Long-Term Results of Deeper Muscle Fibers Recession of an Inferior Rectus Operation

Birsen Gokyigit, MD; Serpil Akar, MD; Pelin Kaynak, MD; Ahmet Demirok, MD; Omer Faruk Yilmaz, MD

ABSTRACT

Purpose: To report the efficacy in preventing lower eyelid retraction and long-term results of a new technique of inferior rectus (IR) recession for vertical strabismus and compare this method with the results obtained by a conventional IR recession operation.

Methods: This retrospective study included 35 patients who underwent a new IR recession method (study group) and 22 patients who underwent the conventional IR recession (control group) for vertical strabismus. In the study group, an IR recession was applied to the deeper fibers and included approximately 90% of the IR muscle thickness. This group was divided into two subgroups: small IR recessions (4 to 6 mm) and large IR recessions (7 to 8 mm). In the control group, an IR recession of the entire muscle was applied without exceeding 6 mm. The photographs were analyzed for lower eyelid position. Digital image analysis was used to standardize each patient’s preoperative and postoperative photographs at final follow-up examination. The main outcome measures were the margin-to-reflex distance, lower eyelid retraction, and vertical deviation angles (at near and distance fixation).

Results: The mean change in margin-to-reflex distance after surgery was 0.03 mm in the small IR recessions group, 0.1 mm in the large IR recessions group, and 2.04 mm in the control group. Postoperatively, the lower eyelid retraction in the study group, which occurred after both small and large IR recessions, was significantly less than that in the control group (P < .001). There was no significant difference between the study and control groups in improvements in near and distance vertical deviations and success ratios (P > .05).

Conclusions: At long-term follow-up, recession of the deeper fibers layer, including approximately 90% of the IR muscle thickness, was a procedure that minimized or eliminated the possibility of lower eyelid retraction and did not limit the success of strabismus surgery.

INTRODUCTION

Surgery on the vertical rectus muscle is an effective procedure and some complications can be reduced, provided certain precautions are taken. Lower eyelid retraction is a frequent complication following recession of the inferior rectus (IR) muscle. Several techniques have been introduced as attempts to avoid lower eyelid retraction. Jampolsky began to recess the IR muscle and capsulopalpebral fascia separately, and Kushner and Pacheco further developed this technique. In 1996, Meyer et al. introduced a different approach and described the lysis of these retractors during surgery. There have been several studies on both techniques and...
versions of them have been used successfully.\textsuperscript{7-11} A new technique of IR recession for vertical strabismus was introduced by Gokyigit et al. in 2006.\textsuperscript{12,13}

We report the efficacy in preventing lower eyelid retraction and long-term results of a new technique of IR recession for vertical strabismus. This new technique for IR recession allows for larger amounts of recession without causing lower eyelid retraction. We compared the results of this new method with those obtained by conventional IR recession.

\textbf{PATIENTS AND METHODS}

Approval from the Prof. Dr. N. Resat Belger Beyoglu Education and Research Eye Hospital Institutional Review Board and Ethics Committee was obtained. Informed consent was obtained from each patient or one or both of the parents for patients younger than 18 years. The study and data collection conformed to all local laws and were compliant with the tenets of the Declaration of Helsinki.

We reviewed the medical records of consecutive patients who underwent IR recession for vertical strabismus in the Strabismus Department of the Prof. Dr. N. Resat Belger Istanbul Beyoglu Education and Research Eye Hospital from May 2003 to January 2012. The study group was composed of patients who had undergone surgery with the new method of IR recession from May 2005 to January 2012. The control group was composed of patients who had undergone a conventional IR recession between May 2003 and January 2012. We never performed this technique over 6 mm because of the well-known lower eyelid retraction complication of the conventional IR recession technique when applied over 6 mm. Many of the cases from the control group were operated on before 2005.

Inclusion criteria were as follows: presence of preoperative vertical deviation greater than 10 prism diopters (PD) that remained constant for more than 6 months and presence of standardized preoperative and postoperative eye photographs (external). Exclusion criteria were dermatochalasis obscuring the eyelid margins, restrictive strabismus with lower eyelids fixed to orbital tissues by old scarring, dysthyroid restrictive strabismus, and serious restriction of the IR muscle (found using the forced duction test). Patients with postoperative follow-up of less than 12 months were also excluded.

