SURGICAL ALIGNMENT PRIOR TO SIX MONTHS OF AGE FOR CONGENITAL ESOTROPIA*

BY *Malcolm R. Ing*, MD

ABSTRACT

Purpose: To complete the first independent and largest multicenter outcome investigation to analyze the motor and functional results of a series of patients surgically aligned *prior to* age 6 months and followed for a minimum of 4 years.

Methods: Sixteen patients, surgically aligned at an average age of 4.2 months, were examined at an average of 7.1 years to assess their motor and functional outcomes.

Results: Motor and sensory tests showed 11 patients to have a small or negligible motor misalignment at near point with both binocular fusion and gross stereopsis ability. A single patient aligned by 3 months of age demonstrated reproducible refined stereoacuity on sensory testing. However, the patients who achieved alignment by 4 or 5 months did *not* demonstrate any better quality of binocularity than that found in a previously studied group of patients aligned at 6 months.

Conclusion: Binocularity that includes refined stereoacuity remains an elusive target and a rare outcome for an ophthalmologist treating congenital esotropia, despite very early surgical alignment.

INTRODUCTION

The functional value of surgical alignment for congenital esotropia by age 2 years has been confirmed by at least 2 large studies.[1,2] The heretofore optimum result of fusional ability and gross stereopsis despite slight final residual motor misalignment has been considered "subnormal binocularity" or a monofixation syndrome. The binocular result, if achieved at all, is usually devoid of refined stereoacuity ability, and this result is apparently not better quality for patients aligned by 6 months versus 12 months versus 24 months of age. Recently, investigators have lowered the age of alignment to close to what is considered the developmental time window occurring

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between 2 and 4 months of age in an effort to improve on the binocularity result.[3] Indeed, one study has reported refined stereoacuity in a patient aligned before age 6 months.[4]

The present study is the first independent and largest multicenter outcome investigation to analyze the motor and functional results of a series of patients surgically aligned prior to age 6 months and followed for a minimum of 4 years.

METHODS

The author wrote several other investigators for permission to study with motor and sensory tests any congenital esotrope who had been surgically aligned to within 10 prism diopters (PD) of orthotropia for a minimum of 6 months having achieved initial alignment prior to age 6 months. These patients were required to have normal neurologic behavior and sufficient maturity (age 4 years or older) to perform sensory tests.

The author traveled to the various centers and personally performed the motor and sensory analysis prior to examining the chart for the clinical history. The independent examination included a measurement of visual acuity with Snellen chart, cover-uncover, simultaneous prism cover, and alternating cover test with prisms. Sensory testing for binocularity included Bagolini striated lenses, and conventionally sized (macro) Worth 4 lights, as well as smaller (micro) Worth 4 lights and stereopsis tests. Stereoacuity was analyzed with Titmus circles and also with Randot-2 circles in all but 4 patients (these 4 patients were examined before the latter test for stereoacuity was available).

Following the motor and sensory evaluation, the chart was abstracted for age at initial examination by an ophthalmologist, age at initial surgical alignment, initial refraction, and subsequent therapy, such as additional surgery, glasses, prisms, and/or miotics. A notation also was made of the evaluations for binocularity done by the patients' own ophthalmologist.

RESULTS

The complete results for 16 patients seen for the study are reported in Table 1. The range of age at examination was 4 years to 14 years 6 months (average, 7 years 1 month). The range of age at alignment was 3 to 5 months (average, 4.2). The initial refractive error range was +0.50 to +3.75D (average, +2.05). The range of initial deviation (all presumably measured at near) by the various investigators was reported to be an esotropia of 35 to 75 PD (average, 56). Initial surgery was reported to be a bilateral medial rectus recession in all cases, with inclusion of a resection of one lateral rectus in 1 patient (13) and a secondary resection of both lateral recti in one case. Vertical muscle surgery had been performed on 3 vertical muscles: 2 for overacting inferior

