The relationship of age at surgical alignment and the development of stereopsis in infantile esotropia

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Objective: To determine the power of the stereopsis and the relationship between the development of stereopsis and age at surgical alignment in patients with infantile esotropia.
Methods: A cross sectional study on 110 children with infantile esotropia who underwent a single operation from 1/1/2011 to 1/1/2014 and had alignment within 10 PD of orthotropia at all follow-up examinations. Stereopsis was assessed by the Original Randot Stereotest.
Results: The mean age at surgery was 36.79 ± 16.05 months (range, 16–72 months). The percenrtage of patients having stereopsis was 30.9% (34 patients). 26 patients operated at 16-24 months (68.42%) and 8 patients operated at 24-48 months (20.51%) had stereopsis. No patient operated after 39 months had stereopsis. There was a statistically significant correlation between age at surgery and final stereopsis (rS = 0,649; p<0.001). Receiver operating characteristic curve analysis revealed that the optimum cut-off value of the age at surgery for predicting stereopsis was 21.5 months (Youden index = 0.378; area under ROC curve = 0.827; 95% CI: 0.74-0.92; p<0.001).
Conclusion: Age at surgery plays an important role in the development of stereopsis. Surgery for infantile esotropia is most likely to result in measureable stereopsis if patient age at alignment is not more than 21.5 months.
Conflicts of interest: The authors report no conflicts of interest.
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Introduction

Strabismus is a syndrome defined by the difference between the visual axis of one eye to another, which affects the movements and functions of the eyes. One form of strabismus that can directly and seriously affect the visual function of children if not treated soon is infantile esotropia. This form of strabismus makes up 0.25% of infants and usually accompanies with abnormal binocular visual function of their eyes.[5] In 1939, Chavasse brought up a theory that the cause of unusual binocular vision of children with esotropia an onset of esotropia before the age of 6 months, known as infantile esotropia, was due to the presence of esotropia during the children's binocular vision developing period. This theory guided the clinicals to the decision to perform the alignment surgery early, hoping to recover the binocular vision of patients. However, the optimum age for corrective surgery in children with infantile esotropia remains controversial. The purpose of this study is to determine the correlation between the development of binocular vision and the age of align-

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ment surgery to determine the optimal age of surgical intervention in children with infantile esotropia.

Methods

Subjects : The patients undergoing a single surgery for infantile esotropia were followed up at Ho Chi Minh Eye Hospital from 1/1/2011 to 1/1/2014.

Methods : Inclusion criteria for this study were as follows: (1) Infantile esotropia patients who had surgery from 1/1/2011 to 1/1/2014, (2) Final alignment within 10 PD of orthotropia, (3) Visual acuity between two eyes differ ≤ 2 lines, (4) Best corrected visual acuity ≥ 3/10.

Children with conditions such as preoperative amblyopia, manifest or latent nystagmus, anisometropia >1.5 D, limitations in abduction consistent with Duane syndrome or abducens nerve palsy, and patients with neurologic defects,

meningitis, or other major medical conditions were excluded.

Initial measurements were performed with a prism-and-cover test if possible or by means of the Krimsky method. All patients with histories of constant-angle esotropia before 6 months or a diagnosis of infantile esotropia by an ophthalmologist before 8 months of age were accepted as having infantile esotropia, following the inclusion criteria described in a study by Birch and colleagues. All patients had only one bilateral medial rectus recession procedure; inferior oblique tenotomy performed during the same operation for inferior oblique overaction was recorded and investigated for the association with the later stereopsis. Patients identified by record review were recalled and examined for stereopsis which was assessed using the Randot test.

Results were analyzed using SPSS version 20 (SPSS Inc, Chicago, IL). All statistical tests were 2-sided; the threshold of significance was $p \leq 0.05$. The Mann-Whitney test was used to compare between two groups, and a statistical evaluation of the correlation was performed using the Spearman test because of the ordinal scale of the stereopsis power in the Randot test. The ROC curve analysis was performed to determine whether results would have changed had success been defined as alignment to within 10 PD of orthotropia.

Results

1.The particular traits of the samples

Within the duration of this study from December 2016 to June 2017 at our Strabismus Clinic in Ho Chi Minh City Eye Hospital, we have chosen 110 children within the inclusion criteria, all of which have consent from their parents to participate in the study.

