

Improvement in distance stereoacuity following surgery for intermittent exotropia

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PURPOSE	To evaluate whether distance stereoacuity improves following surgery for intermittent exotropia using the Frisby Davis Distance (FD2) and Distance Randot stereotests.
METHODS	Eighteen patients (median age, 24 years; range, 5 to 68 years) with intermittent exotropia were prospectively enrolled. Stereoacuity was measured pre- and 6 weeks postoperatively using the FD2 and Frisby near tests (real depth tests) and Preschool Randot and Distance Randot tests (polaroid vectographs).
RESULTS	Distance stereoacuity measured with the FD2 improved from a median preoperative value of 80 to 40 arcsec postoperatively ($p = 0.04$) and stereoacuity measured with the Distance Randot improved from a median of nil to 200 arcsec ($p = 0.06$). In those that had subnormal stereoacuity preoperatively, there was even more marked improvement in distance stereoacuity (FD2 median nil vs 40 arcsec, $p = 0.002$; Distance Randot median nil vs 200 arcsec, $p = 0.004$). Near stereoacuity measured with Frisby and Preschool Randot remained unchanged pre- to postoperatively (median, 60 and 80 arcsec, respectively).
CONCLUSIONS	There was improvement in distance stereoacuity measured with both the FD2 and the Distance Randot stereotests in patients who underwent surgery for intermittent exotropia. The FD2 and Distance Randot may be useful outcome measures in future clinical trials of interventions for intermittent exotropia. (J AAPOS 2008;12:141-144)



Measurement of distance stereoacuity has previously been used to assess severity of intermittent exotropia and to monitor for deterioration.¹⁻³

Deterioration in stereoacuity has been suggested as a possible indicator of need for surgery in patients with intermittent exotropia, and distance stereoacuity has been used as an outcome measure following surgical intervention.³⁻⁵

Using older measurement techniques, some authors have reported an improvement in distance stereoacuity

following surgery for intermittent exotropia.³⁻⁵ Distance stereoacuity, in these studies, was measured using the Baylor Visual Acuity Tester (BVAT) and Binocular Visual System (Mentor, Norwell, MA), equipment that is no longer widely available. Two new tests of distance stereoacuity have been recently introduced, the Frisby-Davis Distance (FD2) test⁶ (www.frisbystereotest.co.uk) and the Distance Randot test.⁷ (Stereo Optical Co., Inc., Chicago, IL)

Using the new FD2 and Distance Randot for measuring distance stereoacuity, we have previously reported that stereoacuity is often reduced in patients with intermittent exotropia.² Based on previous data, we found that stereoacuity was more frequently degraded when measured using the Distance Randot, and we therefore suggested that the Distance Randot appeared to be more sensitive to minimal disruption of binocularity.² In the present study, we investigated whether distance stereoacuity measured using these two new tests improved following surgery for intermittent exotropia.

Subjects and Methods

Institutional Review Board approval was obtained for this study. All experiments and data collection were conducted in a manner compliant with the Health Insurance Portability and Accountability Act.

Patients

We prospectively enrolled 18 consecutive patients with intermittent exotropia who were scheduled for surgical intervention. There were 10 males and 8 females ranging in age from 5 to 68

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years (median, 24 years) with 6 of these patients under 18 years old. Patients with basic type intermittent exotropia (the same deviation at distance and near) or divergence excess exotropia (exotropia greater at distance than near fixation) were included. Patients with convergence insufficiency type exotropia, defined as a near angle $\geq 10^\Delta$ greater than the distance angle, and patients with constant exotropia at both distance and near were excluded. Patients were not excluded if they had apparently constant exotropia only at distance (intermittent or phoric at near) or no measurable distance stereoacuity. Of our 18 patients, 5 were initially judged to have constant exotropia in the distance but two of these had measurable FD2 stereoacuity (20 and 80 arcsec) and one had measurable Distance Randot stereoacuity (60 arcsec), since they could fuse at distance with effort. As we and others have previously reported,^{2,3,8} distance exotropia that appears constant and absent distance stereoacuity are part of the spectrum of intermittent exotropia. Patients were also excluded if they had worse than 20/40 vision in either eye or if they could not comprehend any of the four stereoacuity tests. Preoperative alignment (1-23 days before surgery) and postoperative alignment (27-66 days after surgery) was measured at near and distance fixation with simultaneous prism and cover test (SPCT) and alternating prism cover test (APCT).

