The Effect of Anterior Transposition of the Inferior Oblique Muscle on the Palpebral Fissure

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Background: Anterior transposition of the inferior oblique muscle is a popular treatment for dissociated vertical divergence. It seems that this surgical procedure may alter the palpebral fissure.

Objectives: To investigate the alteration of the palpebral fissure with inferior oblique muscle anterior transposition when it is performed as the sole operative procedure and to report the cases of patients who developed noticeable upper eyelid retraction after inferior oblique muscle anterior transposition preceded by large superior rectus muscle recessions.

Methods: The change in the height of the palpebral fissure surgery was evaluated from photographs by 2 masked observers in 3 groups of patients. The control group underwent inferior oblique muscle recession without transposition. The second group (or the insertion study group) underwent transposition of the inferior oblique muscle that was level with the inferior rectus muscle insertion. The third group (or the 2-mm study group) had the inferior oblique muscle placed 2 mm anterior to the inferior rectus muscle insertion. Also, the insertion study and the control groups were evaluated after surgery for bulging and elevation of the lower eyelid on upgaze.

Results: The narrowing of the palpebral fissure after surgery (mean±SD) was −0.14±0.6 mm in the 16 patients in the control group, −1.2±0.9 mm in the 14 patient in the insertion study group, and −2.1±0.5 mm in the 6 patients in the 2-mm study group. The differences were statistically significant between the control and the insertion study groups (P<.001, t test) and between the control and the 2-mm study groups (P<.001, t test). One of the 16 control patients and 10 of the 14 insertion study patients showed bulging of the lower eyelid on upgaze after surgery. This difference was statistically significant (P<.001, Fisher exact test). In addition, 3 patients were seen who developed marked upper eyelid retraction when anterior transposition of the inferior oblique muscles followed previous large superior rectus muscle recessions.

Conclusions: Anterior transposition of the inferior oblique muscle causes significant narrowing of the palpebral fissure as a sole procedure. When preceded by large superior rectus muscle recessions, it can cause upper eyelid retraction.


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*ANTERIOR*transposition of the inferior oblique muscle is a popular treatment option for correcting dissociated vertical divergence (DVD) associated with inferior oblique muscle overaction.1,6 This procedure, popularized by Elliott and Nankin,1 is based on theoretical work by Scott.7 He suggested that transposing the inferior oblique muscle anteriorly and placing it at the temporal corner of the inferior rectus muscle insertion would increase the effect of a recession. Subsequently, it was theorized that anterior transposition of the inferior oblique muscle creates a vector for depression, because it places the new insertion of the muscle anterior to the equator.3,6 This anti-elevating force seems helpful in controlling DVD. Subsequently, others have recommended transposing the inferior oblique muscle even further anteriorly, positioning it as much as 2 to 4 mm anterior to the insertion of the inferior rectus muscle.2 Although anterior transposition of the inferior oblique muscle seems effective for treating DVD associated with inferior oblique muscle overaction, several adverse outcomes have been reported. Particularly when performed unilaterally, this procedure can create a limitation of elevation of the operated on eye and may cause hypotropia in the primary position.5,6,9 When performed bilaterally and particularly if the posterolateral fibers of the inferior oblique muscle are
SUBJECTS AND METHODS

The study contains a prospective aspect and a retrospective aspect. The prospective arm consists of consecutive patients in whom I performed anterior transposition of the inferior oblique muscle to treat DVD associated with inferior oblique muscle overaction, in whom the inferior oblique muscle was the only muscle operated on in the fixing eye at the time of the surgical procedure that was evaluated in this article. If patients had freely alternating fixation, they were only included if anterior transposition of the inferior oblique muscle was the sole surgical procedure in each eye. Anterior transposition of the inferior oblique muscle was carried out in a manner similar to that described by Elliott and Nankin, except that in all cases the anterior end of the muscle was bunched and sutured level with the inferior rectus muscle insertion. The 2 scleral tunnels were approximately 1 to 2 mm apart horizontally. Hence, these patients are referred to as the “insertion study group.” The control group consisted of consecutive patients meeting the same criteria as the insertion study group, with the exception that the inferior oblique muscle was recessed (without anterior transposition) between 10 and 12 mm in the standard manner. For the control group, the inferior oblique muscle was also bunched and sutured either 3 mm posterior and 2 mm temporal to the temporal end of the inferior rectus muscle insertion, or 4 mm posterior and 0.5 mm temporal to the temporal end of the inferior rectus muscle insertion for either approximately a 10-mm or 12-mm recession, respectively, based on data by Apt and Call. Preoperative photographs were taken with the habitually fixing eye looking at the center of the camera lens with approximately ×4 magnification. Postoperative photographs were taken in an identical manner approximately 3 months after surgery (range, 2.5-4.5 months). At surgery the corneal horizontal diameter was measured to use as a conversion factor for the magnification in the photographic slides, which were reproduced as 4 × 6-in prints. Photographs were graded by measuring the distance between the upper and lower eyelid margin at the point that bisected the light reflex on the cornea. Two different examiners graded each photograph and were masked to the patients’ identity, clinical history, and whether the photograph was taken before or after surgery. In addition, to assess reproducibility of the measurement technique, 10 selected photographs were graded by each of the 2 examiners at 2 different grading sessions, several months apart. The difference between the height of the palpebral fissure before and after surgery for each patient, determined by the 2 examiners, was averaged and used for data analysis. The mean difference of the palpebral fissure after surgery in the 2 groups was compared (unpaired 2-tailed t test). In each case, only the data from the habitually fixing eye were used for data analysis. Photographs were cropped so the examiner could not see the fellow eye and hence not determine if there was a manifest strabismus present, because the presence of a manifest strabismus might be suggestive that a given photograph was taken before surgery.