TABLE 1: COMPLETE RESULTS FOR 16 PATIENTS IN STUDY*

PATIENT		AGE EXAM	AGE DX'D	AGE ALGN	REF RT	REF LT	INIT DEV	SURGERY AND AGE AT SURGERY	SPECS	MIOT	PRESENT VISION	PRESENT ALIGNMENT	STR GLS	WORTH MACRO	WORTH MICRO	TITMUS	RANDOT	BINOC INVES	BINOC OWN MD
1	KH(D)	72	1.0	3.0	+3.00	+3.50	55	Recess MROU 0:3	NO	NO	20/20 20/25	EX 0 X'4	YES	YES	YES	40	20	++	+
2	RP(A)	73	3.0	3.5	+2.25	+2.25	40	Recess MROU 0:3	NO	NO	20/40 20/40	EX 0, DVD OS X'4, DVD'OS	YES	YES	YES	3000	none	++	+
3	TB(B)	133	4.0	4.0	+1.50	+1.50	70	Recess MROU 0:4 Recess IOOU 7:5	NO	NO	20/25 20/20	E 2 E'4	YES	YES	YES	800	n/a	++	+
4	SH(B)	97	4.0	4.0	+1.00	+1.00	70	Recess MROU 0:4 Recess LROU 1:7	NO	NO	20/30 20/30	ET 8, DVD OU ET'8-10, DVD'OU	YES	YES	NO	3000	n/a	++	+
5	KK(D)	104	3.0	4.0	+3.75	+3.75	55	Recess MROU 0:4	NO	NO	20/25 20/25	XT 25. DVD OS X(T)'25	NO	NO	NO	80°	50°	+	+
6	MM(A)	56	3.0	4.0	+2.50	+2.50	35	Recess MROU 0:4	NO	NO	20/40 20/60	ET 10-16, LHT 4 ET'6	YES	NO	NO	none	none	none	none
7	CM(D)	48	3.0	4.0	+1.50	+1.50	40	Recess MROU 0:4	NO	NO	20/30 20/30	XT 25, DVD OU X'4	YES	YES	NO	800	400	++	+
8	TJ(A)	72	3.0	4.0	+1.50	+2.00	60	Recess MROU 0:4 Recess LSR 5:9	NO	NO	20/30 20/30	XT 15 RH'2 (DVD OD)	YES	YES	NO	200	200	++	+
9	KS(A)	60	4.0	4.0	+3.25	+3.25	50	Recess MROU 0:4	YES	NO	20/50 20/50	EX 0 EX'0	YES	YES	YES	3000	400	++	+
10	LO(A)	84	3.0	4.0	+1.00	+1.00	50	Recess MROU 0:4	YES	NO	20/30 20/30	XT cc 8, DVD OU ET'4	YES	YES	NO	400	none	++	+
11	KS(A)	85	4.0	4.0	+1.50	+1.50	35	Recess MROU 0:4	NO	NO	20/25 20/25	LHT 4 E'4, LHT'2	YES	NO	NO	none	none	none	none
12	JH(B)	174	5.0	5.0	+0.50	+0.50	70	Recess MROU 0:5 Resect LROU 1:7 Recess IOOU 7:8 Recess LROU 11:8	YES	YES	20/20 20/20	XT 18, DVD OU LHT'6	YES	YES	YES	800	n/a	++	+
13	CM(C)	72	4.0	5.0	+1.50	+1.50	70	Recess MROU 0:5 Resect LLR 0:5	NO	NO	20/40 20/30	ET 4, DVD OU ET'4, DVD'OU	YES	YES	NO	none	n/a	+	+
14	AH(A)	73	5.0	5.0	+2.00	+2.25	75	Recess MROU 0:5	YES	NO	20/25 20/25	RHT cc 8 E(T)'5	YES	YES	YES	200	200	++	+
15	SS(A)	83	3.0	5.0	+2.00	+2.00	50	Recess MROU 0:5	YES	NO	20/25 20/25	ET 6-12 ET'6-10	YES	YES	NO	3000	400	++	+
16	SC(A)	72	4.0	5.0	+3.25	+3.25	75	Recess MROU 0:5	YES	NO	20/200 20/25	ET 60 ET'35	NO	NO	NO	none	none	none	none

