Vertical Rectus Surgery for Knapp Class II Superior Oblique Muscle Paresis

Burton J. Kushner, MD

Objective: To evaluate the efficacy of treating Knapp class II superior oblique muscle palsy with 7-mm nasal transposition of the ipsilateral inferior rectus muscle combined with recession of the contralateral inferior rectus muscle when the primary position hypertropia is 10 prism diopters (PD) or less.

Method: A retrospective review of 8 consecutive patients with superior oblique muscle paresis who had nasal transposition of the inferior rectus muscle in the paretic eye and recession of the inferior rectus muscle in the nonparetic eye. Ocular motility, including objective and subjective torsion, were evaluated before and after surgery.

Results: The mean (SD) preoperative hypertropia was 5 PD (1.5) and 13.1 (3.6) PD in the primary position and downgaze, respectively. After surgery the mean (SD) hypertropia was 1.25 (1.0) and 3.25 (1.3) PD in the primary position and downgaze, respectively. The mean (SD) subjective excyclotropia decreased from 6.6° (1.3°) preoperatively to 0.5° (0.9°) after surgery, and there was a mean (SD) objective decrease in the excyclotorsion of the paretic eye by 7.8° (1.4°). All patients were diplopic before surgery and asymptomatic after surgery.

Conclusion: Treatment with 7-mm nasal transposition of the ipsilateral inferior rectus muscle combined with recession of the contralateral inferior rectus muscle can effectively treat Knapp class II superior oblique muscle palsy when the primary position hypertropia is 10 PD or less.


IN THE FIRST ANNUAL SCOBEE LECTURE, Knapp presented a classification and treatment schema for superior oblique muscle palsy that has become a classic in the field of strabismus.1 Though subsequent advances in our understanding of superior oblique tendon anatomy2-5 and the popularization of adjustable sutures6,7 have made some of his treatment recommendations outdated, the underlying concepts behind his recommendations are quite useful. Specifically, Knapp recommended that the magnitude of the deviation determine how many muscles should be operated on, and the incomitance pattern should determine which muscles should have surgery. He chose to operate on muscles that would have the greatest effect in the field of gaze with greatest vertical misalignment and that also address any torsional abnormality. Subsequent authors have incorporated these principles into newer schemas for treating superior oblique muscle paresis, though they deviated from Knapp’s recommendations.8-12

Knapp classified a deviation that was greatest in the field of the paretic superior oblique muscle (adduction in downgaze) as being class II, for which he recommended tucking the tendon of the paretic superior oblique muscle. However, many strabismologists tend to avoid tucking the superior oblique tendon whenever possible.10,13 Others prefer to limit that procedure to patients in whom the tendon is lax. Thus, they would not perform a superior oblique tendon tuck in patients with a Knapp class II superior oblique muscle paresis if it was an acquired problem, and in which a lax tendon is typically not found.5,11,14,15 When the deviation in the primary position is large enough that surgery to weaken 2 vertical muscles is safe, there are good alternatives to tucking the superior oblique tendon. These include ipsilateral inferior oblique muscle weakening combined with either contralateral inferior rectus muscle recession or ipsilateral superior rectus muscle recession. However, for patients in whom the deviation in the primary position is relatively small, an effective alternative to tucking the superior oblique tendon would thus be useful for treating Knapp class II superior oblique muscle paresis. One possible alternative in this setting would be to recess the inferior rectus muscle in the
contralateral eye to address the vertical deviation and perform a nasal transposition of the ipsilateral inferior rectus muscle to address the exyclotropia. 16,17

The purpose of this study is to describe an experience with 7-mm nasal transposition of the ipsilateral inferior rectus muscle combined with recession of the contralateral inferior rectus muscle to treat Knapp class II superior oblique muscle paresis with a small primary position hypertropia.

