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CLINICAL STUDY

'Largest angle to target' in surgery for intermittent exotropia

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Abstract

Purpose **To evaluate the safety of the approach based on the notion that the surgical dose for intermittent exotropia should be based on the largest angle ever measured.**
Design **Prospective case series of 33 patients.**
Methods **A total of 33 patients with intermittent exotropia, in whom angles of misalignment at distance or near showed a difference of 15 prism diopters (PD) or more among visits, were included. All the patients were treated by bilateral lateral rectus recession by the same surgeon (JMH), and all were followed up for a minimum of 6 months postoperatively. Short- and long-term surgical results after the initial procedure for intermittent exotropia were analysed.**
Results **The short-term average result at a postoperative 1 week was 9.3 PD esotropia at distance (range 30 esotropia – 16 exotropia). The long-term average results postoperative 6 or 9 months were 4.8 PD exotropia at distance (range 12 esotropia – 30 exotropia). At the last follow-up, no overcorrection over 2 PD esophoria at distance was found, and 9 PD of intermittent esotropia and esophoria at near was observed in two patients, respectively.**
Conclusions **The strategy of surgical dose for intermittent exotropia based on the largest angle ever measured did not result in overcorrections and is believed to be safe.**

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Keywords: bilateral lateral rectus recession; intermittent exotropia; largest angle

Introduction

Postoperative result of exotropia is sometimes frustrating, both for surgeons and patients, because of the high rate of undercorrection with the passage of time.[1] The cause of this high rate of undercorrection is still not clear. Pritchard[2] once mentioned variability in the measurement of exotropia and pointed out that the most simple and obvious potential explanation for this high rate of recurrence of intermittent exotropia may be not operating to the full angle of the deviation. Kushner[3] suggested that patients who had 'outdoor sensitivity' or 'vergence aftereffect at distance' in the outdoor measurement through the window or postocclusion measurement at 6 meters should undergo surgery for the largest angle measured, because undercorrections typically exceed overcorrections in exotropia.

Although most patients with intermittent exotropia show a stable exotropic angle with the repeated preoperative measurements, some patients show variable angles of exotropia during the measurements. In these cases, it should be determined whether the surgical dose should be based on the largest angle ever measured or on the most common angle measured. To our knowledge, this subject has never been studied. This study was designed to evaluate the safety of the strategy that surgical dose for intermittent exotropia should be based on the largest angle ever measured.

Subjects and methods

Using the exclusion criteria listed in Table 1, 33 patients (19 male and 14 female patients) between 27 and 123 months of age were prospectively entered into this study from January 1999 to January 2002. The mean and median age of the children was 61 and 57 months, respectively. Most of the patients were younger than 10 years. The mean age at the time of surgery was 77.3 months, with a standard deviation of 26.7 months (33–132 months).

Patients were considered to have intermittent exotropia if the deviation was intermittently

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Table 1 Exclusion criteria

Age older than 12 years
Constant exotropia
Postoperative follow-up less than 6 months
Manifest or latent nystagmus
Extraocular muscle palsy
Dissociated strabismus complex
Mechanical cause for strabismus
Unilateral recession and/or resection surgeries
Use of slanted recession or adjustable sutures
Concomitant vertical muscle surgeries
Neurologic abnormalities
Developmental delay
Mental retardation
Previous eye surgery
Any organic lesion of the orbit or eye

manifested either at distance or near. Patients with intermittent exotropia in whom the angles of misalignment either at distance or near showed differences of 15 prism diopters (PD) or more among visits were included. Patients with A or V patterns or oblique muscle overactions were not excluded.