*Legend: Patient, Subject initials and ID of primary surgeon; Age exam, age at study exam, in months; Age dx'd, Age first diagnosed as congenital esotropia by ophthalmologist, in months; Age algn, Age first achieved alignment, in months; Ref rt, Refractive error, right eye; Ref lt, Refractive error, left eye; Init dev, Initial deviation; Surgery and age at surgery, Procedure and age at time of procedure, in years; months, when performed; Specs, Spectacle correction used; Miot, Miotics used; Present vision, Present visual acuity, right and left eye respectively; Present alignment, Alignment status at time of exam for this study; Str gls, Bagolini striated lens test, positive; Worth macro, Worth 4 macro light test, positive; Worth micro, Worth 4 micro light test, positive; Titmus, Titmus test, in seconds of arc; Randot, Randot test, in seconds of arc; Binoc inves, Evidence for binocularity found by investigator; Binoc own MD, Evidence for binocularity found by primary surgeon.

obliques in 1 patient and 1 for dissociated vertical deviation in another patient. Recession of lateral recti for subsequent exotropia had been performed on 2 patients.

Glasses were used for hyperopia in 6 patients.

Motor alignment results showed 4 patients with orthophoria or an esophoria and 7 patients with a tropia less than 10 PD for distance targets. One patient was found to have a large angle of esotropia for distance targets. Exotropia for distance targets was found in 5 patients. Despite this finding of distance exotropia, a phoria or intermittent fusion response was found for near targets for all 5 of these patients with distance exotropia, indicating that the near deviation following surgical alignment generally determined the presence or absence of binocularity. Near deviation measurements were within 10 PD of orthotropia for 14 of the 16 patients. Dissociated vertical deviation was found in a high percentage of patients (8 of 16).

Sensory testing with Bagolini lenses showed no binocularity response in 2 patients. Worth 4 light fusion with the macro dots was present for 12 patients, with 6 patients also reporting fusion with the micro dots indicating a relatively smaller scotoma on binocular testing for these latter patients. The most significant sensory finding was that refined stereoacuity (40 seconds by Titmus and 20 seconds of arc by Randot) was found for only one patient in the series. This patient was aligned at 3 months of age. Gross stereoacuity was found in 11 other patients.

TABLE 2: RESULTS OF WORTH 4 LIGHT AND STEREOPSIS TESTING

ALIGNMENT AGE (MO)	FUSION	STEREOPSIS	NEITHER	NO. OF CASES
3	2	2	0	2
4	6	7	2	9
5	4	3	1	5
TOTAL	**12**	**12**	**3**	**16**

Composite results of motor and sensory testing showed the optimum result for 11 of 16 patients, which included near motor alignment within 10 PD of orthotropia and *both* sensory fusion and stereopsis (Table II).

The sensory findings in patient 5 warrant special reporting: The absence of a binocular response with Bagolini lenses and Worth 4 dot testing would seem to be paradoxical in the presence of recordable stereoacuity. It should be noted that this investigator was also *observing* the motor

alignment of the patient while performing the sensory testing. This patient demonstrated *intermittent* exotropia, and was clearly seen to be divergent during Worth 4 dot and Bagolini lens testing but definitely aligned during the stereopsis testing. These facts explain the presence of stereopsis without satisfactory fusion with the other sensory tests.

DISCUSSION

The present study represents the best case results and does not include data from any patients who may have received surgery but did not achieve alignment.

