Published in final edited form as:
JAMA Ophthalmol. 2015 March 1; 133(3): 326–332. doi:10.1001/jamaophthalmol.2014.5265.

Improvement in Binocular Summation After Strabismus Surgery

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Abstract

Importance—Binocular summation (BiS), or improvement in visual acuity using binocular vision compared with the better eye alone, is diminished in patients with strabismus. However, it is still not known how strabismus surgery affects BiS.

Objective—To determine whether BiS improves after strabismus surgery.

Design, Setting, and Participants—Prospective study of 97 patients undergoing strabismus surgery between September 1, 2011, and January 31, 2014, comparing preoperative and postoperative measures of BiS. Patients were recruited within 1 month before undergoing strabismus surgery. The study took place at an academic pediatric ophthalmology and strabismus practice.

Intervention—Strabismus surgery.

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Author Contributions: Dr Pineles had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Study concept and design: Pineles, Birch.
Acquisition, analysis, or interpretation of data: All authors.
Drafting of the manuscript: Pineles.
Critical revision of the manuscript for important intellectual content: Demer, Isenberg, Birch, Velez.
Statistical analysis: Pineles.
Obtained funding: Pineles.
Administrative, technical, or material support: Isenberg, Velez.
Study supervision: Demer, Birch.

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

Main Outcomes and Measures—All patients underwent high- and low-contrast visual acuity testing binocularly and monocularly at preoperative and 2-month postoperative visits. Binocular summation was calculated for high-contrast Early Treatment of Diabetic Retinopathy Study charts and Sloan low-contrast acuity charts at 2.5% and 1.25% contrast as the difference between the binocular score and that of the better eye. Preoperative and postoperative values were compared.

Results—There was an improvement in BiS at the 2 low-contrast levels for all patients and for all contrast levels in the 75 patients in whom surgery successfully restored binocular alignment. For low-contrast acuity, the proportion of patients with a BiS score of at least 5 letters postoperatively was almost twice that of preoperatively (21% to 30% and 13% to 26% for 2.5% contrast and 1.25% contrast, respectively). Similarly, the proportion of patients with binocular inhibition (BiS score worse by at least 5 letters than the better eye score) was decreased postoperatively at all contrast levels (from 22% to 14% for 1.25% contrast). Thirty-one percent of patients experienced improvement in BiS scores postoperatively at the lowest contrast level.

Conclusions and Relevance—Binocular summation scores improved postoperatively in most patients undergoing strabismus surgery. This occurred most frequently at the lowest contrast level. These findings suggest that improved BiS could represent a newly recognized functional benefit from the surgical correction of strabismus. Further studies evaluating the correlation of BiS with stereopsis, visual field expansion, and quality of life will be necessary to fully evaluate the role that improved BiS has in improving binocularity postoperatively.

Binocular summation (BiS), or the improvement in visual acuity when using binocular vision compared with the better eye alone, is diminished in patients with strabismus.[1] In addition, patients with strabismus have been found to be more likely to demonstrate binocular inhibition, or a worsening of visual performance with binocular viewing compared with the better eye alone.[1] Binocular inhibition or impaired BiS may underlie some of the nonspecific complaints articulated by patients with strabismus, including the occasional preference to close 1 eye, despite a lack of diplopia. Similar to other conditions that diminish BiS, such as optic neuritis,[2] unilateral cataract,[3] and advanced age,[4] decreased BiS in patients with strabismus is most evident at low contrast levels.[1] In a previous study, we showed that diminished BiS and the presence of binocular inhibition are associated with decreased quality of life in patients with strabismus.[5] Because diminished BiS and the presence of binocular inhibition negatively impact the quality of life and functional binocular visual acuity, it is important to determine if these deficits can be remediated by surgical repair of strabismus. Moreover, BiS may provide a measurement of functional binocular vision, especially in patients without potential for stereopsis. Binocular summation can be easily measured in a clinical setting and is not subject to the monocular cues that often negatively affect tests of stereoacuity. However, it is still not known how ocular alignment by strabismus surgery affects BiS.