All patients underwent complete ophthalmologic examinations before the operation. Patients with hyperopia greater than +3.00 dioptres (D), myopia of −1.00 D or more, or astigmatism of ±1.50 D or more were prescribed with glasses before a final surgical decision was made. In patients with hyperopic intermittent exotropia, glasses of approximately +1.00 to +1.50 D less than the full cycloplegic hyperopic refraction with cyclopentolate hydrochloride 1% were given. Prism and alternate cover test with accommodative targets for fixation at 1/3 and 6 meters in most of the patients, and a modified Krimsky method at 1/3 m in a few uncooperative patients were conducted by one of the authors (JMH). Prism and alternate cover test was performed for cooperative patients while they looked through a window and fixated on a distant outdoor target. An additional proximal measurement was obtained after 1 h of monocular occlusion of the habitually deviating eye, and another post-occlusion proximal measurement was obtained with an additional +3.00 D sphere over each eye prior to allowing the patient to regain binocular fusion.

Surgery was recommended if there was a deterioration of the frequency or magnitude of the exotropia despite nonsurgical therapy such as alternate occlusion or minus lens therapy in most of the patients, and a manifest tropia was present for more than 50% of the time, as determined either by examination or by obtaining an ophthalmic history. All of the patients were treated by bilateral lateral rectus recession under general anaesthesia. All surgeries were performed by the same surgeon (JMH) for the largest angle ever measured using a surgical dosage table.[4]

The short-term surgical results within the first week following the surgery, the long-term results at a postoperative 6 or 9 months, and final alignment at the last visit were assessed. We divided our patients into groups according to the amount of postoperative deviations to represent the quality of postoperative results: (1) more than 5 PD of esotropia (poor), (2) 1–5 PD of esophoria/tropia (good, if binocular function is maintained), (3) orthophoria (excellent), (4) 1–10 PD of exophoria/tropia (good), and (5) more than 10 PD of exophoria/tropia (poor).

If the patient showed diplopia with overcorrection of more than 15 PD at postoperative 1 day, alternate monocular patching was conducted until the diplopia was resolved. If overcorrection persisted for longer than 2 weeks, a cycloplegic refraction was performed again and glasses for a hyperopia of more than +1.00 D were prescribed. If the esotropia did not reduce with alternate patching after 4 weeks, the patient was placed in base-out Fresnel press-on prisms (3 M Health Care, St Paul, Mn, USA) to allow constant fusion.

Results

The mean preoperative follow-up was 16.1±15.2 (1–60) months. The average number of preoperative measurement occasions was 7.1±2.3 (4–12). The average differences among measurements at distance were 19.2 PD (range 5-43 PD) and those at near were 22.3 PD (range 9–42 PD) (Table 2). Out of 26 patients, 11(42.3%) who had measurement at outdoor fixation showed an 'outdoor sensitivity'[3] of more than 3 PD, and two of 11 patients revealed their largest angle ever measured in the outdoor measurement through the window. No patient had a high AC:A ratio. Family history was positive in five patients. There were two patients with an A pattern more of than 10 PD and two patients with a V pattern of more than 15 PD. Four patients with an A or V pattern underwent infra- or supra-transposition of the lateral rectus muscles.

The average postoperative follow-up period was 13.8 months (range 6–36 months). The short-term results on the first week following surgery were 9.3 PD of esotropia (30 PD esotropia–16 PD exotropia) at distance and 8.0 PD of esotropia (30 esotropia–16 exotropia) at near on the average. The long-term results at postoperative 6 or 9 months were 4.8 PD of exotropia (12 esotropia–30 exotropia) at distance and 4.6 PD of exotropia (18 esotropia–25 exotropia) at near on the average. Only two patients were overcorrected by 10 PD or more at distance and near at a postoperative 6 or 9 months. The average angle at final visits was 6.8 PD of exotropia (2 esotropia–30 exotropia) at distance and 6.2 PD of exotropia (9 esotropia–30 exotropia) at near on the average (Table 3).

