HUMAN BIOLOGY
2024, VOL. 94, ISSUE 4
ORIGINAL ARTICLE

OPEN ACCESS

Characteristics of Esotropia in Japanese Adults: A Retrospective Evaluation of 105 Patients Who Underwent Esotropia Surgery at Inoue Memorial Hospital

Akiko Yokoyama[1,2], Takehito Iwase[1,2], Kana Watanabe[1], Yuri Kurosawa[1]*

ABSTRACT

Background: This study evaluated etiological factors, changes in alignment angle post-surgery, and binocular vision function improvement in Japanese adults with esotropia.

Methods: This retrospective study included 105 patients with esotropia who underwent surgery at our hospital. We reviewed the medical records to determine the causes of esotropia, patient motivation for surgery, changes in alignment angle post-surgery, improvement in binocular vision function, and correlation between the operated muscle length and corrected eye alignment angle. The alternate prism cover test was performed to assess the angle of misalignment. Binocular vision function was determined using the Titmus Stereo Test, major amblyoscope, Bagolini striated lenses test, and an afterimage test. One-to-four muscle surgery, involving medial rectus muscle recession or lateral rectus muscle resection, was performed.

Results: The etiologies included acquired progressive esotropia with myopia (n=51); congenital esotropia (n=6); partial accommodative esotropia (n=5); cerebral infarction or cerebral breeding (n=5); sagging eye syndrome (SES) (n=5); brain tumors (n=3); sensory esotropia (n=2); consecutive esotropia after exotropia surgery (n=2); face trauma (n=1); Duane syndrome (n=1); and unknown origin (n=24). Eye alignment improved in all patients. However, four patients needed a second operation. Binocular vision function improved in patients with acquired progressive esotropia with myopia; partial accommodative esotropia; cerebral infarction or cerebral breeding; SES; and brain tumors. Binocular vision function was unchanged in patients with sensory and congenital esotropia.

Conclusions: Esotropia surgery in adults can lead to improved eye alignment and binocular vision function. However, the patients with sensory esotropia and congenital esotropia were unable to acquire binocular vision function.

INTRODUCTION

Recent attention has focused on the surprising occurrence of esotropia in older adults without associated neurological abnormalities Godts et al. (2013). Sagging eye syndrome (SES) manifests blepharoptosis, superior sulcus defect, and elongation of the lateral rectus muscle-superior rectus muscle band Chaudhuri et al. (2013). A report evaluating 236 Japanese patients with binocular diplopia aged 60 years or older found that 24.2%, 25.0%, 30.1%, and 20.8% had exotropia, esotropia, vertical strabismus, and combined strabismus, respectively. In the esotropia group, 35.6% had orbital pulley disorder (further classified as SES [85.7%] and highly myopic strabismus [14.3%]), whereas 33.9% had sixth cranial nerve palsy Kawai et al. (2018).

Esotropia with diplopia in young adults often involves a significant proportion of esotropia accompanied by myopia Zheng et al. (2018).

Many patients with strabismus visit our hospital with two primary reasons for opting for surgery. The first is diplopia, which makes them unable to drive, work, or even walk. The second is improving their appearance because strabismus has subjected them to various disadvantages. We have performed many esotropia surgeries. Therefore, we aimed to elucidate the tendency of esotropia in Japanese adults by reviewing medical records.

[1]Inoue Memorial Hospital Ophthalmology department, Shindencho 1-16, Chuoku, Chibashi, Chibaken, Japan. [2]Chiba University School of Medicine, Inohana 1-8-1, Chuoku, Chibashi, Chibaken, Japan.

Correspondence to: Akiko Yokoyama, Inoue Memorial Hospital Ophthalmology department, Shindencho 1-16, Chuoku, Chibashi, Chibaken, Japan. Email: m-yoko@ra2.so-net.ne.jp.

Keywords: esotropia surgery; acquired progressive esotropia with myopia; sagging eye syndrome; congenital esotropia; partial accommodative esotropia; binocular vision function; eye alignment.

