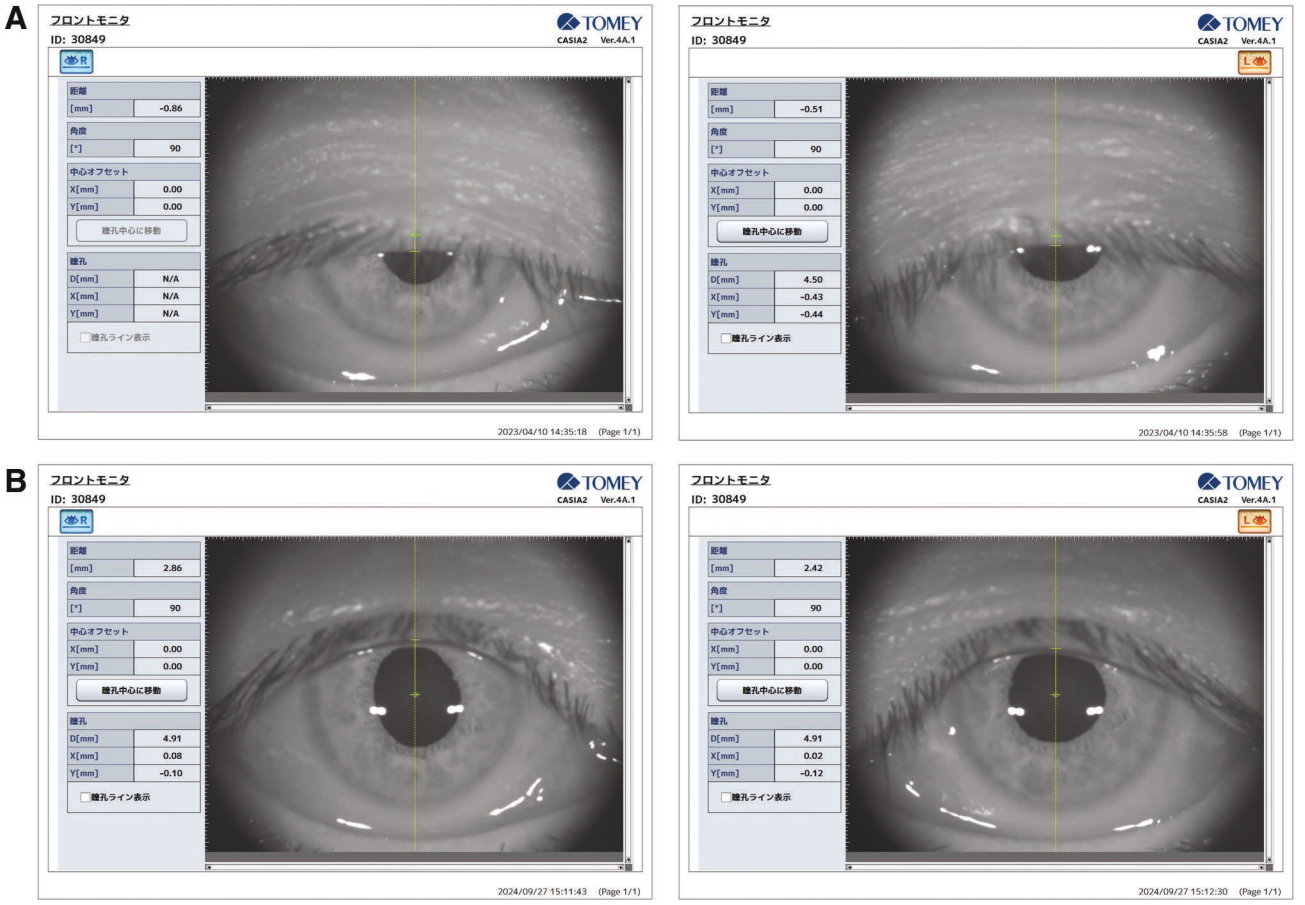

Fig. 7. Anterior segment optical coherence tomography findings of the patient shown in Figure 6. A, Preoperatively. B, 2 years postoperatively. The efficacy of ΔMRD-1 after surgery is 3.72 mm in the right eye and 2.93 mm in the left eye.

