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The Role of Stereopsis and Binocular Fusion in Surgical Treatment of Intermittent Exotropia

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Abstract

Background/Aims: The purpose of this study is to identify the appropriate timing for surgical treatment of intermittent exotropia (XT) in the pediatric population by examining several parameters that may contribute to surgical planning.

Methods: A retrospective chart review was conducted on patients between the ages of 3 and 17 years undergoing surgical management for intermittent XT. Preoperative and postoperative data regarding age, past medical history, visual acuity, stereopsis, magnitude of deviation and control was recorded. Medical records were reviewed and analyzed to determine if preoperative control of near misalignment, stereopsis, or presence of amblyopia may play a role in surgical outcome.

Results: Ninety-five patients met inclusion criteria. Mean age was 6.71 years. Mean follow up period was 10.79 months. At least 140 sec arc of stereopsis using Titmus testing was present in 39.5% of patients preoperatively, while 55.8% of patients had less than 140 sec arc preoperatively, indicative of poor fusion at near. 47.2% of patients had good control of the near misalignment preoperatively, while 52.7% of patients had fair to poor control preoperatively. There was no statistically significant difference in surgical outcomes when comparing preoperative level of control of misalignment at near (P=0.2284) and stereopsis (P=0.2537). Presence of amblyopia preoperatively also had no association with surgical outcome (P=1.00).

Conclusion: The use of worsening stereopsis and/or alignment control at near as parameters to determine the appropriate time for surgical intervention does not predict improved outcomes in patients with intermittent XT.

Keywords: Intermittent exotropia; Fusion; Stereopsis; Strabismus surgery; Lateral rectus recession

Introduction

Intermittent exotropia (XT) is defined as an exodeviation intermittently controlled by fusional mechanisms. This is the most common form of strabismus, affecting approximately 1% of the population [1,2]. It may be diagnosed in early childhood, although it may present later in life. Its course may vary throughout a patient's life, worsening in some patients and remaining stable or even improving in others. The clinical severity is determined by several factors representative of fusional ability, specifically control of deviation and stereopsis [1-3].

Fusion, defined as the brain's ability to view objects as single, with simultaneous stimulation of corresponding retinal areas [3,4] plays an important role in the control of intermittent XT. If fusional abilities decrease, control of misalignment may be lost and the exodeviation becomes more manifest [4]. Given the close relationship between fusion and stereopsis, it can be proposed that stereopsis serves as a function of fusional ability and binocular vision in a patient with intermittent XT.

Historically, management of intermittent XT varies among Pediatric Ophthalmologists. Patients with a small deviation and good control are usually treated conservatively with observation, spectacles to correct refractive error, part time occlusion, orthoptic exercises, or occasionally prisms or myopic overcorrection [5,6]. Surgery has been classically reserved for those patients who have larger exodeviations, poor control, worsening exodeviations, development of amblyopia, or failure in conservative therapies. While most physicians consider surgery appropriate when control at distance is poor, there are varying opinions on the role of control at near as well as stereopsis, and no clear data has been presented outlining the best parameters to determine the most appropriate timing for surgical intervention.

No studies in the literature to date have evaluated if the role of preoperative near fusion, with the use of stereopsis and control of near misalignment, have an effect on surgical success. In this study, we attempt to identify the appropriate timing for surgical treatment of

intermittent XT in the pediatric population by examining these preoperative parameters that could contribute to surgical planning.

Materials and Methods

A retrospective chart review was conducted evaluating all surgical patients with a diagnosis of intermittent XT seen at the Children's Hospital of Michigan Ophthalmology Clinic between 2005 and 2015. Inclusion criteria consisted of patients between the ages of 3 and 17 years and those who underwent bilateral lateral rectus recession with recorded visual acuity, stereopsis, magnitude of deviation and control. Younger patients and those who were unable to cooperate with these measurements were excluded. Patients with prior ocular surgery and a history of surgical procedures other than bilateral lateral rectus recession were also excluded.

Alignment measurements were measured with alternate prism cover testing. When a deviation was measured initially with spontaneous prism cover testing, and then building with subsequent alternate cover testing, the greatest deviation was measured, signifying the combined tropia and phoria present at each distance and near. Stereopsis was measured using the Titmus test (Chicago, IL 1988) in all patients.

Given clinic protocol, all recorded information for visual acuity, alignment, control and stereopsis was done by an attending physician, certified orthoptist, or Ophthalmology resident. Control is recorded by the orthoptist and/or physician and was classified as poor, fair or good. While control is a subjective measurement, this clinic utilizes and teaches relatively standard guidelines to guide judgement of control. Good control is defined as less than 5 seconds to recovery from dissociation. Fair control is defined as 5-10 seconds or blinking to recover from dissociation. Poor control is defined as more than 10 seconds to recover from dissociation or failure to recover with blink. If more than one opinion on control or magnitude of deviation at distance or near was documented in the chart, the attending physician followed by orthoptist opinion was recorded.