The present study aimed to compare preoperative and postoperative BiS in patients undergoing surgical repair of a wide range of strabismus subtypes to determine whether BiS improves after surgery.

Methods

This study was approved by the University of California, Los Angeles, institutional review board and conformed to the requirements of the US Health Insurance Portability and Accountability Act. Patients with strabismus were consecutively recruited from September 1, 2011, to January 31, 2014, from the preoperative clinic of 4 of the coauthors (S.L.P., J.L.D., F.G.V., and S.J.I.) during preoperative visits. Exclusion criteria included history of amblyopia, age younger than 2.5 years or older than 90 years, dissociated vertical or horizontal deviation as the only form of strabismus, pathologic nystagmus, neurologic disease, or any structural lesion causing an interocular difference in corrected visual acuity exceeding 0.3 logMAR. Patients with dissociated strabismus as their sole form of strabismus were specifically excluded owing to the difficulty in obtaining accurate measurements of the amount of deviation in these forms of strabismus.

All patients underwent a screening examination in which visual acuity was tested using the Early Treatment Diabetic Retinopathy Study (ETDRS) protocol with their habitual refractive correction.[6] Patients younger than 3 years were offered a Lea symbol chart (Precision Vision) if they were unable to perform the ETDRS chart. If visual acuity was worse than 0.2 logMAR in either eye, manifest refraction was performed and the study tests were performed with this refraction. Next, binocular alignment was measured at far (5 m) and near (30 cm) distances using cover/uncover and alternate prism cover testing. Right eye, left eye, and binocular testing was performed in an order randomly assigned prior to testing and was consistently maintained for each patient for the various psychophysical tests. All testing was performed by trained technicians experienced in the examination of patients for research studies with adherence to detailed standard protocols including written scripts and instructions for testing. The following tests were performed (in order of presentation to the patients) at a preoperative visit within 1 month of surgery and the second postoperative month (6 to 10 weeks postoperatively).

High-Contrast Visual Acuity

Visual acuity (VA) was tested using the ETDRS protocol[6] at 3 m. The maximum possible score was 100 letters (Snellen equivalent, 20/12.5).

Low-Contrast Visual Acuity

Sloan acuity was tested (Precision Vision) at low-contrast levels of 2.5% and then 1.25% using the ETDRS protocol at 3 min a dimly lit room. Sloan charts had a similar format to the ET-DRS charts (5 letters per line) with each Sloan chart corresponding to a different contrast level. The maximum low-contrast acuity (LCA) score was 100 letters.

Statistical Analysis

Binocular summation was calculated by subtracting the better eye score from the binocular score (binocular score minus better eye score). As a conservative correction for test variability, a BiS score of 5 or more letters (1 line) was required to demonstrate BiS. Similarly, binocular inhibition was considered to exist when the BiS score was less than or equal to −5 letters. Preoperative and 2-month postoperative BiS scores were compared using a paired *t* test. Subanalyses were performed comparing change in BiS score (difference between post- and preoperative scores) by strabismus subtype, deviation size, age at onset, age at surgery, and presence of subjective diplopia. In addition, these analyses were repeated in a subgroup including only patients whose deviations were reduced to a satisfactory result, which was defined as orthotropia ±10 prism diopters (PDs) for horizontal strabismus and orthotropia ±4 PDs for vertical strabismus. *P* values less than .05 were deemed statistically significant.

Results

Demographic Features

Ninety patients with strabismus and a mean (SD) age of 35.5 (25) years (range, 2.5-90 years) were enrolled. Demographic and visual acuity information are summarized in Table 1.