Ages at surgery

Table 1: Age of the patients in this study

Characteristic (months of age) Age at surgery	N	Percentage (%)
16 – 24 months	38	34.55
24 – 48 months	39	35.45
48 – 72 months	33	30
Average ± standard deviation	36.79 ± 16.05	
Youngest – eldest	16-72	

The children's ages at surgery in this study were categorized into 3 groups (table 1). The numbers of the children in each group were similar across all groups.

Characteristics of participants

Table 2: Characteristics of participants

Post operative characteristics Angle of esotropia (PD)	N	Percentage (%)
0 PD	67	60.9
8 PD	31	28.2
10 PD	12	10.9
Spherical equivalent (D)	1.58 ± 0.91 (0 ± 5.75)	

Figure 1: Describes stereopsis rate in groups of children experiencing esotropia with different surgical ages.

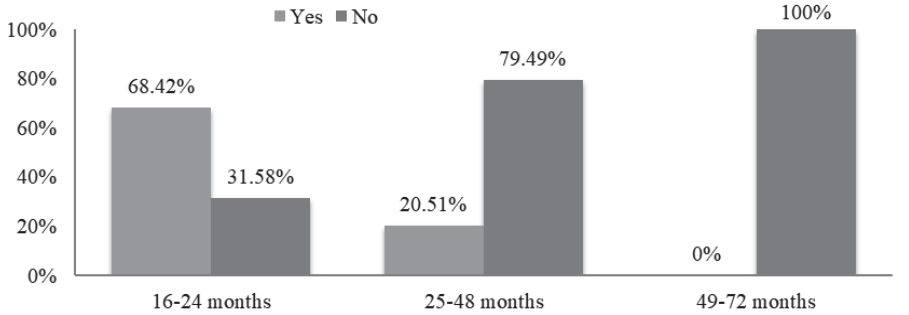

Figure 1: Stereopsis rate in different surgical age groups

In the group with age at surgery between 16 and 24 months, 26 children (68.42%) developed visual stereopsis. Meanwhile, only 8 children (20.51%) between 24-48 months old had stereopsis. All the children who had alignment surgery after 39 months did not demonstrate stereopsis. The average stereopsis of the research group was 841.82 ± 249.91 arcsec (200-1000 arcsec). Most patients demonstrated stereopsis of 600 arcsec (19 children with the ratio of 55.88%).

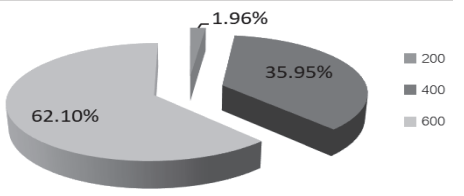

Figure 2. Stereopsis rate of the sample

2. The correlation between binocular vision and age at surgery

In the group with age at surgery between 48-75 months (n=33), all patients did not have stereopsis, so we only chose children with the age at surgery less than 48 months (n=77) to investigate the correlation between binocular vision and the surgery age.

Figure 3 demonstrated the correlation between the stereopsis rate and the age at surgery of the children with onset of esotropia

Binocular vision

Children who developed stereopsis consisted of only 1/3 of the study sample (34 children, equivalent to 30.9%).

before age 6 months. Patients that do not develop the defined visual stereopsis with stereoacuity of 1000 arcsec. Stereoacuity of the patients in the study group had a statistically significant correlation with the age at surgery (Spearman correlative index rs = 0.649; p<0.001).

In order to find the age at surgery to help anticipate the development of stereopsis, we analyzed the ROC receiver operating curve.

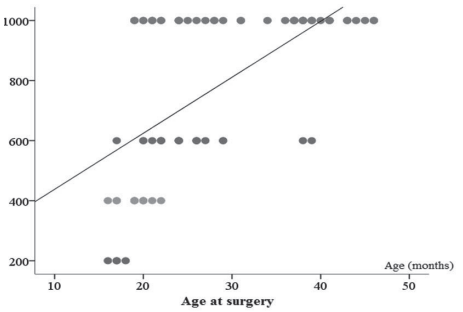

Figure 3: Scatter diagram of the stereopsis by the age at surgery

The analysis result of the ROC (receiver operating curve) showed that the age at surgery can predict the existence of the stereopsis (area under ROC was 0.827; 95% CI: 0.74-0.92; p<0.001). The cut-off value for predicting stereopsis was 21.5 months old (Youden index = 0.378; sensitivity = 83.7%; specificity = 52.9%).