A second aspect of the study was to assess the deformity of the lower eyelid that may occur on upgaze after anterior transposition of the inferior oblique muscle. Because the diagnosis of this finding is subjective and does not lend itself well to quantitative analysis, this issue was addressed in the following manner: Ten consecutive patients in the insertion study group and 10 consecutive control patients

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spread out laterally at the time of resutting to the sclera, a restriction of elevation in abduction associated with a Y or V pattern can result. This complication mimics residual contralateral inferior oblique muscle overaction because, on sidegaze the adducting eye excessively elevates on attempted upgaze due to fixation duress. This set of findings has been named the “anti-elevation syndrome.”

I have the impression that anterior transposition of the inferior oblique muscle causes substantial narrowing of the palpebral fissure, which can be cosmetically noticeable, particularly in patients treated unilaterally. I also believe it results in a characteristic deformity of the appearance of the lower eyelid on upgaze. This manifests as an abnormal elevation of the lower eyelid associated with a noticeable bulging of the central aspect of the lower eyelid on upgaze. To my knowledge, the effect of the anterior transposition on the palpebral fissure has not been studied rigorously. The purpose of this study is to investigate the alteration of the palpebral fissure with inferior oblique muscle anterior transposition when it is performed as the sole operative procedure.

A second purpose of this study is to report the cases of several patients I have examined who developed noticeable upper eyelid retraction after inferior oblique muscle anterior transposition, preceded by large superior rectus muscle recessions. It is known that inferior rectus muscle restriction or marked superior rectus muscle weakness can cause retraction of the upper eyelid on attempted upgaze owing to fixation duress to the levator palpebrae superioris muscle. In theory, the anti-elevating effect of anterior transposition of the inferior oblique muscle, when combined with recession of the superior rectus muscle, might also be an iatrogenic cause for upper eyelid retraction.

This study consists of 36 patients, of whom 14 underwent anterior transposition of the inferior oblique muscle level with inferior rectus muscle insertion (insertion study group), 16 underwent standard inferior oblique muscle recession without anterior transposition (control group), and 6 patients in whom the inferior oblique muscle was placed 2 mm anterior to the inferior rectus muscle insertion (2-mm study group). In addition, there were the previously mentioned 3 patients, who manifested upper eyelid retraction after bilateral superior rectus muscle recessions followed by inferior oblique muscle anterior transposition. The Table gives the descriptive parameters of the patients, as well as the mean change in the palpebral fissure after surgery for the 3 groups. When com-


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were photographed not only in the previously mentioned manner but also with their eyes in upgaze. Photographs were taken both from the front and from the side. Graders were shown standard photographs depicting the normal eyelid configuration of a patient who had not undergone strabismus surgery (Figure 1A-D), and another depicting the bulging and elevation of the lower eyelid on upgaze in a patient who had undergone anterior transposition of the inferior oblique muscle and demonstrated the aforementioned lower eyelid findings (Figure 1E-H). The graders were then asked to evaluate each of the 2 patients (10 from the insertion study group and 10 from the control group) to determine if the lower eyelid deformity was present or absent using these standard photographs for comparison. The aspect of this study evaluating the deforming of the lower eyelid on upgaze, does not have a gold standard of measurement. For this reason, each patient was evaluated by only one grader; however, note that the same grader was not used for each patient. These photographs were not compared with a preoperative photograph, but were merely used as an absolute finding after surgery.