Preoperatively, all patients underwent a full orthoptic and ophthalmic assessment. Preoperative major measurements included vertical deviation angles (near and distance fixation) and measuring the margin-to-reflex (MRD\textsubscript{2}) distance. Lower eyelid retraction was determined by measuring the MRD\textsubscript{2} of the lower eyelid.\textsuperscript{4,10}

Standardized preoperative and postoperative photographs were taken in the following manner. Photographs were taken at a fixed distance, under identical lighting conditions, with the patients in a sitting position and their eyes in primary gaze. The patient’s head was placed firmly in the head rest of a slit lamp, and the lateral canthal angles were aligned with the side marks. An 18-inch metal bar was fixed to the head rest of the slit lamp, projecting forward. The camera was held directly beneath the metal bar, moving forward or backward to focus on the patient’s eyelid margins. The patient was asked to fixate on the camera while the uninvolved eye was occluded. Photographs were taken with a digital camera (Cybershot DSC-F828; Sony Electronics, Inc., Tokyo, Japan) with a macrolens at a reproduction ratio of 1:4.

Digital image analysis was used to standardize each patient’s preoperative and postoperative photographs for accurate objective comparison. Preoperative and postoperative photographs at final follow-up examination were analyzed for lower eyelid position. Adobe Photoshop version 7.0.1 (Adobe Systems, Inc., San Jose, CA) was used to measure the distance (pixels) from the center of the pupil to the lower eyelid margin (MRD\textsubscript{2}) and the corneal diameter.
(Figure 1). The MRD$_2$ was then standardized to an average horizontal corneal diameter (calculated as 11.6 mm in women and 11.7 mm in men) as described previously. The postoperative lower eyelid retraction was calculated by subtracting the preoperative MRD$_2$ from the postoperative MRD$_2$.

Surgical Technique

The conjunctiva was opened with a limbal conjunctival incision and enlarged with blunt dissection. After reaching the IR muscle area, two holes on both sides of the IR muscle were opened. The muscle was held with a hook (Figure 2A, Figure 3A). The intermuscular fascia was recessed by sliding both sides of the muscle approximately 6 mm either by scissors or by holding the membrane tissue with toothless forceps, and curved Vannas scissors were used to open a tunnel under a thin layer (approximately 10% of muscle thickness) of the surface fibers of the IR muscle related to the capsulopalpebral fascia, which are composed of the lower eyelid retractors. The scissors were opened after passing under a thin layer (approximately 10% of the muscle thickness) of the surface fibers of the IR muscle (Figure 3B) and its corresponding tendon. A large iris spatula was passed between the scissors blades and under the surface fibers of the muscle, as the scissors were withdrawn (Figure 3C). Using a large iris spatula, a