### METHODS

This series consists of all consecutive patients with a unilateral Knapp class II superior oblique muscle paresis treated by the author with nasal transposition of the inferior rectus muscle in the paretic eye and inferior rectus recession in the contralateral eye between January 1978 and June 2008. The diagnosis of superior oblique muscle paresis was made on the basis of the 3-step test, 15 excluding patients with known conditions in which the 3-step test can be erroneous. 15,20 Ductions and versions were assessed on a subjective 9-point scale (−4 to +4). A patient was considered to have a Knapp class II pattern if the hypertropia of the paretic eye was greatest in depression in adduction and was less in elevation in adduction than in the primary position. Patients with a hypertropia that was 12 prism diopters (PD) or more in the primary position were excluded because, typically, a surgical plan was chosen that includes 2-muscle surgery directed at reducing the hypertropia in that subset. Most commonly this consisted of an ipsilateral inferior oblique muscle recession and a contralateral inferior rectus muscle recession. There was no arbitrary age limit for inclusion, however, because Knapp class II patterns rarely occur in young patients; there was a self-selecting bias toward adult patients.

All patients had prism and cover testing in the diagnostic fields of gaze at 6 m as well as on head tilt right and left. In all cases surgery consisted of a 7-mm nasal transposition of the inferior rectus muscle in the paretic eye combined with an adjustable suture resection of the contralateral inferior rectus muscle. For the nasal transposition of the inferior rectus muscle, 2 double-armed 6-0 polyglycol 910 sutures were used to secure the muscle near its insertion, with locking bites placed at the nasal and temporal edge. The muscle was then dissected. The temporal-most suture was then passed through the original insertion, 7 mm nasal to its temporal corner, as measured with calipers. Next, the nasal-most suture was passed through the sclera approximately 8 mm nasal to the temporal-most suture at a measured distance from the limbus that was equal to the original limbus-insertion distance. Thus the horizontal width of the new muscle insertion approximated the original muscle width after adjusting for slight narrowing due to the corner lock bites, and the original distance from the limbus was retained throughout. After 2000, the semiadjustable technique was used for the contralateral inferior rectus muscle in all cases. 21 The previously described use of a reference knot permitted accurate determination of the final amount of recession after suture adjustment. 22 Subsequent to 1981, exaggerated forced traction testing was done on all patients to determine the presence of tendon laxity, as described by Guyton. 23 A paresis was presumed to be congenital if there was documentation of it dating back to childhood and there was no antecedent head trauma or other neurologic cause for an acquired problem. Testing for subjective torsion was done with the double Maddox rod test before and after surgery using a white and red Maddox rod. Because almost all of the patients had surgery before it was known that the use of a white Maddox rod caused a color dissociation artifact in which the eye perceiving the white line will tend to be viewed as having no torsion, 24 the subjective torsion was analyzed as the total torsional disparity between the 2 eyes without attention to which eye was subjectively torted. Objective torsion was determined in each eye separately before and after surgery using fundus photography and analyzed using a template overlay in the manner previously described. 25 This technique has been shown to be accurate within 2°. The change in objective torsion at the outcome examination was determined by comparing the preoperative and postoperative fundus torsion in each eye separately from the photographs.

The final outcome determination was approximately 3 months after surgery; however, many patients were followed up for much longer and long-term trends were noted.

This study was approved by the institutional review board of the University of Wisconsin and was compliant with the Health Insurance Portability and Accountability Act.

### RESULTS

The study consisted of 8 patients who met the inclusion criteria described above. Details of the patients before and after surgery are in the Table. All patients had diplopia prior to surgery in the primary position and in the read-

---

**Table. Characteristics of Patients Before and After Surgery**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Before Surgery</th>
<th>After Surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Paretic eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Left</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Congenital</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Acquired</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Tendon laxity, if tested</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** PD, prism diopters; SO field, downgaze in adduction.  
*Amount of recession done at time of surgery.*  
*Amount of recession that was left after postoperative adjustment.*
Ipsilateral nasal transposition of the inferior rectus muscle combined with contralateral inferior rectus muscle recession is effective in treating superior oblique muscle paresis when the deviation is 10 PD or less in the primary position, is greatest in the field of the affected superior oblique muscle, and is not accompanied by substantial ipsilateral inferior oblique muscle overaction (eg, does not have a larger hypertropia in the field of the inferior oblique muscle).