Subtypes of strabismus included infantile esotropia with onset before 1 year of age (n = 13), childhood esotropia with onset between 1 and 8 years of age (n = 7), esotropia acquired after8 years of age (n = 11), intermittent exotropia (n = 22), consecutive exotropia after surgery for infantile esotropia (n = 9), acquired constant exotropia with onset after 1.5 years of age (n = 3), presumed congenital superior oblique palsy (n = 10), acquired hypertropia after 1.5 years of age (n = 12), and mixed acquired horizontal and vertical strabismus with horizontal and vertical components each larger than 10 PDs in central distance gaze (n = 3). Of the included patients, 82 of 90 (91%) were older than 5 years of age. Seventy-five of the 90 included patients who met the criteria for surgical success defined above.

Binocular Summation

At baseline, a 1-sample *t* test demonstrated nonzero BiS in patients with strabismus at the 1.25% low-contrast level (mean = −1.6 letters; 95% CI, −3.1 to −0.05 letters; *P* = .02) preoperatively, but not for the ETDRS charts or 2.5% low-contrast Sloan charts (*P* = .30 and .06, respectively). This indicates that BiS at the higher contrast levels was not different from 0 preoperatively but scores were negative at 1.25% contrast.

Mean BiS is summarized in Table 2. For the entire cohort of patients, there was an improvement in BiS scores at the 2 low-contrast levels for all patients. For the 2.5% LCA chart, the mean improvement was from 1.3 letters (95% CI, −0.1 to 2.7) to 2.8 letters (95% CI, 1.4 to 4.3, *P* = .01), for the 1.25% LCA chart, the mean improvement was from −1.6 letters (95% CI, −3.1 to −0.05) to 1 letter (95% CI, −0.6 to 2.4) (*P* = .01), and for all contrast levels (including high-contrast ETDRS charts) for the 75 patients who were successfully aligned by surgery (*P* = .02, .04, and .03 for the ETDRS chart, 2.5% LCA charts, and 1.25% LCA charts, respectively). The mean improvement for all 90 patients was 0.8 letters (95% CI, −0.6 to 2.2 letters) for the ET-DRS chart, 1.5 letters (95% CI, 0.1 to 3.1 letters) for the 2.5% LCA chart, and 2.5 letters (95% CI, 0.5 to 4 letters) for the 1.25% LCA chart. For the 75 patients with successful results, the mean improvement was 1.3 letters (95% CI, 0.2 to 2.5 letters) for the ET-DRS chart, 1.4 letters (95% CI, −0.2 to 3 letters) for the 2.5% LCA chart, and 1.9 letters (95% CI, −0.1 to 3.8 letters) for the 1.25% contrast chart.

At the lowest contrast, the mean BiS score improved from a negative value (binocular inhibition) to a positive value (BiS). Postoperatively, mean BiS scores were positive and different than 0 for the ETDRS and 2.5% LCA charts (1.3 letters, 95% CI, 0.1 to 2.3 letters, $P = .02$ and 2.8 letters, 95% CI, 1.4 to 4.3 letters, $P = .002$, respectively), but were not different from 0 for the 1.25% LCA chart (1 letter, 95% CI, −0.6 to 2.4 letters, $P = .12$).

Table 3 depicts the proportion of patients with BiS (BiS score of ≥5 letters) and binocular inhibition (BiS score of ≤ −5 letters) for all 3 psychophysical tests at the preoperative and postoperative visits. For the LCA tests, the proportion of patients with summation postoperatively was almost twice that of preoperatively for the 1.25% LCA (21% to 30% and 13% to 26% for the 2.5% and 1.25% contrast levels, respectively). Similarly, the proportion of patients with binocular inhibition decreased postoperatively at all contrast levels.

Table 4 depicts the percentage of patients with an overall improvement or decrement in BiS of at least 5 letters. Among all patients undergoing surgery, 19 (21%), 24 (27%), and 28 (31%) patients had more than a 5-letter improvement in BiS score for the ETDRS, 2.5% LCA, and 1.25% LCA charts, respectively.