The most important finding in the present study is that refined stereoacuity was demonstrated in only one patient, and that patient was aligned at 3 months of age. All of the other patients who were aligned prior to 6 months of age, including one who was aligned at 3.5 months, did not have any better quality of binocularity than the usual finding of subnormal binocularity as designated by von Noorden or a sensory result within the confines of the monofixation syndrome as described by Parks.

The present series of patients can be compared with a group of patients aligned by 6 months of age who were previously studied by this investigator. In the previous series, 12 of 16 patients demonstrated near alignment within 10 PD of orthotropia and showed both fusion and stereopsis.[1] Therefore, there was no significant difference in the percentage of patients who achieved the functional results in those surgically aligned prior to age 6 months compared with those aligned at age 6 months, except for the one patient who was aligned at age 3 months who demonstrated refined stereoacuity.

There is continuing speculation, amply described by Helveston,[5] that the development of congenital esotropia lies within the framework of a defective fusion faculty as originally proposed by Worth, which, in turn, is perpetuated by a defective motor loop when the surgical alignment is not achieved in the first 2 years of life. Jampolsky has said, "The stereo development window is probably between 2 and 4 months of age."[6] Indeed, the time window for surgical alignment for the attainment of perfect stereopsis may be, as proposed by Wright,[4] at 3 months of age. This possibility of a very short time window is supported by experimental work by Crawford and von Noorden,[7,8] who also demonstrated irreversible damage to the binocular cells in primates if these animals were subjected to disruption of binocularity by wearing prisms during the sensitive period.

The quest for alignment by age 3 months is further complicated, however, by findings by Nixon and associates[9] demonstrating that the majority of congenital esotropes are not truly esotropic at birth. Furthermore, since unsteady motor behavior, along with absent stereo response, is found in *normal* infants before 4 months of age, the surgeon who

undertakes surgery before that time may be operating unnecessarily and jeopardizing the possibility of normal infant binocularity.[9]

It has been the experience of this investigator that a rare but definite decrease in the amount of esotropia found at 3 months may regress all the way to orthophoria, despite the fact that most of the patients usually show an increase in the quantity of the strabismus when followed by the clinician.[10] Nevertheless, the burden of proof of bona fide esotropia would be upon the ophthalmologist following these cases. The treating ophthalmologist would be caught between observing to see if there was a tendency toward spontaneous remission and motivation to operate early to salvage, perhaps, a better binocular result. Thus, the goal of surgical alignment at age 3 months becomes a dilemma.

Documentation of a refined stereoacuity result in a congenital esotropia has been described by Parks.[11] However, Parks' patient was not aligned until after age 6 months and had remained severely esotropic by history from birth before his alignment procedure. In addition, the author of the present study has examined another congenital esotrope with a refined stereoacuity result. This latter patient was observed to be severely esotropic at age 3 months when seen in a neighboring pediatrician's office by the treating ophthalmologist. This same ophthalmologist examined and confirmed the presence of congenital esotropia in this patient at 6 months of age but was unable to surgically align the patient's eyes until age 1 year 3 months.[12] Despite the fact that this particular patient, when compared with the patients in the present series, received relatively late surgical alignment, the patient demonstrated 40 seconds of arc stereoacuity (confirmed by the author of this present series at age 26).

Consequently, given the relative instability of the strabismus at age 3 months, coupled with the possibility of rare, but definite, refined stereoacuity result even if the alignment is achieved after age 6 months, it remains controversial to recommend at this time very early surgery (ie, before 6 months of age) in the hopes of achieving a better quality of binocularity.

SUMMARY AND CONCLUSIONS

Sixteen patients, surgically aligned at an average age of 4.2 months, were examined at an average age of 7.1 years. Motor and sensory tests showed 11 patients to have a small or negligible motor misalignment at near point with both binocular fusion and gross stereopsis ability. A single patient, aligned by 3 months of age, did demonstrate reproducible refined stereoacuity on sensory testing. It was observed, however, that patients who achieved alignment by 4 or 5 months did not demonstrate any better quality of binocularity than that found in a previously studied group of patients aligned at 6 months.