Table 2 Variability profile of misalignment at distance and at near in 33 intermittent exotropia patients

Patient no.	D_{max}	D_{min}	$D_{max}-D_{min}$	D_{fluc} *(%)*	N_{max}	N_{min}	$N_{max}-N_{min}$	N_{fluc} *(%)*	*Op dosage*	*No. of examinations*	*Preop FU (months)*
1	23	18	5	20	35	20	15	43	35	4	4
2	25	18	7	28	30	15	15	50	30	6	18
3	40	30	10	25	40	20	20	50	40	5	3
4	30	18	12	40	30	14	16	53	30	9	3
5	25	12	13	52	30	1	29	97	30	12	24
6	35	20	15	43	33	10	23	69	35	7	21
7	40	25	15	38	45	35	10	22	40	5	7
8	35	20	15	43	29	4	25	86	35	7	1
9	40	25	15	38	40	10	30	75	40	9	16
10	40	25	15	38	35	18	17	49	40	5	4
11	30	15	15	50	35	20	15	43	35	7	21
12	40	25	15	38	35	16	19	54	40	7	15
13	30	15	15	50	25	16	9	36	30	6	39
14	30	14	16	53	30	6	24	80	30	7	5
15	30	14	16	53	25	0	25	100	30	8	39
16	35	18	17	49	30	10	20	67	35	6	6
17	40	23	18	44	30	4	26	87	40	7	16
18	30	11	19	63	25	0	25	100	30	12	58
19	40	20	20	50	25	10	15	60	40	7	5
20	30	10	20	67	30	12	18	60	30	12	15
21	50	30	20	40	40	23	18	44	50	4	1
22	40	20	20	50	40	23	18	44	40	7	2
23	35	14	21	60	35	14	21	60	35	6	15
24	40	18	22	55	40	11	29	73	40	4	5
25	50	28	23	45	45	20	25	56	50	10	22
26	45	23	23	50	50	20	30	60	50	6	10
27	50	25	25	50	40	0	40	100	50	6	13
28	35	10	25	71	33	16	17	51	35	6	12
29	40	14	26	65	40	17	23	58	40	7	36
30	50	20	30	60	35	15	20	57	50	5	14
31	45	14	31	69	45	12	33	73	45	5	2
32	55	20	35	64	48	6	42	88	55	12	19
33	60	18	43	71	45	18	27	60	60	9	60
Minimum	23	10	5	20	25	0	9	22		4	1
Maximum	60	30	43	71	50	35	42	100		12	60
Average	38.3	19.0	19.2	49.4	35.5	13.2	22.3	63.7		7.1	16.1
SD	8.9	5.5	7.7	12.9	7.0	7.8	7.6	19.8		2.3	15.2

D_{max}, the largest angle at distance measured; D_{min}, the smallest angle at distance measured; N_{max}, the largest angle at near measured; N_{min}, the smallest angle at near measured; D_{fluc}%, $(D_{max}-D_{min}) / D_{max} \times 100$, N_{fluc}%, $(N_{max}-N_{min})/N_{max} \times 100$; SD, standard deviation; FU, follow-up

The distributions of postoperative deviations at distance and near are shown in Figures 1 and 2. A high percent of patients (75.8%) (25/33) at distance, and (72.7%) (24/33) at near were esophoric/tropic in the first week. However, in spite of the high incidence of an initial esodeviation, many patients (14 at distance, 15 at near) showed an exodeviation by postoperative 6–9 months. At the last follow-up, 13 patients were orthophoric at near, nine had an exodeviation of 10 PD or less at near, nine had an exodeviation of more than 10 PD, and finally only two had a persistent esodeviation. In short, 22 out of 33 patients showed an 'excellent or good' result.