Because anterior transposition of the inferior oblique muscle is typically used to treat DVD and because most patients undergoing surgery for DVD are children, this study had an arbitrary upper age limit of 18 years. There was no lower age limit provided that the patient was cooperative for the necessary photographs.

An additional aspect of this study was to assess if the amount of narrowing of the palpebral fissure from surgery was related to the number of millimeters of anterior transposition performed on the inferior oblique. In 1997, I recognized that the anti-elevation syndrome was more likely to occur if the inferior oblique muscle was placed anterior to the inferior rectus muscle insertion.10 As a result of that study, I no longer transpose the inferior oblique muscle that far anteriorly. Consequently, for the aspect of this study dealing with the effect of the magnitude of the anterior transposition of the inferior oblique muscle, a retrospective review of my earlier experience was necessary. I identified 6 patients from this retrospective review in whom I had placed the inferior oblique muscle 2 mm anterior to the inferior rectus muscle insertion, and who otherwise met all the inclusion criteria (including preoperative and postoperative photographs). These patients are referred to as the “2-mm study group.” Because these patients were part of a previously published study correlating axial length with the effect of surgery, I had measured the corneal diameters during surgery.12 These photographs were analyzed in a similar manner as was done for patients in the prospective aspect of this study.

A final group of patients consists of 3 children whom I examined during the course of this study, who were noted to have upper eyelid retraction after having undergone bilateral anterior transposition of the inferior oblique muscle by other ophthalmologists to treat DVD, several months to several years after previous bilateral superior rectus recessions of 8 mm or greater. Although these patients were not rigorously studied in a masked manner, they were included in this study because they highlight an important additional complication of anterior transposition of the inferior oblique muscle.

The protocol for this study was approved by the institutional review board of the University of Wisconsin Hospitals and Clinics, Madison, and all patients in the prospective phase of this study had informed consent.

The evaluation of reproducibility of measurements showed a high degree of agreement between examiners with a mean (±SD) difference in findings of 0.18±0.2 mm. When the same examiner measured the same photograph on different occasions, the mean difference in the measurements was 0.09±0.12 mm. These differences are negligible.

For the 3 patients with a history of both inferior oblique muscle anterior transposition and superior rectus muscle recession, the 2 procedures were separated by 1 year, 3 years, and 4 years. The amounts of superior rectus muscle recession carried out were 9, 8, and 10 mm bilaterally in the 3 patients, respectively. The inferior oblique muscle was positioned either 1 mm or 2 mm anterior to the inferior rectus muscle insertion in these 3 patients. In all of them the superior rectus muscle recession was performed first, and no alteration of the palpebral fissure was seen after that operation. However, for each patient, after the inferior oblique muscle anterior transposition had been performed, the parents noted marked upper eyelid retraction, some limitation of upgaze, and a subsequent tendency for a chin-up head posture (Figure 3). The upper eyelid retraction decreased on downgaze suggesting that it was in fact, fixation duress causing the retraction rather than primary involvement of the levator palpebrae superioris muscle as is seen in Graves orbitopathy. Although further strabismus surgery will be needed for some of these patients, none have undergone additional surgery as of the writing of this article.

This study suggests that anterior transposition of the inferior oblique muscle does cause a narrowing of the palpebral fissure and a deformity of the lower eyelid on upgaze, which in some patients can be cosmetically noticeable. Many factors go into choosing the optimum surgical procedure for a given patient. Dissociated vertical divergence is difficult to cure, and many surgeons...
do prefer transposing the inferior oblique muscle anteriorly to treat that entity. These data do not imply that anterior transposition of the inferior oblique muscle is an inappropriate surgical procedure. They do suggest, however, that just as one advises patients undergoing an inferior rectus muscle recession about the possibility of alteration of the palpebral fissure after surgery, a similar warning may be appropriate when anterior transposition of the inferior oblique muscle is proposed. This may be particularly advisable if patients have previously undergone large recessions of the superior rectus muscles.

The parents of all 3 of the patients who developed upper eyelid retraction following both inferior oblique muscle anterior transposition and superior rectus muscle recessions did note and comment on the palpebral fissure abnormality. These patients also had some degree of limitation of elevation on maximum attempted upgaze.