This study was not adequately powered to evaluate whether the various strabismus subtypes were associated with changes in BiS score postoperatively. However, there was a trend toward a contribution by strabismus subtype ($P = .06$, analysis of variance), with patients in the intermittent exotropia, acquired hypertropia, acquired exotropia, and congenital superior oblique palsies having the greatest improvement and patients with childhood esotropia having the least improvement (and most cases of deterioration) of BiS scores post-operatively. When patients with infantile or childhood esotropia were compared with the remaining patients with the 7 other strabismus subtypes, they were less likely as a group to demonstrate improvements in BiS score postoperatively (Table 5). In addition, when patients with intermittent exotropia were compared with the remaining patients, they were more likely to show improvement in BiS scores postoperatively (Table 5). Patients were also evaluated by age at onset, age at surgery, and presence or absence of diplopia, but no significant associations were found with respect to changes in the BiS score postoperatively. When patients who were younger than 5 years of age were excluded from the analysis, there was no change in any of the overall findings described earlier.

A subgroup analysis comparing patients who were orthotropic postoperatively (n = 38) was performed to compare orthotropic patients with those who had any manifest deviation. For the ETDRS chart, 23% of the orthotropic patients had an improvement of 5 or more letters postoperatively, 71% were stable, and 6% had a decrease of 5 or more letters postoperatively compared with 25% of the remaining patients who had an improvement of 5 or more letters, 69% remaining stable, and 10% having a decrease of 5 or more letters postoperatively ($P = .88$, Fisher exact test). For the 2.5% LCA chart, 23% of the orthotropic patients had an improvement of 5 or more letters postoperatively, 63% were stable, and 14% had a decrease of 5 or more letters postoperatively compared with 31% of the remaining patients having an improvement of 5 or more letters, 54% remaining stable, and 15% having a decrease of 5 or more letters postoperatively ($P = .69$, Fisher exact test). For the 1.25%

LCA chart, 29% of the orthotropic patients had improvement of 5 or more letters postoperatively, 51% were stable, and 20% had a decrease of 5 or more letters postoperatively compared with 34% of the remaining patients who had an improvement of 5 or more letters, 54% remaining stable, and 11% having a decrease of 5 or more letters postoperatively ($P = .52$, Fisher exact test).

Discussion

Although BiS has been widely studied in laboratory settings for more than 50 years, it is not well studied in patients with strabismus in clinical settings. For healthy patients, it is well accepted that BiS for low-contrast stimuli is negatively affected both by advanced age[4] and interocular differences in visual acuity. Patients with large interocular differences in visual acuity either artificially induced by neutral density filters,[7] glare,[8] or owing to pathologic states, such as unilateral cataract,[9] anisometropia,[8] or amblyopia,[10] have decreased BiS. Studies of the role of retinal correspondence have also shown that stimulation of noncorresponding points outside of the fusional range results in decreased neural BiS.[11-14] In cases that exceed the tolerated range of interocular differences, a destructive neural interaction occurs known as binocular inhibition. We previously hypothesized that strabismus may alter BiS by inducing an artificial interocular difference in visual acuity by placing the image from 1 eye in a nonfoveal or suppressed region of the retina.[1] However, laboratory studies of BiS in patients with strabismus are conflicting, with most published studies using less than 20 patients and many of them using visual evoked responses in patients younger than 5 years.[15-23] The results of these previous studies are conflicting, probably owing to small sample sizes, differing experimental conditions, and the variability in strabismus subtypes being compared. Our previous large, prospective clinical study revealed that patients with strabismus have diminished BiS and are prone to experiencing binocular inhibition at the lowest levels of contrast.[1] While we did not find significant differences among various strabismus subtypes (which may be owing to insufficient statistical power) in the current study, other authors have found that BiS may be more affected in esotropia than exotropia in animal models,[24,25] owing to a deeper area of suppression in esotropia.

