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Quantitative Intraoperative Torsional Forced Duction Test

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Purpose: We developed a method for quantifying intraoperative torsional forced ductions and validated the new test by comparing patients with oblique dysfunction and controls.

Design: Comparative case series.

Subjects: We studied 33 eyes with oblique dysfunction (9 with presumed congenital superior oblique palsy [SOP], 13 with acquired SOP, 7 with Brown syndrome, and 4 with inverted Brown syndrome) and 31 controls. We also studied 6 eyes after superior oblique (SO) disinsertion and 2 eyes after inferior oblique (IO) disinsertion.

Methods: Under deep general anesthesia, the 12 and 6 o'clock positions at the limbus were marked and the globe was maximally excyclorotated and incyclorotated without retroplacement until the first resistance was felt, and the angle of rotation (in degrees) was read on a Mendez ring by the surgeon. A photograph was taken in each position to be read by a masked observer.

Main Outcome Measures: Maximal excyclorotation and maximal incyclorotation in each oblique dysfunction and in controls by both surgeon's report and photographic assessment. We duplicated the photographs to evaluate test–retest reliability and to evaluate agreement between the surgeon's assessments and the photographic assessment.

Results: Surgeon's assessment revealed greater maximal excyclorotation in eyes with presumed congenital SOP than in controls (median, 40 vs. 30 degrees). Maximal excyclorotation in eyes with acquired SOP was similar to that in controls (30 degrees in both). Eyes with Brown syndrome and inverted Brown syndrome had lower maximal excyclorotation than in controls (10 and 20 vs. 30 degrees, respectively). Maximal incyclorotation in eyes with inverted Brown syndrome was lower than in controls (12.5 vs. 30 degrees), whereas it was similar to that of controls in eyes with presumed congenital SOP, acquired SOP, and Brown syndrome (30 degrees in each condition). Median maximal excyclorotation after SO disinsertion was 62.5 degrees, and maximal incyclorotation after IO disinsertion was 60 degrees. Photographic assessment yielded findings essentially identical to the surgeon's report. Test–retest reliability of the photographic reading was excellent, and agreement between the surgeon's report and the photographic reading was also excellent (95% limits of agreement, 4.4 and 11.6; intraclass correlation coefficient, 0.97 and 0.82, respectively).

Conclusions: The new torsional forced duction test enables quantitative assessment of SO and IO tightness and laxity. *Ophthalmology 2015;122:1932-1938 © 2015 by the American Academy of Ophthalmology.*

Supplemental video is available at www.aaojournal.org.

Intraoperative assessment of tightness or laxity of the superior oblique (SO) tendon and inferior oblique (IO) muscle may be important for diagnosis and may provide essential information for surgical planning. In 1981, Guyton[1] described a method for assessing SO tightness during surgery and reported a grading system. Guyton's method depends on the feeling of a "jump over the band"[1] when rolling the globe back and forth over the stretched SO tendon while gently pushing the globe into the orbit. Plager[2] also described "traction testing in superior oblique laxity" and reported a grading scale.[3] Nevertheless, both Guyton's and Plager's grading scales for tightness or laxity of oblique muscles are based on qualitative assessments, and the scales are reported as ordinal values: 0 to +4 for SO tightness[1] and −1 to −4 for SO laxity.[3] Kushner[4] described comparing symmetry of excyclorotation and incyclorotation using a rotary forced duction test without quantification. Ludwig[5] and Ludwig et al[6] described a torsional forced duction test estimating the amount of torsion but did not describe a method of measurement.

We describe a simple method to more precisely quantify SO and IO tightness or laxity by measuring the number of degrees of torsional movement possible during an intraoperative torsional forced duction test. In addition, we validated the new test by comparing the quantitative values obtained between patients with abnormal oblique muscles and controls.

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Methods

Torsional Forced Duction Test

All measurements were performed under deep general anesthesia and before starting any surgical procedure. Nearly all patients (27/29 patients with abnormal oblique conditions and 21/31 control patients) received a short-acting depolarizing muscle relaxant (succinylcholine), and 1 control patient received a nondepolarizing muscle relaxant (rocuronium). If a short-acting depolarizing muscle relaxant was administered during induction, our test was performed at least 10 minutes after its administration when there should be no residual effect of the relaxant.[7] A secondary analysis of controls with or without succinylcholine revealed essentially identical values (discussed later).

The 6 and 12 o'clock positions at the limbus were marked with a blue skin-marking pen,[8,9] and a Mendez ring (product number 9-705R-1; Duckworth and Kent Ltd., Hertfordsire, UK) was aligned with these reference marks and a photograph was taken (Fig 1A). The eye was then grasped at the limbus with 0.3-mm toothed forceps at the 2 and 8 o'clock positions (Fig 1A, Video 1), and the eye was excyclorotated while maintaining the natural anteroposterior axis without retropositioning the globe. When the first resistance was felt (which we defined as "maximal excyclorotation"), the angle of excyclorotation was recorded by the surgeon (J.M.H.) in degrees, and a photograph was taken for later assessment by a masked reader (Fig 1B, Video 1). This procedure was repeated for maximal incyclorotation (Fig 1C, Video 1).