ΔMRD-1 was used as a reference, the efficacy of eyelid elevation with the present surgical method was significantly greater in group B than in group A (Fig.4). The survival rate of patients who could be followed up for 2 years postoperatively was analyzed using the Kaplan–Meier method. When ΔMRD-1 was set at 2 mm or more, the survival rate was significantly higher in group B than in group A (Fig.5) (P = 0.032). Changes in MRD-1 were assessed every 3 months for a year. MRD-1 tended to decrease in group A, but no significant decrease was observed. This is likely due to the fact that many patients with a large MRD-1 tested positive for phenylephrine in this study, resulting in a significantly higher preoperative MRD-1 in group A than in group B.

Regarding the interpretation of the results of this study, because there was no significant difference in the function of the levator aponeurosis of the upper eyelid between group A and group B, the levator aponeurosis of the upper eyelid is considered to be equally shortened. As for the shortening effect tended to decrease postoperatively in group A, and it is necessary to examine whether the Müller muscle plays a role in attenuating the effect.

Studies by Matsuo,[11] Yuzuriha et al,[12] and Ban et al[13] propose the theory that the Müller muscle serves as a sensory proprioceptive organ, acts as an afferent mechanoreceptor, and transmits its stimulus to the levator muscle of the upper eyelid, causing the eyelid to lift.[14] Recent studies have clarified the central neural pathway from the Müller muscle to the brain.[13,14] Landau-Prat et al[15] have reported in detail that the Müller muscle is histologically and histochemically classified into a sensory proprioceptive organ. In studies involving patients who underwent transconjunctival or percutaneous shortening of the levator aponeurosis of the upper eyelid under local anesthesia, the degree of a postoperative eyelid droop was evaluated according to the presence or absence of epinephrine, which stimulates sympathetic nerves during surgery. The results showed that the degree of postoperative eyelid droop was significantly greater in patients who received epinephrine, and there was a correlation between patients who tested positive for phenylephrine before surgery.[16,17]

Considering our results, results of the preoperative phenylephrine test, and the correlation between the efficacy of an anesthetic with intraoperative epinephrine,[16,17] we hypothesize that the Müller muscle relaxes preoperatively, the muscle's ability to act as a stretch receptor (mechanical receptor) is weak, and its ability to stimulate the levator muscle of the upper eyelid is insufficient in patients who experience an eyelid droop after the present

surgical method. Therefore, although the state in which the Müller muscle is stretched by tucking after surgery appears to be similar in group A and group B, the preoperative function of the Müller muscle to the levator muscle of the upper eyelid differs between group A and group B, suggesting that the stretching stimulation to the levator muscle of the upper eyelid is more pronounced and persists in group B (Fig. 8).

The most widely used technique for involutional blepharoptosis in Europe and the United States is MMCR,[2–4] a technique in which the amount of the Müller muscle resected is determined by its response to phenylephrine, although various algorithms have been devised.[18,19] It is understandable that a greater response to phenylephrine would result in a greater degree of shortening of the Müller muscle. However, it has not been clearly interpreted whether resection and shortening of the Müller muscle alone are sufficient to achieve upper eyelid elevation.[20,21] Although Lake et al[22] and Baldwin et al[23] have shown that open-sky Müllerectomy is effective even in patients who tested negative for phenylephrine, a thread was passed through the Müller muscle stump and from the upper margin of the eyelid plate to the skin in their reports.[23,24] As a result, the levator aponeurosis seemed to be simultaneously advanced. In other words, it is assumed that when the Müller muscle is advanced, the levator aponeurosis is also simultaneously advanced, resulting in good elevation of the levator muscle of the upper eyelid. For the discussion of mechanisms in MMCR, we consider the report of Ben Simon et al.[21] They showed that phenylephrine testing before MMCR underestimated the blepharoptosis correction achieved with MMCR by 40%, and the elevation effect of MMCR was not invariable among patients. Together with the present results and the previously mentioned studies,[20–24] we suppose as a possible mechanism of response to MMCR that resection and shortening of the Müller muscle enhance the traction effect of the mechanical receptors on the levator muscle of the upper eyelid and advance the levator aponeurosis of the upper eyelid. Such combined effects elevate the upper eyelid.