Preoperative measurements

Demographic information such as age, gender and past medical history was obtained from all patients. Visual acuity at near and distance, stereopsis at near, magnitude of deviation and control at near and distance, presence of inferior oblique overaction, presence of A or V pattern and presence of amblyopia were recorded at initial presentation. Preoperative visual acuity at near and distance, stereopsis at near, magnitude of deviation and control at near and distance, as well as time from presentation to surgery were also recorded.

Postoperative measurement

Postoperative data regarding visual acuity at near and distance, stereopsis at near, magnitude of deviation and control at near and distance was collected. This data was collected for the first postoperative visit at week one, second postoperative visit at one-two months and for the last visit noted in the chart.

Seven surgeons, all of whom specialize in Pediatric Ophthalmology, performed all surgeries. Surgery was considered to have a successful outcome if the postoperative deviation at distance and near was only phoria or a manifest intermittent tropia of less than 10 prism diopters on the last postoperative visit. If the patient had an intermittent tropia, it was considered successful only if control of the deviation was good.

We obtained approval to conduct this study from Wayne State University School of Medicine and the Detroit Medical Center Institutional Review Boards.

Statistical Analysis

Medical records were reviewed and analyzed to determine if preoperative control of near misalignment, stereopsis and/or presence of amblyopia affect surgical outcome.

Preoperative control was divided into good versus poor, which included both fair and poor control. To standardize this measurement, 140 seconds of arc was use as the threshold between good versus poor stereopsis in all patients [7-9]. A successful outcome was determined by postoperative alignment within 10 prism diopters (PD) of orthophoria at distance and near, as well as good control of deviation of manifest deviation was observed.

Statistical analysis was conducted using Fisher's exact test and a p-value of 0.05 was deemed significant.

Results

Of 340 charts identified and reviewed, 95 patients met inclusion and exclusion criteria. Mean age of patients was 6.71 ± 3.66 (range 3 to 17) years. There were 47 females (49.5%) and 48 males (50.5%) included in the study. A summary of this demographic information, also including past medical history, is described in Table 1.

Mean age	6.7 ± 3.7 years
Sex	
Female	49.50%
Male	50.50%
Past medical history	
Attention deficit hyperactivity disorder	5.30%
Acute lymphocytic leukemia	2.10%
Asthma	17.90%
Bipolar	1.10%
Congenital nystagmus	1.10%
Craniosynostosis	1.10%
Developmental delay	2.10%
Hypothyroidism	1.10%
Neurofibromatosis type 1	1.10%
No known medical history	64.20%
Pituitary tumor	1.10%
Retinopathy of prematurity	2.10%
Seizures	5.30%
Sickle cell disease	1.10%

Table 1: Demographics

The mean preoperative deviation was 35 ± 5.56 (range 7 to 85) PD at near and 60 ± 6.22 (range 12 to 75) PD at distance. Preoperatively 48 patients (55.8%) had good stereopsis and 34 (39.5%) had poor stereopsis. Preoperative good control of intermittent XT at near was seen in 34 patients (47.2%) and fair-poor control was seen in 38 patients (52.7%). Time to surgery was determined exclusively by surgeon preference and decision making with the family members. The average time from clinical presentation to surgery was 3 ± 0.31 (range 0.5 to 78) months.

Postoperative data was compared and analyzed using the last visit noted in the chart. The mean follow up period was 10.79 ± 17.03 (range 0.5 to 84) months. Thirty patients (31.5%) were considered to have surgical success at their final post-operative visit. In those patients determined to have a successful outcome, or well-controlled intermittent tropia within 10 PD of orthophoria, only one patient had a manifest esotropia, which was 5PD well-controlled esotropia at distance and 5PD esophoria at near. No other patients designated within the successful surgical outcome group had a manifest esotropia. Mean postoperative deviation was 20.50 ± 4.27 PD of exotropia (range 10 PD esotropic overcorrection to 32 PD exotropic undercorrection) at near and 13 ± 1.94 PD of exotropia (range 14 PD esotropic overcorrection to 30 PD exotropic undercorrection) at distance. Fifty patients (72.5%) had good postoperative stereopsis, while 19 patients (27.6%) had poor postoperative stereopsis. Postoperative control of intermittent XT was good in 54 patients (85.7%) and poor in 9 patients (14.3%) (Table 2). Of the patients who had poor surgical outcome as defined as greater than 10 prism diopters of a manifest strabismus, 25 patients (38.5%) had good control of this misalignment at both distance and near postoperatively. Data missing from both of these measurements is due to loss of follow up after surgery in two patients and the remaining was not recorded during the visit. This would explain the lower number of patients in some of the postoperative results given that several data points were not recorded during postoperative visit.