Discussion

The need to uncover latent exodeviation by occlusion of one eye for 30–45 minutes[5,6] or outdoor measurement[3] has been stressed by many authors. Abbasoglu *et al*[7] suggested that the lack of agreement in terms of factors influencing response may be due to the greater variation of preoperative angles of deviation in exotropic patients. Pritchard[2] also mentioned variability in measurements of exotropia. Increased luminance has also been reported to increase the deviation of intermittent exotropia.[8] As was suggested, different tonic vergence, accommodative convergence, vergence aftereffect at distance, or

Table 3 Short-term and long-term results in 33 intermittent exotropia patients

Patient no.	*Postoperative 1 week*		*Postoperative 6-9 months*		*Follow-up (months)*	*Last Follow-up*	
	D	*N*	*D*	*N*		*D*	*N*
1	4	2	−6	−16	7	−6	−16
2	6	4	0	−8	21	−16	−16
3	16	12	0	9	6	0	9*E*(*T*)′
4	4	10	−16	−18	15	−20	−25
5	16	16	−9	−9	7	−9	−9
6	20	20	0	0	6	0	0
7	4	4	−16	−25	32	−20	−12
8	30	30	12	10	9	0	0
9	0	0	0	0	11	0	0
10	−16	−8	−14	0	19	−10	0
11	30	16	0	0	8	0	0
12	20	20	0	0	11	0	0
13	10	0	−8	−2	7	−8	−2
14	20	14	0	0	10	0	0
15	3	3	0	0	7	0	0
16	10	16	−30	−4	29	−30	−12
17	12	12	0	0	12	0	0
18	14	4	−7	−9	7	−7	−9
19	14	14	0	0	6	0	0
20	10	14	0	0	24	−4	0
21	8	8	12	18	11	2	9E′
22	0	0	0	0	23	0	−5
23	18	12	0	0	8	0	0
24	10	16	−14	0	9	−23	−6
25	−10	−16	−7	−7	12	−7	−9
26	0	0	0	−4	20	0	−4
27	−2	−12	−12	−18	11	−12	−18
28	10	14	0	0	21	−4	−6
29	23	25	−14	−20	18	−16	−18
30	8	8	−25	−18	14	−30	−30
31	20	12	0	0	10	0	−6
32	0	0	0	−12	36	0	0
33	−4	−6	−6	−18	7	−6	−18
Minimum	30	30	12	18	6	2	9
Maximum	−16	−16	−30	−25	36	−30	−30
Average	9.3	8.0	−4.8	−4.6	13.8	−6.8	−6.2
SD	−10.5	−10.3	−9.0	−9.4	8.0	−9.1	−9.0

(−) sign means undercorrection (exodeviation) and no sign means overcorrection (esodeviation).
D, measurement of exodeviation at distance (prism diopter); N, measurement of exodeviation at near (prism diopter); SD, standard deviation.

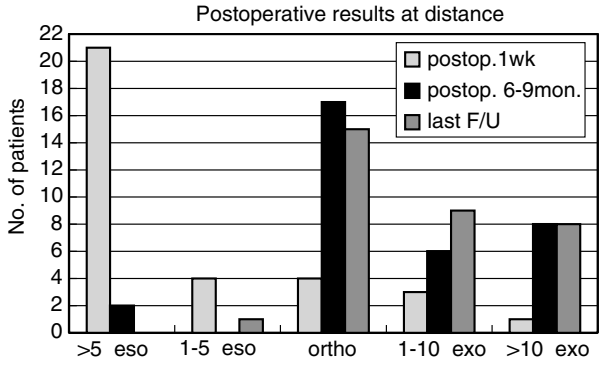

Figure 1 The postoperative results at distance.

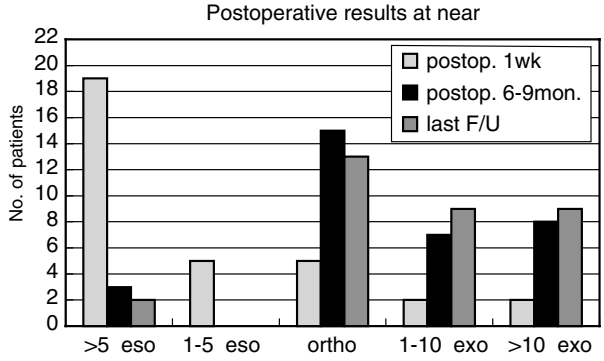

Figure 2 The postoperative results at proximity.

luminance at different times could produce different measurements of deviated angle even without occlusion or plus lenses.