Binocularity that includes refined stereoacuity remains an elusive target

and a rare outcome for the ophthalmologist treating congenital esotropia, despite very early surgical alignment.

REFERENCES

1. Ing MR: Early surgical alignment for congenital esotropia. *Trans Am Ophthalmol Soc* 1981; 79:625-663.
2. von Noorden GK: A reassessment of infantile esotropia. XLIV Edward Jackson Memorial Lecture. *Am J Ophthalmol* 1988; 105:1-10.
3. Helveston EM, Ellis FD, Plager DA, et al: Early surgery for essential infantile esotropia. *J Pediatr Ophthalmol Strabismus* 1990; 27:115-118.
4. Wright KW, Edelman PM, McVey JH, et al: High grade stereoacuity after early surgery for congenital esotropia. *Arch Ophthalmol* 1994; 112:913-919.
5. Helveston EM: Esotropia. *Trans Am Ophthalmol Soc* 1988; 86:441-460.
6. Jampolsky A: In discussion: Helveston EM: Esotropia. *Trans Am Ophthalmol Soc* 1988; 86:441-460.
7. Crawford ML, von Noorden GK: The effects of short-term experimental strabismus on the visual system in *Macaca mulatta*. *Invest Ophthalmol Vis Sci* 1979; 18:496-505.
8. Crawford ML, von Noorden GK: Optically induced concomitant strabismus in monkeys. *Invest Ophthalmol Vis Sci* 1980; 19:1105-1109.
9. Nixon RB, Helveston EM, Miller KK, et al: Incidence of strabismus in neonates. *Am J Ophthalmol* 1985; 100:798-801.
10. Ing MR: Progressive increase in the angle of deviation in congenital esotropia. *Trans Am Ophthalmol Soc* 1994; 92:117-131.
11. Parks MM: Congenital esotropia with a bifixation result: Report of a case. *Doc Ophthalmol* 1984; 58:109-114.
12. Taylor DM: In discussion: Helveston EM: Esotropia. *Trans Am Ophthalmol Soc* 1988; 86:441-460.

DISCUSSION

DR. EDWARD L RAAB. I am very pleased to discuss Dr Ing's paper, as it addresses an issue of great contemporary interest in the pediatric ophthalmology and strabismus community.

Over the years, Dr Ing has been among the leaders in defining the *upper* age limit for the treatment of congenital esotropia with the goal of fusion and stereopsis. Now his emphasis shifts to considering whether what we now regard as "early" is early enough, in light of recent information that the time window for the development of binocularity is about 3 months of age. Dr Ing examines whether age 6 months is not actually relatively late for realignment of those infants.

For both fusion and stereopsis, Dr Ing compared his observations to those of a similar prior study of his own. He has again employed the device of independently assessing the patients of several colleagues. His analysis required that these children be 4 years or older the time of his masked examination, to allow for reliable responses to sensory tests. He computed the number of children demonstrating peripheral and central binocularity, based on several tests for fusion and stereopsis, for those reported to have been realigned by the treating ophthalmologist to within the conventional

limits of 10 prism diopters from orthophoria before age 6 months.

Dr Ing observed that the sensory results were comparable whether alignment was first achieved at age 6 months or earlier. Because both series are small, it would have been difficult to detect any but a substantial advantage of one or the other age of treatment. This probably requires a prospective approach, including a determination of what degree of difference in outcome would be clinically meaningful so that an appropriate sample size can be identified, and either a uniform follow-up interval or a life-table analysis for varying follow-up.

However, we can agree with his conclusion that the elusive goal of refined stereopsis probably is not promoted by treatment at either age interval, as he could identify only a single patient across both studies who attained 40 seconds of arc. Counter to this observation, he cites other rare congenital esotropia patients who achieved similar refinement when realignment was delayed by several months. Whether very early surgery will improve the chances of achieving lesser grades of binocular cooperation is the more immediate of the questions he has raised.