![Figure 2. A new technique of inferior rectus recession. (A) After reaching the inferior rectus muscle area, two holes on both sides of the inferior rectus were opened and the muscle was held with a hook. (B) Initially, it was separated by the fascial sheath covering the inferior rectus muscle and the tendon adjacent to it, as much as possible on both sides of the insertion. Then, a thin layer of the surface fibers (approximately 10% of muscle thickness) was detached from the deeper fibers (approximately 90% of the muscle thickness) by blunt dissection and the tunnel was enlarged by a spatula with blunt dissection, as much as possible posteriorly (approximately 6 to 8 mm). A 6-0 absorbable suture on a spatulated needle was placed on the deeper tendon adjacent to the sclera and locked at both edges of the tendon. (C) The deeper tendon layer was disinserted from the muscle insertion. (D) The deeper tendon layer and its corresponding fibers layer of muscle (approximately 90% of the muscle thickness) were fixed to the sclera 3 to 8 mm from the insertion with sutures on both sides. 1 = conjunctiva; 2 = fascial sheath of inferior rectus muscle and its extensions; 3 and 3A = the layer of surface fibers of inferior rectus muscle tendon; 3B = the layer of the deeper fibers of the tendon; 4A = the layer of surface fibers (approximately 10% of inferior rectus muscle thickness); 4B = the layer of the deeper fibers (approximately 90% of the muscle thickness); 5 = sclera; 6 = the deeper fibers of the tendon that were disinserted from the muscle insertion.]
thin layer of the surface fibers was detached from the deeper fibers, including approximately 90% of the muscle thickness, by blunt dissection (Figure 3D). The tunnel was enlarged by a spatula while the surface layer was protected with toothless forceps, as far from the muscle incision as possible posteriorly with blunt dissection (approximately 6 to 8 mm) (Figure 3E). A 6-0 absorbable suture (6-0 polyglactin 910) on a spatulated needle was placed on the deeper tendon part for each side separately adjacent to the sclera and locked at both edges of the tendon (Figure 3F, Figures 3G-3I). The deeper tendon layer was disinserted from the muscle insertion (Figure 3H). For the surface and deeper fibers to enlarge toward the posterior, the muscle was held with a clamp and stretched back gently (Figure 3I). These deeper parts of muscle, including approximately 90% of the muscle thickness, were fixed to the sclera 3 to 8 mm from the insertion with sutures on both sides (Figure 2D, Figures 3J-3K). The conjunctiva was closed with a 8-0 absorbable suture (Figure 3L).

In the control group, the IR muscle recession (3 to 6 mm) was performed through a limbal incision following a standard technique with variable blunt dissection of the intermuscular membrane of the IR and of the fascial attachment between the IR and Lockwood’s ligament as far to the posterior as possible.4,5,16,17 One millimeter of the recession was performed for each 3 PD of vertical deviation.15 When indicated, surgery to other extraocular muscles was undertaken at the same time or as a second procedure as an IR recession.

The examinations were repeated 1 week before surgery and postoperatively at 1, 3, 6, and 12 months, and then annually. The final examinations were performed at a mean postoperative follow-up time of 49.9 months for the new method of IR...
recession and at a mean postoperative follow-up time of 47.7 months for conventional IR recession.

Postoperative success was defined as orthotropia or a vertical undercorrection of less than 4 PD in the primary position on the final examination.

Statistical Analysis
Data were analyzed with SPSS for Windows, (version 16; SPSS, Inc., Chicago, IL). Descriptive statistics, frequency, and percent for categorical variables and mean ± standard deviation for numeric variables were calculated. The differences in preoperative and postoperative data between the study and control groups were compared. For quantitative variables, an independent samples t test was used. Fisher’s exact test was used for qualitative variables. In the study and control groups, the data were analyzed for evidence of lower eyelid retraction and a correlation between the amount of muscle recessed and the magnitude of the lower eyelid retraction using a linear regression analysis. For this analysis, the study group was divided into two subgroups: small IR recessions (4 to 6 mm) and large IR recessions (7 to 8 mm). Analysis of covariance was performed comparing the slopes of the regression lines (lower eyelid retraction [mm] as a function of the IR recession [mm]) of the study and control groups.

RESULTS
This study included 57 patients. Thirty-five (17 female, 18 male) of these patients underwent the new method of IR recession (study group) and 22 (12 female, 10 male) underwent a conventional IR recession (control group). IR recession was the sole procedure in 26 cases of the study group. Nine cases underwent a contralateral inferior oblique weakening operation either at the same time or as a second procedure. In the control group, 14 cases underwent horizontal muscle surgery at the same time as the IR recession.

Study Group
The mean age of onset of strabismus was 27.7 ± 8.6 years (range: 4 to 73 years). Seventeen of the 35 patients had a diagnosis of double elevator palsy, 9 had fourth cranial nerve palsy, and 9 had partial third cranial nerve palsy. The mean follow-up period was 49.96 ± 2.13 months (range: 12 to 84 months).