In the few studies of patients whose strabismus has been corrected with surgery, results have shown either a failure to regain normal levels of BiS[26] or a normalization of BiS scores,[16,23] depending on strabismus subtype or age at onset or age at surgical correction. We found that in a large sample of patients with strabismus, BiS improved overall for LCA post-operatively. Importantly, at the lowest contrast level, mean BiS improved from a negative value, signifying binocular inhibition to a positive score, suggesting BiS. In addition, 28% of patients had an improvement in BiS scores postoperatively by at least 5 Sloan letters (1 line). Although this change was most evident at LCA, it was also present at high contrast in the patients who were successfully aligned by surgery. In addition, the proportion of patients with BiS at the lowest contrast level nearly doubled from13% to26% while the percentage with inhibition decreased from 22% to 14%.

The BiS scores of patients with strabismus in our study can also be compared with normative data, showing that the mean (SD) BiS score for patients aged 3 to 65 years was 6

(4) letters, and 3 (4) letters for the 2.5% and 1.25% LCA charts, respectively.[27] Postoperatively, this study's cohort scores were improved from their own preoperative values, yet were still lower than normal scores (2.8 letters and 1 letter for the postoperative BiS scores for the 2.5% and 1.25% LCA charts, respectively). Therefore, patients who were operated on did not regain normal BiS for 2 months following surgical repair of strabismus. This finding can be explained by several factors including residual strabismus, a paucity of binocularly driven cortical cells, or the presence of subclinical amblyopia in some patients.

Although the trend was not always statistically significant, we also found that patients with certain strabismus subtypes had greater improvement in BiS scores postoperatively. The subtypes with the worst postoperative results were those with infantile- and childhood-onset esotropia. Many of the strabismus subtypes that fared better would likely be amenable to larger improvements in BiS because of the high probability of preoperative bifoveal fusion during early visual development. Patients with presumed congenital superior oblique palsies and intermittent exotropia were likely to have spent much of their critical visual developmental period either fusing or at least intermittently fusing; therefore, postoperatively, they were likely to be able to engage a normal amount of binocuarly driven cortical cells. Similarly, patients with acquired hypertropia or exotropia were likely to have acquired strabismus later in life and may also have a normal number of binocularly driven cortical cells. In addition, these groups were likely to have had good bifoveal fusion postoperatively. In contrast, patients with strabismus subtypes that had the worst improvement in BiS scores postoperatively (childhood- and infantile-onset esotropia) may not have regained bifoveal fusion postoperatively and also may have a decreased number of binocularly driven cortical cells; therefore, they may not have had full potential for normal binocular summation, even after strabismus surgery. There are likely to be other factors that contribute to a patient's ability to achieve improvements in BiS after ocular realignment, such as age at onset, age at surgery, and presence or absence of diplopia, but our study was not powered to detect these differences.

The findings of our study must be understood within the context of their limitations. First, our study sample was heterogeneous and included multiple age groups and strabismus subtypes. Although this was beneficial in allowing us to obtain a diverse and readily applicable sample, it was underpowered for detection of differences among various ages and strabismus subtypes. Additionally, the results may not be generalizable to all patient populations. Our study sought to exclude amblyopia but because some patients were enrolled during late childhood or adulthood, we could not exclude the possibility of subclinical amblyopia in some patients. In addition, our primary outcome of BiS score was based on visual acuity scores, which are known to be subject to intertesting variability. Finally, our definition of successful surgical repair of strabismus was arbitrary, although consistent with much of the literature. However, our goal was to evaluate successes in situations unlikely to require reoperation.

Conclusions

This study provides further evidence that there may be functional benefits to strabismus surgery beyond improved stereopsis, visual field normalization, and psychosocial concerns.

In this study, patients with infantile- and childhood-onset esotropia had less effect on BiS scores from strabismus surgery than patients with other strabismus subtypes. To fully assess the role of BiS in improved binocular function postoperatively, further studies are necessary to compare improvements in BiS with stereopsis, visual field expansion, and quality of life. Given that BiS scores for LCA are easily measured and show improvement after ocular realignment, BiS may also be a useful metric by which to assess functional binocular vision in large samples of patients with strabismus for clinical trials.