Since for his sensory analysis Dr Ing had to select only infants successfully realigned prior to age 6 months, we do not know whether the chances of achieving motor realignment are better or worse with such early treatment. This is important, since only last year at this podium, Dr Ing described the difficulty of reliably ascertaining the preoperative deviation in congenital esotropia, and this problem is compounded at this extremely early age. Even a convincing demonstration that refined binocularity is more achievable at very early ages of alignment might not encourage such a practice if it was associated with a convincingly lower likelihood of satisfactory and stable motor alignment necessary to achieve the sensory advantages. Perhaps he has this information and can comment.

Four patients required supplemental surgery at a later time, for either residual esotropia, overacting inferior obliques, or consecutive exotropia. There is some ambiguity in stating that these infants were successfully aligned before age 6 months. I conjecture that they were so originally and that they required the additional surgery when alignment was lost later. In all four cases, subsequent surgery resulted in both fusion and stereopsis at the time of Dr Ing's evaluation. Perhaps he can tell us how long these patients retained their initial satisfactory realignment, since this may indicate a minimum necessary interval of straight eyes to reinforce binocular capacity at whatever age.

Eliminating patients requiring multiple procedures from this report results in 8 of 12 (67%) patients, compared with 7 of 9 (78%) patients from his 1981 study (reported in his thesis for this Society) that he found realigned by age 6 months but not earlier, who achieved both fusion and stereopsis. This reworking of his data suggests that super-early surgery may even be the *less* advantageous strategy, but, again, the number of observations is small

and statistical significance is not reached.

Dr Ing has approached this intriguing subject with his usual tenacity, and we should appreciate the difficulties he faced in acquiring the necessary information. His caution about embracing a treatment that may seem fashionable at the moment is well placed, and his observations have much value for future work on this question.

DR MARSHALL PARKS. Having arrived at the level of knowledge by the late '50's that extramacular binocular vision can be produced in congenital esotropic infants by aligning their eyes with surgery within the first two years of life, the next step was to address the question that perhaps we were not aligning these children early enough to produce macular binocular vision. Starting in 1965 I also set out to surgically align some of these esotropic infants earlier than what was the conventional age of 6 months for doing the first operation, just as Dr Ing described. Dr Ing and I can supply you with eight additional cases that I aligned less than six months of age. Two patients were aligned at 3 months, 5 patients at 4 months and 1 patient at 5 months of age. None of the 8 developed macular binocular vision while all developed extramacular binocular vision. The range of their follow-up was 8 to 22 years with an average of 13 years.

Despite my report in 1984 (1) of a congenital esotropia patient aligned at 6 months of age who did develop macular binocular vision, I have become a disbeliever that earlier than conventional surgery affords the possibility that macular binocular vision may develop in these patients. And I will tell you why. In my 1969 AOS thesis (2) on the Monofixation Syndrome, I discovered while studying 793 patients with neither a history nor a finding of strabismus and no anisometropia, all with equal visual acuity in the 2 eyes or no greater than 20/50 amblyopia in 1 eye, that 1% of the (19 of 738) patients also had the monofixation syndrome. That is , they were devoid of macular binocular vision, but had extramacular binocular vision. I did not realize at the time of the study that because of my high volume strabismus practice, I probably included many siblings of congenitally esotropic patients and possibly some of these 19 patients had the same genetic cause for being devoid of macular binocular vision, but due to variability in expressing the total genetic pattern they did not develop the congenital esotropia. A more recent study (3) suggests this is a plausible thesis since 5 percent of apparently normal parents of congenital esotropic children (7/117) had absence of macular binocular vision. Four percent (5/129) of the parents of congenitally esotropic children also had congenital esotropia.