Surgical Intervention

Thirteen (72%) of 18 patients underwent unilateral lateral rectus recession and medial rectus resection, 4 patients (22%) underwent three-horizontal-muscle surgery, and 1 patient (5%) had bilateral lateral rectus recessions. Twelve surgeries were performed using adjustable sutures and, when performed this way, the initial distance alignment was set at 2^Δ to 10^Δ esotropia postadjustment with the expectation of an exotropic drift.

Stereoacuity

Distance stereoacuity was measured using the FD2 at 3 m (20-200 arcsec) and Distance Randot at 3 m (60-800 arcsec).^{7,9,10} Near stereoacuity was measured at the previously described test distances for the near Frisby (40-400 arcsec) and at 40 cm for the Preschool Randot (40-800 arcsec).^{11,12} Stereoacuity was recorded as "nil" if the largest disparity could not be passed.

Analysis

Stereoacuity thresholds were compared pre- and postoperatively with nonparametric Wilcoxon signed rank tests.

Results

Alignment

Preoperatively, at distance fixation, the angle of exodeviation ranged from 16^Δ to 60^Δ by APCT (median, 32.5^Δ). Six weeks postoperatively, the angle of deviation at distance fixation ranged from 12^Δ esotropia to 8^Δ exophoria by APCT (median, 0^Δ). Six patients (33%) had a small-angle esotropia at distance fixation ranging from 2^Δ to 12^Δ (median, 3^Δ esotropia) measured with SPCT (e-Supplement 1, available online at jaapos.org).

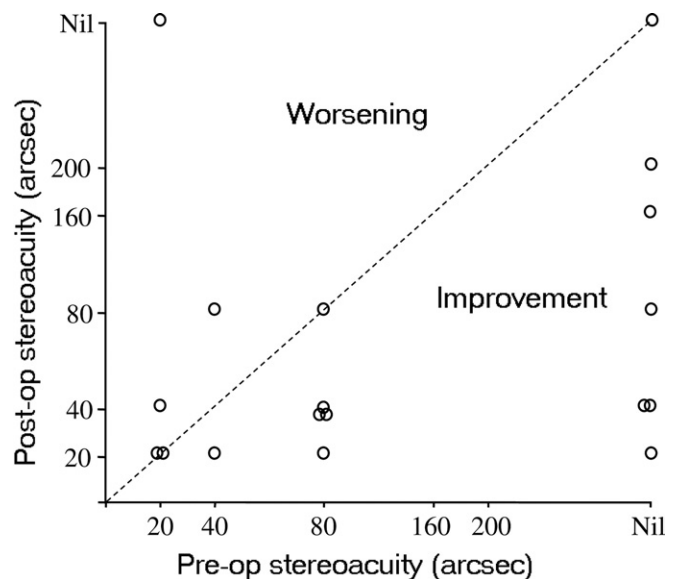


FIG 1. Pre- and postoperative distance stereoacuity measured using the FD2 stereotest.

Distance Stereoacuity Measured Using the FD2

Preoperatively, distance stereoacuity measured using the FD2 ranged from 20 arcsec to nil (median, 80 arcsec) with 7 (39%) of 18 patients having no measurable (nil) distance stereoacuity (Figure 1). Postoperatively, distance stereoacuity measured using the FD2 improved in 11 (61%) of 18 patients to an overall median of 40 arcsec (range, 20 arcsec to nil; $p = 0.04$; see Figure 1 and e-Supplement 1 (available at jaapos.org) and only 2 patients had nil stereoacuity postoperatively. One patient who had nil stereoacuity preoperatively showed no improvement. One of the patients who developed a postoperative esotropia lost measurable stereoacuity postoperatively. Two other patients appeared to worsen: one from 40 to 80 arcsec and one from 20 arcsec to 40 arcsec (Figure 1).

To avoid the potential bias of stereoacuity being unable to improve if the preoperative stereoacuity was already normal, an additional analysis was performed that included only patients with subnormal stereoacuity. Of 18 patients, 12 (67%) had subnormal distance stereoacuity (ie, 60 arcsec or worse) preoperatively, measured using the FD2. In this group of patients, FD2 improved from a median of nil preoperatively to 40 arcsec postoperatively ($p = 0.002$). Of these 12 patients, 7 (58%) achieved normal stereoacuity postoperatively (e-Supplement 1).