Acknowledgments

Funding/Support: The study was supported by grant NEI K23EY021762 from the National Institutes of Health (Dr Pineles) and the Knights Templar Eye Foundation (Dr Pineles) and Oppenheimer Family Foundation (Dr Pineles).

Role of the Funder/Sponsor: The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

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Table 1

Demographic Features of Patients With Strabismus

	Mean (SD) [Range]					
			Both Eyes, No. of Letters			
Characteristic	Age at Visit, mo	Age at Onset, mo	ETDRS	IOD	Angle of Strabismus in Primary Position, PDs	Diplopia Present, %
All patients (n = 90)	426 (305) [30-1088]	237 (308) [1-1064]	86 (8) [57-98]	5.7 (5) [0-15]	23 (14) [2-70]	47
Esotropia						
Infantile (n = 13)	330 (253) [48-950]	11 (11) [1-36]	83 (7) [67-91]	6 (6) [0-15]	34 (16) [20-70]	30
Childhood (n = 7)	346 (350) [30-958]	37 (24) [18-72]	81 (5) [75-89]	9 (12) [1-15]	32 (15) [12-55]	0
Acquired (n = 11)	697 (235) [228-956]	631 (260) [60-912]	85 (6) [75-94]	5.7 (4) [0-14]	15 (5) [10-25]	100
Exotropia						
Intermittent (n = 22)	211 (194) [28-817]	91 (102) [6-460]	86 (10) [57-98]	4 (3) [0-14]	28 (12) [12-65]	18
Consecutive (n = 9)	376 (299) [112-794]	20 (33) [2-108]	87 (6) [78-98]	3 (2.7) [0-9]	24 (12) [4-45]	22
Acquired (n = 3)	364 (323) [136-734]	284 (379) [36-720]	83 (2) [81-85]	9 (4) [5-12]	30 (18) [14-50]	33
Congenital SOP (n = 10)	446 (228) [33-709]	223 (242) [6-620]	89 (5) [84-68]	6 (7) [0-15]	17 (6) [6-25]	90
Acquired HT (n = 12)	732 (214) [331-1088]	648 (265) [192-) 1064]	80 (7) [64-89]	6 (6) [1-15]	11 (9) [2-35]	100
Combined V/H (n = 3)	637 (304) [286-814]	502 (414) [24-744]	86 (2) [84-88]	8 (8) [3-15]	23 (19) [8-45]	67

Abbreviations: ETDRS, Early Treatment Diabetic Retinopathy Study visual acuity; HT, hypertropia; IOD, interocular difference; PDs, prism diopters; SOP, superior oblique palsy; V/H, vertical and horizontal strabismus (each component greater than 10 PDs).

Table 2

Binocular Summation (Binocular Score Minus Better Eye Score) in Patients Undergoing Strabismus Surgery

	Mean (SD) [95% CI]		
		LCA, No. of Letters	
Variable	**ETDRS, Letters**	**2.5%**	**1.25%**
All patients (n = 90)			
Preoperative	0.5 (4.5) [−0.5 to 1.5]	1.3 (6) [−0.1 to 2.7]	−1.6 (7.3) [−3.1 to −0.05]
Postoperative	1.3 (5) [0.1 to 2.3]	2.8 (7) [1.4 to 4.3]	1 (7) [−0.6 to 2.4]
P value[a]	.25	.05	.01
Successfully aligned patients only (n = 75)			
Preoperative	0.2 (5) [−0.9 to 1.3]	1.6 (6) [0.1 to 3.1]	−0.7 (7) [-2.3 to 0.9]
Postoperative	1.5 (3.6) [0.7 to 2.3]	3 (6) [1.3 to 4.6]	1.2 (6) [−0.4 to 2.8]
P value[a]	.02	.04	.03

Abbreviations: ETDRS, Early Treatment Diabetic Retinopathy Study; LCA, low-contrast acuity.

[a] Paired *t* test for matched pairs, 2-tailed.