There was a statistically significant difference between preoperative and postoperative near and distance vertical deviations (P = .001). Twenty (77%) of 26 patients who underwent IR recession as the sole procedure in the study group had a satisfactory outcome in primary position (< 5 PD), and 6 (23%) patients were undercorrected. When the total study group was evaluated, 28 (80%) had a satisfactory outcome (< 5 PD), and 7 (20%) patients were undercorrected. No patients developed an overcorrection. Seventeen percent of the small IR recession group showed between 0.1 and 0.3 mm (mean ± standard deviation = 0.03 ± 0.01 mm) of lower eyelid retraction, and 25% of the large IR recession group showed between 0.1 and 0.6 mm (mean ± standard deviation 0.1 ± 0.01).

Control Group
The mean age of onset of strabismus was 25.7 ± 8.6 years (range: 5 to 61 years). Eleven of the 22 patients had a diagnosis of double elevator palsy, 6 had fourth cranial nerve palsy, and 5 had partial third cranial nerve palsy, necessitating recession of an IR muscle. The mean follow-up period was 47.76 ± 2.37 months (range: 12 to 82 months).

There was a statistically significant difference between the preoperative and postoperative near and distance vertical deviations (P = .001). Of these patients, 17 (78%) had a satisfactory outcome and 5 (22%) patients were undercorrected. None of the patients developed significant overcorrection. Ninety-five percent of the control group showed from 0.5 to 5.5 mm (mean = 2.06 mm; standard deviation = ±0.88) of lower eyelid retraction.

The comparison of preoperative and postoperative measurements for patients in the study and control groups is shown in Table 1. There was a statistically significant difference between the study and control groups regarding preoperative near and distance vertical deviations (P = .001). Of these patients, 17 (78%) had a satisfactory outcome and 5 (22%) patients were undercorrected. There was no statistically significant difference between the two groups regarding postoperative near and distance vertical deviations, improvements in near and distance vertical deviations, and success ratios (P = .845, .468, .195, .257, and .731, respectively) (Table 1).

Changes in MRD1 in patients undergoing IR muscle recession (by mm of recession) are shown in Table 2. There was no statistically significant difference between the preoperative standardized MRD1 of the control group and the small IR recessions group (P = .152), although there was a statistically
significant difference between the postoperative standardized MRD$_2$ of both groups ($P < .001$). There was no statistically significant difference between the preoperative standardized MRD$_2$ of the control group and the large IR recessions group ($P = .209$), but there was a statistically significant difference between the postoperative standardized MRD$_2$ of both groups ($P < .001$) (Table 2). The lower eyelid retraction, which occurred after both small and large IR recessions in the study group, was significantly less than that in the control group ($P < .001$ and .001, respectively).

In the control group, linear regression analysis revealed a correlation between the amount of IR recession and the magnitude of lower eyelid retraction ($r = 0.893, P < .001$) (Table 3). The slope of the linear regression line for the study group was essentially zero, because a similar small amount of lower eyelid retraction occurred regardless of the amount of IR recession (Figure 4). Analysis of covariance revealed that the slope of the study group data and that of the control group data were significantly different ($P < .001$).

**DISCUSSION**

Recession of the IR muscle is an established treatment for vertical strabismus.$^{7,14,15}$ Some studies
have reported good postoperative alignment in cases undergoing IR recession,⁵,⁶,⁸⁻¹⁰ but other studies have reported progressive overcorrection following an initially good postoperative alignment.¹⁸,¹⁹ A new technique of IR recession for vertical strabismus was introduced by Gokyigit et al. in 2006.¹²,¹³ In the current study, we report the long-term results of this technique. Of the study group patients who underwent IR recession as the sole procedure, 77% had a satisfactory outcome in primary position (< 5 PD), and 23% were undercorrected. Following additional operations either at the same time or as a second procedure, 80% of the cases in the study group and 78% of the cases in the control group had a satisfactory outcome. None of the patients developed significant overcorrection. There was no difference between the two groups in terms of improvements in near and distance deviation and success ratios after surgery. Scotcher et al. reported that

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>Changes In MRD² Distance In Patients Undergoing IR Muscle Recession⁴</th>
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</thead>
<tbody>
<tr>
<td>IR Recession</td>
<td>New IR Recession, Mean ± SD MRD² (mm)</td>
</tr>
<tr>
<td>No. of Eyes</td>
<td>Preop</td>
</tr>
<tr>
<td>3</td>
<td>–</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
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<td>6</td>
<td>4</td>
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<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>35</td>
</tr>
</tbody>
</table>

MRD² = margin-to-reflex distance; IR = inferior rectus; SD = standard deviation; preop = preoperative; postop = postoperative
⁴By millimeter of recession.
⁵Change means the postoperative lower eyelid retraction.