Distance Stereoacuity Measured Using the Distance Randot

Preoperatively, distance stereoacuity measured using the Distance Randot ranged from 60 arcsec to nil (median nil), with 11 (61%) of 18 patients having no measurable distance stereoacuity (Figure 2). Postoperatively, distance stereoacuity measured using the Distance Randot improved in 9 (50%) of 18 patients to an overall median of

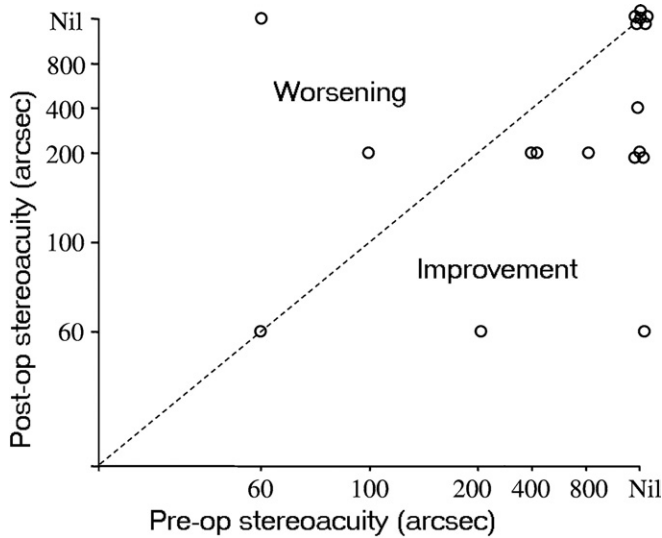


FIG 2. Pre- and postoperative distance stereoacuity measured using the Distance Randot stereotest.

200 arcsec (range, 60 arcsec to nil; $p = 0.06$), with 7 (39%) of 18 patients having no measurable distance stereoacuity postoperatively (Figure 2). Six patients who had no measurable stereoacuity preoperatively showed no improvement. The one patient who developed a moderate angle esotropia postoperatively and lost stereoacuity measured using the FD2 also lost stereoacuity when measured using the Distance Randot. One other patient appeared to worsen from 100 to 200 arcsec (Figure 2).

A secondary analysis, analogous to that performed with the FD2, was limited to those patients with subnormal stereoacuity preoperatively. In 16 (89%) of 18 patients with subnormal distance stereoacuity (ie, 60 arcsec or worse) measured using the Distance Randot, stereoacuity improved from a median of nil to 200 arcsec ($p = 0.004$), but only 2 (13%) achieved normal stereoacuity (e-Supplement 1).

Near Stereoacuity

Preoperatively, near Frisby stereoacuity was measured in 17 of 18 patients and ranged from 40 arcsec to nil (median, 60 arcsec) and only 2 (12%) of 17 patients had no measurable near Frisby stereoacuity preoperatively. Postoperatively, stereoacuity was unchanged (median, 60 arcsec) and the two patients who had no measurable stereoacuity preoperatively still had no measurable stereoacuity postoperatively. One patient with the largest postoperative esotropia lost near stereoacuity measured by the near Frisby test (40 arcsec preoperatively to nil postoperatively).

Preoperatively, near stereoacuity measured using the Preschool Randot ranged from 40 arcsec to nil (median, 80 arcsec) with only 4 (22%) of 18 patients having no measurable near stereoacuity. Postoperatively, median stereoacuity measured using the Preschool Randot was unchanged (median, 80 arcsec). Three of the four patients who had no measurable stereoacuity preoperatively still

had no measurable stereoacuity postoperatively, although one patient acquired 100 arcsec. The one patient mentioned above with the largest postoperative esotropia (12^Δ) also had significant reduction in near Stereoacuity measured by the Preschool Randot test (60 arcsec preoperatively to 400 arcsec postoperatively).

Discussion

Distance stereoacuity measured using the FD2 and Distance Randot showed overall improvement following surgery for intermittent exotropia. This improvement was particularly evident in those who had subnormal preoperative distance stereoacuity. Our results using these newly introduced tests of distance stereoacuity are consistent with previous studies³⁻⁵ using the older BVAT technology, which is important because the BVAT hardware is no longer widely available.