Table 3

Proportion of Patients With BiS and Binocular Inhibition

	Summation (BiS ≥ 5)		Indeterminate (−5 > BiS >5)		Inhibition (BiS ≤ −5)	
Variable	**No. (% of Total)**	**95% CI**	**No. (% of Total)**	**95% CI**	**No. (% of Total)**	**95% CI**
ETDRS						
Preoperative	12 (13)	8-22	69 (77)	66-83	9 (10)	5-18
Postoperative	15 (17)	11-27	68 (76)	65-82	7 (8)	4-15
2.5% LCA						
Preoperative	19 (21)	14 to 31	59 (56)	50-74	12 (13)	8-22
Postoperative	27 (30)	22-41	54 (60)	48-69	9 (10)	5-18
1.25% LCA						
Preoperative	12 (13)	8-22	58 (64)	53-73	20 (22)	15-33
Postoperative	23 (26)	18-36	54 (60)	49-69	13 (14)	9-24

Abbreviations: BiS, binocular summation; ETDRS, Early Treatment Diabetic Retinopathy Study; LCA, low-contrast acuity.

Table 4

Patients Undergoing Strabismus Surgery With a Change in BiS Score of 5 or More Letters Postoperatively

	No. (%)		
Variable	**Improvement**	**Stable**	**Decrement**
All enrolled patients (n = 90)			
ETDRS	19 (21)	64 (71)	7 (8)
2.5% LCA	24 (27)	53 (59)	13 (14)
1.25 LCA	28 (31)	49 (54)	13 (14)
All patients sucessfully aligned (n = 75)			
ETDRS	15 (20)	53 (71)	7 (9)
2.5% LCA	17 (23)	47 (63)	11 (9)
1.25% LCA	23 (31)	39 (52)	13 (17)

Abbreviation: BiS, binocular summation; ETDRS, Early Treatment Diabetic Retinopathy Study; LCA, low-contrast acuity.

Table 5

Changes in BiS Score of Patients With Infantile- or Childhood-Onset Esotropia vs Other Strabismus Subtypes After Strabismus Surgery

	Improvement in BiS by ≥5 letters		Indeterminate (Improvement or Worsening <5 Letters)		Worsening of BiS by ≥5 Letters		
Variable	**No. (% of Total)**	**95% CI**	**No. (% of Total)**	**95% CI**	**No. (% of Total)**	**95% CI**	***P* Value for Fisher Exact Test**
ETDRS							.05
Infantile- or childhood-onset esotropia	2 (10)	(3-30)	13 (65)	(41-81)	5 (25)	(11-49)	
All other subtypes	17 (24)	(15-35)	51(73)	(61-82)	2 (3)	(0.1-10)	
2.5% LCA							.24
Infantile- or childhood-onset esotropia	2 (10)	(3-31)	14 (70)	(46-85)	4 (21)	(9-43)	
All other subtypes	22 (31)	(22-43)	39 (56)	(43-67)	9 (13)	(7-24)	
1.25% LCA							.15
Infantile- or childhood-onset esotropia	4 (20)	(9-43)	15 (75)	(51-88)	1 (5)	(1-24)	
All other subtypes	24 (34)	(24-46)	34 (49)	(36-60)	12 (17)	(10-29)	
ETDRS							.11
Intermittent exotropia	5 (23)	(11-45)	17 (77)	(55-89)	0		
All other subtypes	14 (20)	(12-31)	47(69)	(57-79)	7 (11)	(5-21)	
2.5% LCA							.32
Intermittent exotropia	8 (36)	(21-59)	10 (45)	(24-63)	4 (18)	(8-40)	
All other subtypes	16 (23)	(15-34)	43 (64)	(51-74)	9 (13)	(7-24)	
1.25% LCA							.007
Intermittent exotropia	11 (50)	(32-72)	6 (27)	(11-45)	5 (23)	(10-44	
All other subtypes	17 (24)	(16-36)	43 (65)	(51-74)	8 (12)	(6-22)	

Abbreviations: BiS, binocular summation; ETDRS, Early Treatment Diabetic Retinopathy Study; LCA, low-contrast acuity.