Patients

We retrospectively studied patients with 4 abnormal oblique muscle conditions: (1) presumed congenital SO palsy (SOP), (2) acquired SOP, (3) Brown syndrome, and (4) suspected inverted Brown syndrome.[10] Patients with a history of strabismus surgery, ocular trauma, or any restriction of the horizontal or vertical rectus muscles, based on standard intraoperative forced duction tests, were excluded, except for cases of suspected inverted Brown syndrome.

The 4 abnormal oblique muscle conditions were defined as follows: (1) presumed congenital SOP (9 eyes from 9 patients, age 23−75 years) had a history of vertical strabismus or head tilt dating back to childhood, with large vertical fusional amplitudes (>10 prism diopters); (2) acquired SOP (13 eyes from 10 patients, age 62−82 years) had a history of severe head trauma (9 eyes from 6 patients), rheumatoid arthritis (1 eye from 1 patient), neurosurgery (1 eye from 1 patient), or uncontrolled hypertension (2 eyes from 2 patients), and all had sudden onset of vertical or torsional double vision with normal fusion amplitudes and no evidence of pre-existing palsy; (3) Brown syndrome (7 eyes from 6 patients, age 29−78 years) had restriction of eye elevation in adduction and SO tightness on intraoperative Guyton's exaggerated forced duction test[1]; and (4) suspected inverted Brown syndrome (4 eyes from 4 patients, age 70−73 years) had deficiency of depression, particularly in adduction, and positive IO tightness on intraoperative Guyton's exaggerated forced duction test.[10] Two of the patients with inverted Brown syndrome had a history of strabismus surgery; 1 patient underwent SO advancement for SOP 13 years earlier, and 1 patient underwent superior rectus recession combined with inferior rectus resection 1 year earlier.

We also evaluated 31 patients as controls (age 8−77 years). These subjects had no restriction of any horizontal or vertical rectus muscles, had negative Guyton's exaggerated forced duction tests for SO or IO tightness or laxity, and were scheduled to undergo horizontal muscle surgery to correct purely horizontal strabismus. We randomly selected 1 eye from each control patient (n = 31 eyes) for analysis.

We also measured maximal excyclorotation after complete SO disinsertion, before reattachment, in 6 eyes (1 eye with presumed congenital SOP, 1 eye with acquired SOP, and 4 eyes with Brown syndrome). Finally, we also measured maximal incyclorotation after complete IO disinsertion, before reattachment, in 2 eyes with suspected inverted Brown syndrome.

Approval to conduct this retrospective study was obtained from the institutional review board of the Mayo Clinic. The study was conducted in a Health Insurance Portability and Accountability Act−compliant manner, and the study conformed to the tenets of the Declaration of Helsinki. Since 2012, it has been our routine practice to perform the torsional forced duction test in every surgical patient as part of routine forced duction testing.

Analyses

We compared the median maximal excyclorotation of each oblique dysfunction condition with controls, first based on the surgeon's intraoperative report and then based on masked photographic assessment. The reader of the photographs (J.H.J.) was unaware of

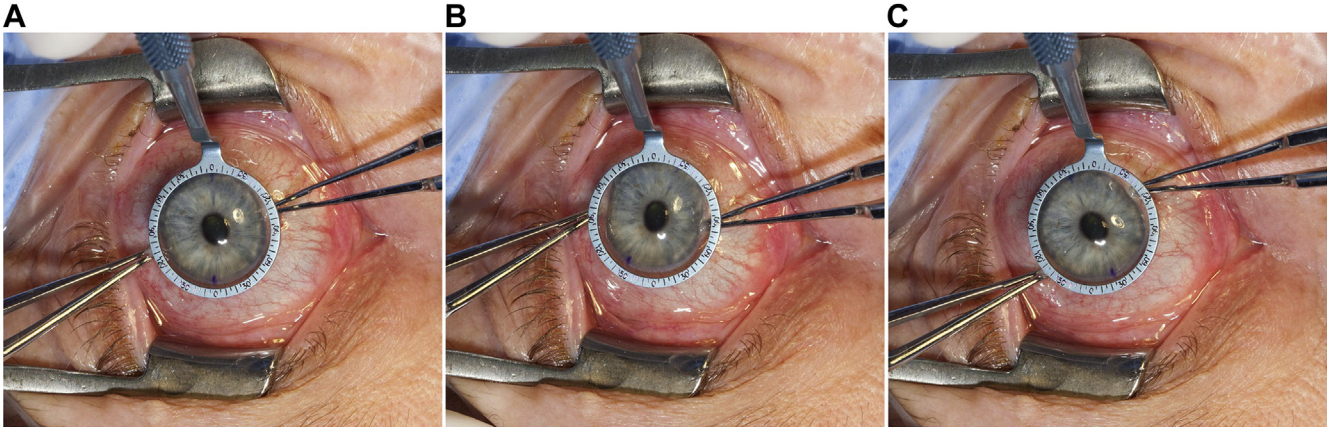

Figure 1. Torsional forced duction test illustrated in the left eye of a control patient. **A**, Initial alignment of Mendez ring to limbal reference marks at 6 and 12 o'clock in the left eye (surgeon's view). **B**, Globe was excyclorotated until the first resistance was felt and this maximal excyclorotation was read as 30 degrees. **C**, Globe was incyclorotated until the first resistance was felt and this maximal incyclorotation was read as 30 degrees.