Therefore, I think doing earlier surgery in treating these congenital esotropic infants with the hope of providing them with macular binocular vision is futile. For the 1 patient I have observed who achieved macular binocular vision, I have a thousand who did not. The more important fact is the large number of first order relatives who also have congenital esotropia

and also among these relatives without esotropia is the group who also are devoid of macular binocular vision. Does not this fact suggest that the inability to develop macular binocular vision is genetically determined and not related to the age the esotropic eyes were aligned?

One of the dangers of very early surgery is that some of the infants will reverse their esotropia to straight eyes at 3 to 4 months of age. If you do early surgery, by the age of 3 months, you may be doing unnecessary or incorrect surgery. In the series of patients I was investigating with this very early surgery, a patient was booked at 3 months of age, for surgery at 4 months of age. When the child appeared for surgery the esotropia had disappeared. This is not a unique situation.

1. Parks MM: Congenital esotropia with bifixation result: Report of a case. *Documenta Ophthalmologica* 1984; 58:109-114.
2. Parks MM: Monofixation syndrome. *Tr Am Opth Soc* 1969; 67:609-657.
3. Scott MH, Noble AG, Raymond WR, Parks MM: Prevalence of monofixation syndrome in parents of children with congenital esotropia. *J. Pediatr Ophth & Strab.* 1994; 31:298-301.

DR G.K. VON NOORDEN. Dr Ing reports that the functional results in congenital esotropes are the same, regardless whether surgical alignment occurred between the 4th and 5th months of life or at the age of 6 months. Only 1 child, operated upon at the age of 3 months acquired refined stereoacuity. Our preliminary results in 13 esotropic children operated on between the ages of 3 and 4.5 months of life are similar, though not all children are old enough for stereopsis testing.

Normal stereopsis is most infrequently attained in infantile esotropia after surgical alignment but it is important to realize that the facility for stereopsis is not a *priori* absent in these children. As a matter of fact, random dot stereopsis has been demonstrated, at least transiently, in esotropic children after prismatic correction[1] and immediately after surgical alignment.[2] Isolated cases of normal or near normal random dot stereopsis have been reported after surgery between the ages of 13 and 19 weeks.[3]

On the other hand, we have shown in infant monkeys that only 7 days of experimental esotropia suffice to permanently deactivate those neurons in the striate cortex that are involved with stereopsis.[4] It is not unreasonable to ask, therfore, whether surgery at the age of 4 months is already too late and we should perhaps operate even earlier. While this approach could be defended on theoretical grounds we find it inadvisable for the following reason: an esotropia present during the first few months of life may not be permanent. I have observed and documented cases in whom spontaneous ocular alignment occurred by the time such children returned at the age of 6 months for their surgical appointment. What would have happened had we operated on these children at the age of 3 or 4 months?

While normal stereopsis reflects optimal binocular function its failure to

develop does not present a major visual handicap in later life. More reasonable treatment goals in infantile esotropia that do not require surgery prior to the age of 6 months are complete ocular alignment, motor fusion with an adequate vergence range and equal visual acuity in both eyes.

1. Mohindra, O. et al: Development of acuity and stereopsis in infants with esotropia, *Ophthalmology*, 1985; 92:691.
2. Archer, S. et al: Stereopsis in normal infants and infants with congenital esotropia, *Am. J. Ophthalmol.* 1986; 101:591.
3. Wright, K. et al. High grade stereoacuity after early surgery for congenital esotropia, *Arch. Ophthalmol.* 1994; 112:913.
4. Crawford MLJ, and von Noorden, GK: The effects of short-term experimental strabismus on the visual system in Macaca mulatta, *Invest Opthalmol. Vis. Sci.* 1979; 18:496.