The extent to which an exodeviation is controlled by fusion depends not only on the size of the angle but also to a large extent on the general health, alertness, attention span, and the level of anxiety of patients at the time of examination.[9] This can also explain the variability of measurements as well as the intermittency of exodeviation. von Noorden[9] mentioned that considerable variation in the degree of fusional control from one examination to another is not a surprising finding, and that patients can exhibit a transient improvement of fusional control and an apparent improvement in exodeviation when admitted for surgery because of anxiety associated with the impending operation. He suggested that this should not deter the experienced surgeon from proceeding as planned with the operation. It is less likely that such variability is due to simple errors of measurement, such as a patient's voluntary convergence with accommodative spasm, because all measurements were repeatedly performed by the same strabismologist at the same distance using the same accommodative targets. This study showed that there may be considerable variability of exotropic angle even when measured by the same observer.

Clarke and Noel[1] suggested that patients be examined when tired or after occlusion for 45 min, especially when repeated examinations have revealed only a relatively small angle; but parents report a much larger deviation when their child is tired. They also advised that all children be brought back for measurement at least on one occasion late in the day after forgoing their afternoon nap. Several authors have suggested a role for prism adaptation to determine the latent angle and the angle of strabismus for surgical planning in patients with intermittent exotropia.[10–13] Kushner[3] suggested that the surgery should be performed for the largest deviation obtained with outdoor measurement. Our idea was that this principle could be extended to patients who show variable angles at different visits.

Although the exact mechanism of the variability is not known, the determination of the optimum surgical dosage in such cases is a critical and practical issue for all strabismus surgeons. When the surgical dose is determined according to the largest angle ever measured, the most troublesome issue is the risk of persistent overcorrection. Overcorrection of an intermittent exodeviation may be harmful,[9,14] and a child may develop nasal suppression, lose binocular function, or develop amblyopia as a result.[15] This study was designed to evaluate the safety of this approach by assessing the postoperative results. We found that there was no development of amblyopia or deterioration of binocular vision induced by overcorrection.

The results of this study show no overcorrection of more than 9 PD of esotropia at distance or near at final visits. Raab and Parks[16] performed bilateral lateral rectus recessions for intermittent exotropia and 2% (3/159) were overcorrected by more than 10 PD between 5 and 8 weeks after surgery. Pratt-Johnson *et al*[17] also found a 2% (2/100) overcorrection rate of more than 10 PD at a postoperative follow-up of at least 1 year. Richard and Parks[18] noted a 6% (7/111) overcorrection rate of more than 10 PD with intermittent exotropia followed for at least 2 years. Comparing these results, our method to determine surgical dosage was not found to be related to a higher overcorrection rate. Initial overcorrections in our study may be considered desirable, as other studies[1,16,19–21] have suggested, although the recommended amounts of overcorrection are different and overcorrection does not guarantee a good final outcome.[22] Surgical doses may be determined according to the largest angle measured without much fear of persistent overcorrection.

In this study, 11 out of 26 patients (42.3%) showed an 'outdoor sensitivity' of more than 3 PD at the admission examination, which is comparable with Kushner's[3] study in that 69 out of 202 patients (34.2%) responded to outdoor fixation. However, only two patients revealed their largest deviation in the outdoor measurement, and the remainder showed a smaller angle than the previous largest measurement with accommodative targets at 1/3 or 6 meters. This finding shows that the far distance measurement is not always the largest angle, and multiple measurements at different times may be more useful than the outdoor measurement to find the largest deviation.