In theory, simply recessing the contralateral inferior rectus muscle might be a simpler alternative for these patients. It will give maximum correction in the field of the paretic superior oblique muscle. Good results have been reported with this approach in patients with very small amounts of subjective torsion. However, inferior rectus recession of the relatively small amount needed in this patient group will have a small effect on decreasing the excyclotropia. In this series, the decrease in objective torsion in the eye treated with inferior rectus recession only had a mean of 2.75°. This may be inadequate in a patient who has more than 5° of subjective excyclotropia. In fact, the initial attempt to combine ipsilateral inferior rectus muscle transposition with contralateral inferior rectus muscle recession was owing to an experience with 2 patients in the late 1970s. Both had undergone a 1-muscle operation in the form of a contralateral inferior rectus muscle recession after this operation. However, results of the procedure I performed in this patient population have been positive. However, it is not a good option for the surgeon who prefers to avoid operating on the superior oblique tendon. In addition, it is technically harder and not as easily reversible as nasal transposition of the inferior rectus muscle.

When the primary position hypertropia is relatively large, there are more treatment options available that may allow the surgeon to avoid tucking the superior oblique tendon. These typically involve operating on 2 vertical muscles that are directed toward decreasing the hypertropia. Although authors have different thresholds for when to operate on a second vertical muscle to decrease a hypertropia that ranges from 10 to 17 PD, many appear to follow the concept that the size of the primary position deviation dictates the number of muscles to weaken or strengthen. These approaches include varying combinations of either weakening the ipsilateral inferior oblique muscle or performing a tuck or Harada-Ito procedure on the ipsilateral superior oblique tendon, combined with contralateral inferior rectus muscle recession. In cases in which there is ipsilateral superior rectus muscle overaction and/or contracture, the plan may involve recessing the superior rectus muscle.

Ipsilateral tucking of the superior oblique tendon, as recommended by Knapp, addresses all aspects of the motility disturbance in patients with a Knapp class II superior oblique muscle paresis. However, tucking the superior oblique tendon remains controversial in some situations. Plager, Helveston, and colleagues have reported that many patients with congenital superior oblique muscle paresis have a lax or redundant tendon. They advise that patients with tendon laxity should have a tucking procedure and those without should not. Although this recommendation is becoming an often-repeated dogma, it has never been clinically tested. The teaching is predicated on the belief that the primary anomaly in these patients is a lax tendon, and if the laxity is taken up with a tucking procedure, the muscle will function more normally. However, Sato has shown that patients with a lax tendon typically have an atrophic superior oblique muscle, as seen on imaging studies, and hence the tendon laxity may be secondary. If that is the case, the rationale for only tucking lax tendons is less compelling. One could argue that tucking tendons that are not lax might be more likely to result in improved function, as the muscle itself may only be paretic and still have some function. This is similar to the principle that a mildly paretic lateral rectus muscle may be strengthened by a resection but a completely flaccid one will not. In fact, there are multiple reports of good results with tucking the superior oblique tendon to treat superior oblique muscle paresis without limiting the indication to patients with
lax tendons. Irrespective of this argument, there are many clinicians who always avoid tucking the superior oblique tendon and others who avoid it if laxity is not found. For these surgeons, an alternative procedure would be useful.

This study has obvious limitations. Being retrospective in nature, it is subject to all of the measurement and interpretation errors that can accompany a retrospective study. Because it was not carried out according to a predetermined protocol, there may have been selection bias in choosing patients for this surgical procedure.

It appears, however, that ipsilateral nasal transposition of the inferior rectus combined with contralateral inferior rectus recession is an effective treatment for Knapp class II superior oblique muscle palsy when the deviation in the primary position is 10 PD or less.

Submitted for Publication: June 28, 2009; final revision received August 14, 2009; accepted August 20, 2009.

Correspondence: Burton J. Kushner, MD, Department of Ophthalmology & Visual Sciences, University of Wisconsin, 2870 University Ave, Ste 206, Madison, WI 53705 (bkushner@wisc.edu).

Financial Disclosure: None reported.

Funding/Support: This study was supported in part by an unrestricted grant from Research to Prevent Blindness, Inc, New York, New York.

REFERENCES