DR DAVID L. GUYTON. Those surgeons who are advocating early surgery for congenital esotropia are making the assumption that the neurological substrate for fusion is present early on and deteriorates over time. Therefore, they advocate early surgery to capture that mechanism before it deteriorates. But maybe that neurological mechanism hasn't yet developed. We know from Nixon and Helveston's work that congenital esotropia is very rare at birth. Perhaps the mechanism for fusion might not yet be developed in those patients who do become esotropic. Perhaps the neurological substrate for fusion is delayed in development. When we operate later, we are hoping that it has developed by that time. I know that Gunter von Noorden has proposed this possibility. Perhaps we shouldn't be asking at what age to operate, perhaps we should be asking if the ability to fuse has developed, yet. After all, we know that accommodation doesn't develop until later, and stereopsis doesn't develop until later, at least until 2 to 4 months of age. Maybe the ability to fuse in these patients hasn't yet developed, and that, in turn, allows them to drift esotropic early in life. We need a test. We have been trying to develop one for years: a test to put these infants in front of-some sensorimotor test-to determine if the fusion ability is present before operating. Perhaps, we should not simply operate at an arbitrarily early age.

DR MALCOLM R. ING. I want to thank all of the discussants, especially Ed Raab, for the very nice contributions. It is sort of like a meeting of the minds on this subject.

As I pointed out in my 1981 AOS thesis, a *prospective* study concerning the surgical alignment of congenital esotropia is virtually impossible because the surgeon never knows exactly when that patient is actually going to be aligned. It may take more than one operation. In your discussion, Ed, you raised the question of whether or not very early attempts at surgical alignment, such as at 3 months, may actually be less effective in establishing motor alignment than those performed at a later date. The answer to that question cannot really be answered by my study, because it is a selective study. All those who failed to achieve alignment were not included in my

study, and my study was confined to those that had the alignment established for a minimum of 6 months. In other words, it was a "best case" study. And so we really didn't address that issue. The present study cannot answer that question.

With regard to the necessity for subsequent surgery: As you pointed out, 4 of the patients required additional surgery after being initially aligned for a minimum of 6 months. This is a rather common finding, by the way, that a certain segment of these patients seem to fall off the straight line, so to speak, and we have to push them back onto the line. So in these 4 patients I did examine the records to determine the minimum necessary time. The minimum period of time with straight eyes that was necessary to be present, to allow a later retrieval of binocular status was studied. It was 1 year, and all those patients had to have alignment established for (at least the ones I studied) a minimum of 1 year during the sensitive period. The patients: Two were reoperated for reoccurrence of esotropia and 2 were operated for overactive inferior obliques and 1 was for DVD (some of these overactive inferior oblique surgeries were done along with horizontal surgeries). Two patients had also required surgery for subsequent exotropia. Also I did analyze how successful this second surgery was. In other words, after the second surgery did they fall off again? No, they did not. The average length of time follow-up on those after the second or last surgeries was 4 years.

Concerning the patients in the second group, who were aligned at 6 months of age, that is, the previous study, the one I did quite a long time ago: 3 were re-operated on for recurrence of esotropia, 4 for exotropia, and 4 patients either had concurrent or independent vertical surgery. An average of 6 years follow-up had elapsed since the last surgery, however, in that group of patients. And all of these patients also regained fusion. So we do have, I think, our work cut out for us. First we get them straightened, and, then, we try to keep them straight, and that could be with glasses and/or additional surgery.

I want to thank Dr Parks for his presentation of the 8 additional cases which were similar to mine in that they do not have refined stereo acuity, except for that one case I have seen. And he brought up the question that there was something wrong in the "wiring" of the binocular system. I also want to thank Dr VonNoorden for his contributions, although only some of his patients had sensory analysis to date. Also, thank you Dr Guyton, for reminding us that the neurological mechanism may not be present for the actual development of the binocular fusion at a very early age. Therefore, we are sort of working backwards in this situation to try to get the eyes straight, hoping that they will remain straight.

In conclusion, I really feel that I am in a unique position, having examined 2 out of 3 of the congenital esotropia patients who have refined stereo acuity that have been reported in the world literature. And I would like to see Dr Parks' patient, now, because I think she might be 30 or 40 years old and this patient would be the only other one that I have not personally examined.