As all the surgeries for intermittent exotropia in this report were bilateral lateral rectus recessions, our result may safely be applied only to such surgery. Further studies are needed to determine whether this approach could be applied to unilateral surgeries. More extensive comparative studies would be required to characterize the approach—surgery for the maximal amount ever measured or surgery for the more common or stable angles—that could reduce undercorrections and improve long-term surgical results.

In conclusion, the strategy of surgical dose for intermittent exotropia based on the largest angle measured did not result in overcorrections and is believed to be safe.

References

1 Clarke WN, Noel LP. Surgical results in intermittent exotropia. *Can J Ophthalmol* 1981; **16**: 66–69.

2 Pritchard C. Intermittent exotropia: how do they 'turn out'? *Am Orthopt J* 1993; **43**: 60–66.
3 Kushner BJ. The distance angle to target in surgery for intermittent exotropia. *Arch Ophthalmol* 1998; **116**: 189–194.
4 Wright KW. *Color Atlas of Ophthalmic Surgery: Strabismus*. Lippincott: Philadelphia; PA, 1991 pp 241–242.
5 Burian HM. Exodeviations: their classification, diagnosis and treatment. *Am J Ophthalmol* 1966; **62**: 1161–1166.
6 Burian HM, Spivey BE. The surgical management of exodeviations. *Am J Ophthalmol* 1965; **59**: 603–620.
7 Abbasoglu OE, Sener EC, Sanac AS. Factors influencing the successful outcome and response in strabismus surgery. *Eye* 1996; **10**: 315–320.
8 Wirtschafter J, von Noorden G. The effect of luminance on exodeviations. *Invest Ophthalmol* 1964; **3**: 549.
9 von Noorden GK. *Binocular Vision and Ocular Motility*, 6th ed. CV Mosby: St Louis, MO, 2002 pp 367–368.
10 Shippman S, Weintraub D, Cohen K, Weseley A. Prism in preoperative diagnosis of intermittent exotropia. *Am Orthopt J* 1988; **38**: 101–106.
11 Ron A, Merin S. The pre-op adaptation test (PAT) in the surgery of exotropia. *Acta Strabologica* 1985; **2**: 57–64.
12 Ron A, Merin S. The use of the pre-op prism adaptation test (PAT) in surgery of exotropia. *Am Orthopt J* 1988; **38**: 107–110.
13 Ohtsuki H, Hasebe S, Kono R, Yamane T, Fujiwara H, Shiraga F. Prism adaptation response is useful for predicting surgical outcome in selected types of intermittent exotropia. *Am J Ophthalmol* 2001; **131**: 117–122.
14 Edelman PM, Brown MH, Murphree AL, Wright KW. Consecutive esodeviation… then what? *Am Orthopt J* 1988; **38**: 111–116.
15 Keech RV, Stewart SA. The surgical overcorrection of intermittent exotropia. *J Pediatric Ophthalmol Strabismus* 1990; **27**: 218–220.
16 Raab EL, Parks MM. Recession of the lateral recti. *Arch Ophthalmol* 1969; **82**: 203–208.
17 Pratt-Johnson JA, Barlow JM, Tillson G. Early surgery in intermittent exotropia. *Am J Ophthalmol* 1977; **84**: 689–694.
18 Richard JM, Parks MM. Intermittent exotropia: surgical results in different age groups. *Ophthalmology* 1983; **90**: 1172–1177.
19 Scott WE, Keech R, Mash AJ. The postoperative results and stability of exodeviations. *Arch Ophthalmol* 1981; **99**: 1814–1818.
20 McNeer KW. Observations on the surgical overcorrection of childhood intermittent exotropia. *Am Orthoptic J* 1987; **37**: 135–150.
21 Souza-Dias C, Uesugui CF. Postoperative evolution of the planned initial overcorrection in intermittent exotropia: 61 cases. *Binocular Vis Eye Muscle Surg Q* 1993; **8**: 141–148.
22 Ruttum MS. Initial versus subsequent postoperative motor alignment in intermittent exotropia. *J AAPOS* 1997; **1**: 88–91.