<table>
<thead>
<tr>
<th>TABLE 3</th>
<th>Results of the Linear Regression Analysis in the Study and Control Groups⁸</th>
</tr>
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<tbody>
<tr>
<td>Group</td>
<td>B</td>
</tr>
<tr>
<td>Study</td>
<td></td>
</tr>
<tr>
<td>Amount of IR recession</td>
<td>0.020</td>
</tr>
<tr>
<td>Constant</td>
<td>-0.064</td>
</tr>
<tr>
<td>Control</td>
<td></td>
</tr>
<tr>
<td>Amount of IR recession</td>
<td>1.678</td>
</tr>
<tr>
<td>Constant</td>
<td>-5.012</td>
</tr>
<tr>
<td>R² = 0.893</td>
<td>F = 62.763</td>
</tr>
</tbody>
</table>

SE = standard error; IR = inferior rectus
⁸The dependent variable was the magnitude of lower eyelid retraction (mm).

Figure 4. Scatterplot of lower eyelid retraction (mm) versus inferior rectus recession (mm) in the study and control groups. Best-fit curves from linear regression analysis for each group are shown (study group = white squares; control group = black squares).
8 of 21 patients who underwent IR recession were undercorrected and two patients developed a progressive overcorrection. In our study, the number of undercorrected cases for both the study and control groups was less than that of Scotcher et al. Recession of the deeper fibers, including approximately 90% of the IR muscle thickness, did not limit the success of the strabismus surgery.

Lower eyelid retraction following IR recession has long been recognized. In some studies, the lower eyelid retraction was noted in 63% to 94% of patients undergoing such surgery. The etiopathogenesis is related to the intimate anatomic connections between the IR muscle and the retractors of the lower eyelid. As a result, the lower eyelid is pulled downward by the recessed IR muscle. More commonly, the inferior scleral show is only a cosmetic problem. Occasionally, lagophthalmos and corneal exposure may result.

Several surgical techniques that minimize or prevent lower eyelid retraction after IR recession have been described. To avoid these complications, Helveston suggested a large dissection going up to the vortex veins. However, other studies reported persistent eyelid retraction despite such wide dissection. Pacheco et al. compared patients who received minimal and variable dissection to patients who had extensive check ligament dissection and reported that there was no significant difference in the magnitude of the lower eyelid retraction.

Jampolsky described a procedure in which the capsulopalpebral head was disinserted from the IR muscle and then sutured back to the recessed IR muscle, close to the original distance of the capsulopalpebral head from the IR insertion. This technique, referred to as an advancement of the capsulopalpebral head from the IR insertion, was evaluated by Kushner. Postoperative lower eyelid retraction was reduced but not eliminated by this technique, with a mean of 0.7 mm of postoperative lower eyelid retraction measured in patients who underwent adjunctive advancement of the capsulopalpebral head compared with 1.3 mm in the control group patients who underwent only IR recession. The patients who had large recessions coupled with postoperative suture adjustment still demonstrated 1.0 to 2.5 mm of postoperative lower eyelid retraction.

Pacheco et al. described a similar technique for applying countertraction to the capsulopalpebral head but used a hang-back suture suspension technique in which the detached capsulopalpebral head was attached to the IR insertion, typically adjacent to the hang-back sutures used for the IR recession. Separate postoperative adjustment of the eyelid position was performed after adjustment of the IR muscle. Postoperative lower eyelid retraction was reduced by this technique with a mean of 0.2 mm (range: 0.1 to 0.4 mm) of postoperative lower eyelid retraction measured in patients who underwent the adjustable suspension of the lower eyelid retractors in addition to the IR recession technique compared with 0.6 mm (range: 0.3 to 1.1 mm) in the control group patients who underwent only IR recession. Pacheco et al. reported that none of their patients who underwent this technique had strabismus related to thyroid ophthalmopathy and suggested that capsulopalpebral head suspension might be of limited use for patients who require large IR recessions.