It is true that there has been some controversy about whether the threading technique provides a stable and sufficient elevation of the levator muscle of the upper eyelid.[24] To date, we have not experienced any complications that might be related to the threading method using nylon threads. It is also conceivable that tucking may result in permanent tissue adhesion. As for the long-term efficacy of the surgical technique, a 2-year survival curve is shown in Figure 5. The efficacy of the present surgical method is comparable to the recent results reported by a prospective multicenter study on MMCR.[25]

This study has several limitations. First, this is a retrospective study, and preoperative MRD-1 significantly differs between group A and group B. The patients were

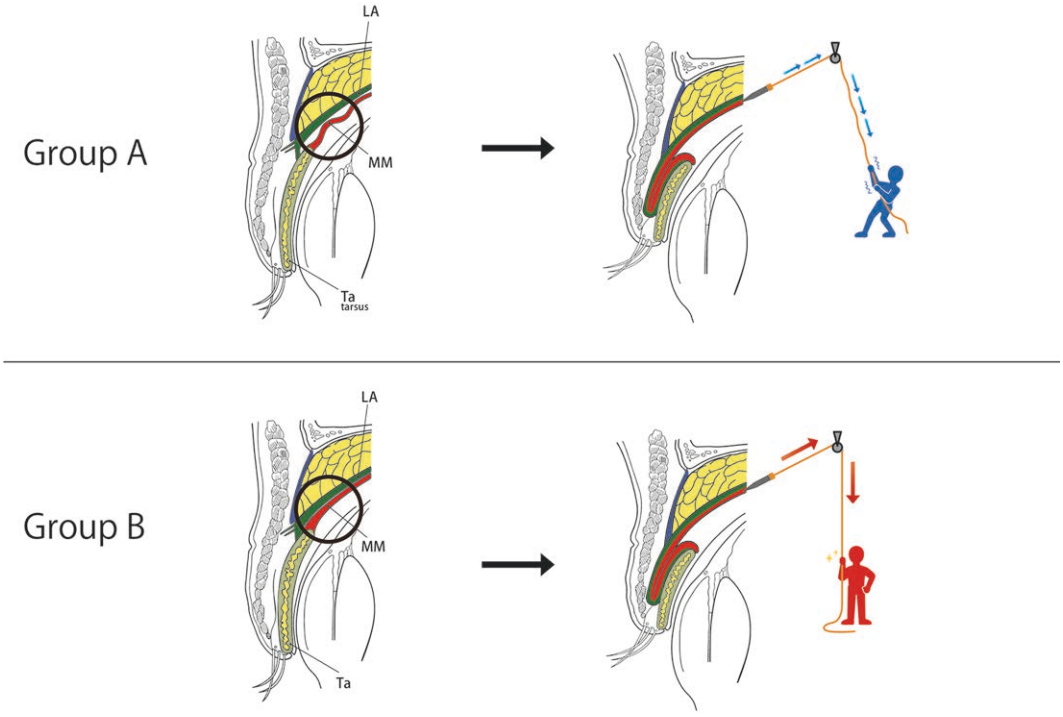

Fig. 8. Schematic sagittal section of preoperative and postoperative extension of the Müller muscle and the levator aponeurosis of the upper eyelid in group A and group B. In group A, the preoperative Müller muscle is presumed to relax, whereas in group B, it is presumed not to relax. Although the Müller muscle is stretched in both groups, the amount of stimulation and stretch of the levator muscle of the upper eyelid by the Müller muscle is different and is considered to be greater in group B than in group A, as shown in an artistic drawing of "stretch sensory mechanism." LA, levator aponeurosis; MM, Müller muscle; Ta, tarsus.

older in age, and the examination of data on younger patients is an issue that needs to be addressed. In this regard, further evaluation in the future is considered necessary after increasing the number of patients. Second, only 5% of the phenylephrine ophthalmic solution is used for the phenylephrine test because other percentages of phenylephrine are unavailable in Japan. In Europe and the United States, 2.5% and 10% phenylephrine ophthalmic solutions can be used, but it has been reported that there is little significant difference in eyelid elevation between ophthalmic solutions with different concentrations.[26] Taken together, the effects of concentrations of phenylephrine ophthalmic solution on the study results are seemingly limited. However, phenylephrine hydrochloride used in the phenylephrine test is an adrenergic alpha-1 agonist; thus, it is unclear whether Müller muscle activity regulated by receptors predominant in the Müller muscle is accurately evaluated.[27,28]

In conclusion, the results of this study demonstrate that the minimally invasive treatment of blepharoptosis through the present surgical method developed by the authors was effective in patients with involutional blepharoptosis, and the efficacy was stable and durable, especially in patients who tested negative for phenylephrine. This suggests that the stretching effect of the Müller muscle differs between patients who tested positive and negative for phenylephrine, supporting the previously reported theory by Matsuo et al.[14]

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DISCLOSURE

The author has no financial interest to declare in relation to the content of this article.

PATIENT CONSENT

The patient provided written consent for the use of his image.

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