Regarding differences between stereoacuity measured using the FD2 and Distance Randot, a greater proportion of patients undergoing surgery for intermittent exotropia achieve normal stereoacuity (60 arcsec or better) postoperatively when measured using the FD2 than the Distance Randot. This finding is consistent with our previous suggestion that the FD2 and Distance Randot seem to measure different aspects of stereoacuity.^{2,13} The FD2 is a real world stereotest, whereas the Distance Randot test is based on a polaroid vectograph. We have previously suggested that the Distance Randot appears sensitive to mild disruption of the binocular visual system,² possibly related to the dissociation induced by the polarized glasses used for the Distance Randot test. It is also possible that the actual alignment at the moment of testing differs between the FD2 and Distance Randot.

Near stereoacuity was excellent in the majority of patients preoperatively and this remained essentially unchanged following surgery. Nevertheless, 4 (22%) of 18 patients had no measurable near stereoacuity pre- and postoperatively with either the near Frisby or the Preschool Randot. Our findings of near stereoacuity, in intermittent exotropia, are consistent with previous studies where near stereoacuity has been shown to be impaired in a proportion of such patients.^{5,14} It has been suggested that these patients have continuous central suppression, regardless of exotropic status, which might explain why their stereoacuity did not improve postoperatively.^{5,14} Central suppression may be illustrated by one of our patients (Patient 1 in e-Supplement 1), who had a microesotropia at near pre- and postoperatively measured using SPCT, which may explain the lack of improvement in stereoacuity. In contrast, preoperative microtropia does not appear to preclude improvement in distance stereoacuity, for example, Patient 14 in e-Supplement 1, who showed a marked improvement in stereoacuity postoperatively.

Regarding surgical overcorrection, six patients had an esotropic overcorrection measured at 6 weeks postoperatively (ranging from 2^Δ to 12^Δ esotropia by SPCT at

distance and 2^Δ to 8^Δ esotropia by SPCT at near fixation). A small postoperative esotropia did not preclude excellent stereoacuity; three of the six patients had normal distance stereoacuity measured using the FD2 and one of the six patients had normal distance stereoacuity measured using the Distance Randot. This finding is consistent with previous reports of up to 4^Δ esotropia being compatible with fine stereoacuity.¹⁵ Nevertheless, patients with larger amounts of postoperative esotropia are at risk of losing their binocular function and in some cases this loss may be permanent.¹⁶ One of our patients had a 12^Δ postoperative esotropia, with loss of stereoacuity, and was subsequently managed with prism glasses. Correction of the misalignment with prism glasses did not immediately improve stereoacuity. At the latest examination (8 months following surgery) the patient's esotropia had reduced to 1^Δ in the distance and 0^Δ at near with recovery of FD2 stereoacuity to 80 arcsec, but Distance Randot stereoacuity remained nil. The risk of losing stereoacuity must be considered when a patient has normal or near-normal stereoacuity preoperatively. There is much more to gain, and less to lose, in patients with intermittent exotropia who have nil stereoacuity preoperatively.

There was a group of patients, within our study of intermittent exotropia, who did not show an improvement in distance stereoacuity postoperatively and most of these patients were not esotropic pre- or postoperatively. A potential explanation for the lack of improvement might be central suppression in the absence of a manifest microtropia or other aspects of an underlying abnormal binocular system in intermittent exotropia.

There are a number of limitations to the findings in this study. We had no control group in this study, but it is unlikely that stereoacuity would improve spontaneously to the degree that we found over the duration of the study (immediately preoperative to 6 weeks postoperative). Nevertheless, the natural history of intermittent exotropia has not been rigorously studied. In our study we found an improvement in distance stereoacuity following surgery for intermittent exotropia but the role of stereoacuity in monitoring intermittent exotropia prior to surgery is still unknown. Further studies are needed to address variability of distance stereoacuity with time, the natural history of intermittent exotropia, and test-retest variability of testing stereoacuity. One weakness of our study is the difference in measurable thresholds between the FD2 and Distance Randot tests; nevertheless, we performed a secondary analysis of the proportion of patients who achieved normal stereoacuity (60 arcsec or better), which confirmed the primary findings of the study. We did not use alternative methods of measuring stereoacuity, such as the Project-

O-Chart slides, since our study was focused on two new methods of assessing distance stereoacuity. Finally, our study could have been improved by masking of stereoacuity assessment. Nevertheless, masking of postoperative status would require examiners that were not involved in any aspect of preoperative care and would require examiners to not look at the patient's eyes, since redness may still be present at 6 weeks.

Distance stereoacuity measured using the new FD2 and Distance Randot tests improves in most patients following surgery for intermittent exotropia and further studies are required to address the role these tests may play in monitoring intermittent exotropia.

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