Meyer et al. described an alternative technique of primary infratarsal lower eyelid retractor lysis at the time of IR recession procedure. This procedure is designed to reduce or eliminate these forces at the level of the tarsus and surrounding eyelid connective tissues. They reported that the mean change in lower eyelid position was essentially zero (range: -1 to 1 mm), which was not statistically significant ($P > .82$), and no patient developed inferior scleral show. One limitation of the study by Meyer et al. is that they did not have a randomized control group of patients undergoing IR recession alone. This technique involves a secondary conjunctival incisional wound and may result in symblepharon formation, which requires further surgical intervention.

Liao et al. described the complete detachment of the capsulopalpebral head from the IR muscle to prevent induced lower eyelid retraction in Graves' ophthalmopathy. Postoperative lower eyelid retraction was reduced by this technique with a mean of 0.04 mm of postoperative lower eyelid retraction measured in patients who underwent large IR recession with detachment of the fascia of the capsulopalpebral head compared with 1.58 mm in the control group patients who underwent IR recession without detachment of the fascia of the capsulopalpebral head. In this study, it was established that dissection reached the extraconal fat, to ensure complete detachment of the capsulopalpebral head fascia. The cause of failure of five patients in the detachment group with induced postoperative eyelid retraction may have been the presence of orbital fat.
Ninety-five percent of patients in our control group that underwent conventional IR recession showed postoperative lower eyelid retraction. Small IR recessions were associated with small amounts of lower eyelid retraction, and the amount of eyelid retraction increased linearly with larger recessions. The lower eyelid retraction, which occurred after both small and large IR recessions with this new technique, was significantly less than that in conventional IR recession. In patients who underwent IR recession with this new technique, a small amount of lower eyelid retraction occurred regardless of the amount of IR recession. In the current study, we demonstrated a technique that reduced or eliminated lower eyelid retraction and permitted larger recession of the IR muscle. In comparing the two procedures, there is a difference in lower eyelid position when recessing more than 4 mm. There may be a reduction of only approximately 10% in muscle fibers between the two methods. This is the reason there is no difference between the two methods in terms of improvements in near and distance deviation and success ratios following surgery. In our technique, the surface part of the muscle included a few of the tendon fibers surrounding the vessels and facial attachment between the IR muscle and Lockwood’s ligament (capsulopalpebral fibers).

We employed an alternative technique of IR recession. Our technique was at least as effective as previously described techniques2–10 to minimize or prevent lower eyelid retraction. The recession of the deeper fibers layer, including approximately 90% of the IR muscle thickness that is present, overcomes some of the limitations of previous procedures; for example, it does not require extensive dissection of the IR muscle with lysis of the surrounding check ligaments and fascial attachments or a dissection reaching the extracanal fat, or lead to the problem of symplepharon, which is related to conjunctival closure. Another advantage of this technique was the preservation of the anterior ciliary arteries. Other rectus muscle procedures can be performed in the same session without impairing anterior segment ischemia.

The technique that we describe avoids lower eyelid retraction in patients with normal anatomical structures with high success rates. We have observed that this technique necessitates the presence of normal or near-normal undisrupted anatomical structures in the IR muscle region for successful outcomes. The technique itself avoids trauma to the IR muscle and its neighboring muscles, ligaments, and intermuscular membranes. The technique requires some expertise in muscle surgery, because approximately 10% of the anterior muscle fiber bundle can be easily disinserted by vigorous manipulation. Therefore, meticulous care in dissecting the two bundles is highly recommended. If the surgeon has enough experience using a microscope during the operation, this technique can easily be performed. However, it needs skillful assistance and specific attention during the operation to protect surface parts. Otherwise, it is not a difficult procedure.

The current study demonstrates that the recession of the deeper fibers layer, including approximately 90% of the IR muscle thickness, is a procedure that minimizes or eliminates the possibility of lower eyelid retraction, permitting a larger recession of the IR muscle and not limiting the success of strabismus surgery through a long period of follow-up.

REFERENCES