	Preoperative fusion parameters	Postoperative successful patients*	P value**
Control			
Good	47.20%	85.70%	
Poor	52.70%	14.30%	0.2284
Stereopsis			
Good	55.80%	72.50%	
Poor	39.50%	27.60%	0.2537
Note: *At final visit, 31.5% of patient has surgical success defined as well-controlled mis **Association of preoperative stereopsis and control with surgical success			

Table 2: The effect of preoperative near control and stereopsis on postoperative success in the treatment of intermittent exotropia

After data analysis, neither preoperative stereopsis (p=0.2284) nor near control of exotropia (p=0.2537) were associated with a greater likelihood of surgical success in patients with intermittent XT treated with bilateral lateral rectus recessions. Also, we found no correlation between successful surgery and patient with both good control and good stereopsis preoperatively (p=0.2151).

Furthermore, the presence of preoperative amblyopia, which was present in 13 patients, had no association with surgical outcomes (p=1.00) in this population. It is a policy of this practice to treat patients with amblyopia prior to surgery. Any patients with amblyopia were either persistent vision loss despite occlusive therapy (treatment failures) or presented at an age beyond amblyopia treatment (over age of 8 years).

Discussion

The question of when to surgically intervene in patients with intermittent XT has remained unanswered and controversial for many years. The criteria each surgeon uses for management varies significantly and there is no standardized method that guides us on how to proceed. Some surgeons feel that earlier intervention while near fusion is intact will lead to better surgical outcomes, as it will more likely drive fusion and control postoperatively; whereas others prefer to wait for near fusion and control to worsen in order for the risk benefit ratio to shift, particularly given the higher amblyogenic risks observed with overcorrection and post-operative esotropia [10].

Our study focused on those parameters we are able to record during patient examination preoperatiely, to guide us as to when to surgically intervene on patients with intermittent exotropia. Loss of control has been one of the main parameters used by surgeons to identify those patients who need surgical management. Many studies focus on control based on the premise that once control has been lost, a patient's fusional ability has been compromised. One of the main concerns in using loss of control for this decision is that it can be a subjective measurement based on the examiner's perspective. Also, intermittent XT's natural history has been proven to be extremely complex and variable especially with its tendency to vary amongst patient encounter [2]. Also, control or deviation in office may differ from observations by family members in the home environment.

O'Neal et al. have identified distance stereoacuity as a measurement for loss of control of intermittent XT [11]. Stathacopoulus et al. also reported poor distance stereoacuity and control grade were a sign of progression in patients with intermittent XT [9]. In these studies, the objective measurement of distance stereoacuity was helpful in determining deterioration of the intermittent XT. Sharma et al. studied the use of both distance and near stereoacuity as parameters for surgical intervention and they concluded that operating before stereoacuity worsens improves surgical outcome [12]. Although the previously mentioned studies describe a correlation among loss of stereopsis, poor control and worsening of intermittent XT, Roseanbaum et al. did not encounter a difference in near stereopsis when comparing normal control to intermittent XT [13]. This could be because near stereopsis is usually one of the last parameters to deteriorate in intermittent XT.

Given previous studies and our clinical experience regarding intermittent XT we hypothesized that control and stereopsis, as measurements of near fusion, would be helpful parameters to guide the need for surgical treatment for this type of strabismus. We, however, identified no statistically significant relationship between control of near misalignment and near stereoacuity with an improved surgical outcome for intermittent XT patients. A trend, however, was noted in which patients with better preoperative stereopsis and control of near misalignment had better surgical success. Perhaps a larger study could help determine if this trend could become significant enough to establish guidelines for surgical planning [14-16].

One limitation with our study is the inclusion of patients from multiple surgeons. Although most practice similar techniques, surgical decision-making and outcomes usually will vary from surgeon to surgeon. Additionally, control is a subjective measurement and documentation may vary by clinician. As a retrospective review inclusive of multiple surgeons, the evaluation of control, in particular, was more difficult, as this could not be scaled or standardized, and was subjective. Another limitation to our study is the rigorous guideline we chose for success. We purposely selected conservative parameters to measure success. However, our definition of success might have limited our study giving us a lower success rate. Some of those patients categorized as failed surgeries may be considered successful by other surgeons. For example, an intermittent XT of 12 PD at distance with good control and exophoria at near would be deemed unsuccessful by our parameters but may be viewed as a successful outcome clinically. Finally, the retrospective nature of our study limits our findings, as documentation of certain clinical parameters was often incomplete [17-20].

Based on the above mentioned studies as well as our own results, the parameters presently used to determine the need for surgical intervention in intermittent XT remain controversial. Although trends can be established and some results do agree with our hypothesis regarding the role of preoperative fusion, these conclusions stem from retrospective studies. This reiterates the need for a prospective randomized controlled study to investigate the use of stereoacuity and control in worsening intermittent XT and surgical outcomes.

Conclusion

This study evaluated the impact of fusional parameters (worsening stereopsis and/or alignment control) on surgical treatment of intermittent exotropia (XT), and found that these parameters do not predict improved outcomes in patients with intermittent XT.

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