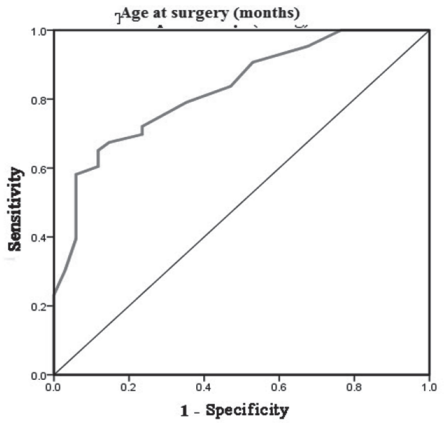

Figure 4: ROC curve between age at surgery and stereopsis

Discussions

1. Particular characteristics of the sample : age at surgery

The average age at surgery as well as the proportion of children with infantile esotropia having alignment surgery after the age of 24 months in our research was higher than those of Simonsz (2005) and Cerman (2014).[3,6] This difference suggests that with time, the progress of surgical techniques and anesthesia, the children's age of alignment surgery has gradually reduced to improve the rate of binocular vision development.

However, because the children with infantile esotropia came to the clinic with an underweight condition, and due to their parents' lack of ability to take care of the children after the anesthesia surgery, the smallest age at surgery at our Strabismus Clinic was 20 months old.

Binocular Vision

Of the 110 children enrolled in this study, 34 developed stereopsis, equivalent to 30.9%. Compared to the research of Birch (2000), Ing (2002) and Cerman (2014), the proportion of stereopsis in our research is lower than that of other authors' research.[1,3,4] In particular, Birch also investigated the development of stereopsis using the Randot test, however, the author only studied children with surgery ages of ≤ 24 months. The rather high proportions of stereopsis in Ing's and Cerman's research might be due to the presence of partial stereopsis when assessing stereopsis with Titmus test and TNO test.

The proportion of < 200 arcsec stereopsis in the research was 6.9%. This number is relatively low, comparing to the result of Birch's research (2006, 20%).[2] This difference was perhaps because Birch did research on children aligned before 6 months old.

2. The correlation between binocular vision and the age at surgery

There was a statistically significant corre-

lation between the quality of stereo acuity and the age at surgery (Spearman correlative index r_s= 0,649; p<0.001). Birch's research in 2000 also concluded that the patients' age at the time of alignment was statistically correlative with the stereo acuity (Spearman correlative index r_s= 0,41; p<0.001).[1] Hence, children with infant esotropia need aligning earlier in order to gain highest quality of stereopsis. Achieving this goal requires cooperation between ophthalmologists and the centers of health communication and education in propagating and advising parents about the children having infantile esotropia, the harms brought by the strabismus condition and the benefits of early surgery to the development of visual function of the children.

The result of ROC curve analysis showed that the age at surgery could predict the development of binocular vision (area under the ROC curve is 0.827; 95% CI: 0.74-0.92; p<0.001) The cut-off value of the age at surgery to predict the presence of stereopsis is 21.5 months old (Youden index = 0.378; sensitivity = 83.7%; specificity = 52.9%). Hence, surgery at the age before 21.5 months may help children with infantile esotropia achieve the best stereopsis. Cerman and partners (2014) also concluded that ROC curve is valuable in predicting the age at surgery that can increase the proportion of children with infantile esotropia achieving stereopsis (area below the curve was 0.784; 95% CI: 0.62 – 0.90; p<0.001). The cut-off value of the age at surgery in Cerman's research was 16 months old (Youden index = 0.474; sensitivity = 63.2%; specificity = 84.2%). The difference between this two research was due to the fact that the children in Cerman's research had smaller age at surgery comparing to those in ours; while the former study's youngest age at surgery was 7 months, the latter was 16 months.

Conclusion

Age at surgery plays an important role in the development of binocular vision of children with infantile esotropia. The proportion of stereopsis highly increases when the children have undergo surgical correction before the age of 21.5 months.

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