### Palpebral Fissure Data

<table>
<thead>
<tr>
<th>Group</th>
<th>Change in Palpebral Fissure After Surgery, Mean ± SD (Range), mm</th>
<th>No. of Patients With Lower Eyelid Deformity Present on Upgaze</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control (n = 16)</td>
<td>−0.14 ± 0.6 (−0.1 to 1.0)</td>
<td>. . .</td>
</tr>
<tr>
<td>Insertion study (n = 14)</td>
<td>−1.2 ± 0.9 (−3.3 to 0.1)</td>
<td>.001 10</td>
</tr>
<tr>
<td>2-mm study (n = 6)</td>
<td>−2.1 ± 0.5 (−3.1 to −1.7)</td>
<td>.001 Not tested‡</td>
</tr>
</tbody>
</table>

*Unpaired t test comparing each study group with the control group. Ellipses indicates not applicable.
†Negative number denotes narrowing of palpebral fissure; positive number, widening.
‡p < .001. Fisher exact test comparing the control group with the transposition of the inferior oblique muscle study groups.

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**Figure 1.** A-D, Standard photographs showing normal subject in the primary position and in upgaze. E-H, Standard photographs of a patient after having undergone anterior transposition of the inferior oblique muscle level with the inferior rectus muscle insertion. Bulging of the lower eyelid is evident on upgaze in the patient who underwent surgery (Figure 1E-F) as compared with the normal subject (Figure 1A-B). Also the lower eyelid elevates on upgaze in the patient who underwent surgery (Figure 1E) compared with the normal subject (Figure 1A).

**Figure 2.** Noticeable narrowing of the palpebral fissure on the left is present in this patient who underwent unilateral strabismus surgery. The left inferior oblique muscle was transposed 2 mm anterior to the inferior rectus muscle insertion.

**Figure 3.** Patient who underwent bilateral anterior transposition of the inferior oblique muscles to 2 mm anterior to the inferior rectus muscle insertions 1 year after undergoing bilateral 9-mm recessions of both superior rectus muscles. A, There is a limitation of elevation on maximum attempted upgaze. B, Upper eyelid retraction is present in the primary position.

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of limitation of upgaze, and all had a noticeable cosmetic deformity. This series of 3 patients, albeit small, suggests that transposition of the inferior oblique muscle anterior to the insertion of the inferior rectus muscle in patients who had undergone prior large superior rectus muscle recessions may result in trading one cosmetic deformity (DVD) for another (upgaze limitation and upper eyelid retraction). However, none of the parents of the patients who underwent anterior transposition of the inferior oblique muscle bilaterally (without prior superior rectus muscle recession) reported narrowing of the palpebral fissure. The only patients in whom it was bothersome were those few in whom the procedure was carried out unilaterally.

This study needs to be viewed in light of its limitations. Data analysis for this study was based on the assumption that the amount of change in the palpebral fissure after surgery is equal to the amount by which the lower eyelid is elevated by the surgical procedure. In fact, this assumption may underestimate the change in position of the lower eyelid secondary to surgery, because the upper eyelid may elevate somewhat after surgery, secondary to fixation duress. The net effect of such an elevation would be to decrease the amount of palpebral fissure narrowing detected by my method. Accurate assessment of the changes in both eyelids would necessitate measuring the distance to the respective eyelid margins from a specific point on the cornea, such as the light reflex. I chose to assess the overall palpebral fissure height because that measurement represents what is most obvious to patients and parents. Also a headrest and bite bar is needed for optimum assessment of eyelid position in photographs, or a measurement artifact may result. I believe this problem is minimized by the method used in this study because I measured the overall palpebral fissure, which is affected less by minor degrees of chin elevation or depression than the absolute position of either eyelid separately. Although this study shows that anterior transposition of the inferior oblique muscle does cause narrowing of the palpebral fissure, this must be viewed in relation to its clinical importance. In most cases, the narrowing of the palpebral fissure was not a cosmetic issue and was not bothersome to the patients. Because all of the surgery in the prospective aspect of this study dealing with the narrowing of the palpebral fissure was performed by me, it is possible that the findings are a function of surgical technique, rather than the procedure per se. I think, however, that this is unlikely. In the course of my practice, I frequently see patients who have undergone strabismus surgery by other ophthalmologists. I have the impression that I can typically predict if a patient’s previous surgery had consisted of anterior transposition of the inferior oblique muscle merely by observing the appearance of the lower eyelid on upgaze. When I confirm my suspicion with a review of previous operative records, my predictions are usually correct.

In conclusion, anterior transposition of the inferior oblique muscle can have a noticeable effect on the size of the palpebral fissure and the lower eyelid configuration in upgaze.

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