MATERIALS AND METHODS

This study included 105 patients with esotropia who underwent esotropia surgery at Inoue Memorial Hospital from October 20, 2004, to April 21, 2023 were included. Alignment angles were assessed two or three times before surgery, 1 week after surgery and at least 1, 3, or 6 months after surgery. The patient with the longest follow-up had 15 years of follow up (Table 1). Patients who had vertical heterotropia or cyclotropia and needed oblique muscle, superior rectus muscle, or inferior rectus muscle surgery simultaneously with medial rectus "muscle recession" or lateral rectus muscle resection were excluded. Four patients with sensory esotropia were also excluded because looking at something with their weaker eye demonstrated esotropia and weaker eyes do not have central fixation. Therefore, we did not plan to induce orthophoria, as proven using the alternate prism cover test.

One-to-four muscle surgeries (medial rectus muscle recession or lateral rectus muscle resection) were performed. We excluded patients that needed vertical muscle surgery, such as inferior oblique and superior rectus muscle recession.

Binocular vision function was also tested before and after surgery using the Titmus Stereo Test (TST) for near binocular vision function and the major amblyoscope for far binocular vision function. When a patient did not have gross stereopsis (could not hold the wings of the horsefly above the TST plate, threshold 3000 seconds of arc), the Bagolini striated lenses test was used. If a patient answered only one line of the Bagolini, we performed the afterimage test for weaker binocular vision function. For assessing binocular vision function, we categorized smaller stereoscopic parallax as high function, bigger stereoscopic parallax as middle function, simultaneous view center cross of Bagolini as lower function, simultaneous view center cross of the afterimage test as the second lowest, and only one line of the afterimage test or two lines abnormally crossed as the lowest function. In graph creation, we assigned the number 16 for binocular parallax stereopsis of 40 seconds. Subsequently, we assigned the numbers 15, 14, 13, 12, 11, 10, 9, and 8 for 50, 60, 80, 100, 140, 200, and 400 seconds, respectively. We assigned the number 7 to recognize Fly protrusion, number 6 for the simultaneous view center cross of Bagolini, number 4 for the simultaneous view center cross of the afterimage test, and number 2 for only one line of the afterimage test or two lines abnormally crossed.

Patients with myopia greater than -5D (spherical equivalents) or axial lengths of more than 26 mm were classified as having acquired progressive esotropia with myopia.

We classified the patients as having SES when the pulley between the superior and lateral rectus muscles was extended or ruptured in the axial section of the magnetic resonance imaging, accompanied by ptosis in both eyes. The patients were classified as having partial accommodative esotropia when they had been treated with hyperopia-prism glasses or their hyperopia was greater than +3D. The patients with esotropia and hyperopia were treated with hyperopia glasses for more than 6 months and underwent surgery for residual esotropia.

The total amount of muscle recession or resection during surgery was based on a previous report Yokoyama et al. (2018). We retrospectively checked the clinical records for etiology data, changes in eye alignment angle caused by surgery, improvement in binocular vision function, and correlation between the operated muscle length and the amount of corrected eye alignment angle.

RESULTS

The patient ages ranged from 14 to 77 (average, 40.0) years. The preoperational deviation angle during near gaze ranged between 4 prism diopter base out (⊿BO) and 125 ⊿BO (average, 36.7 ⊿BO). Furthermore, during far gaze, it ranged between 6 ⊿BO and 160 ⊿BO (average, 37.8 ⊿BO). The patients underwent surgery for double vision (76.2%), appearance (26.7%), or both (2.9%). Classifying the disease type, we identified 51 cases of acquired progressive esotropia with myopia (average age 37.1 years, average preoperational angle gaze: near 36.9 ⊿BO far 38.6 ⊿BO, average preoperational binocular vision function of 400 seconds using TST). The double vision in 49 patients disappeared after surgery. However, one patient needed a second medial rectus muscle recession due to recurrent double vision 3.5 years after the first surgery. Another patient needed prism correction owing to recurrent double vision 2 years after the first surgery. Six patients with congenital esotropia were identified (average age 33 years, average preoperational angle gaze: near 66.7 ⊿BO, far 58.8 ⊿BO; all patients had the rack of retinal correspondence). Notably, one patient had undergone bilateral medial rectus muscle recession as an infant; however, esotropia remained after surgery. Five partial accommodative esotropia cases were identified (average age 23.4 years; average preoperational angle gaze: near 35.2 ⊿BO, far 27.2 ⊿BO; average preoperational binocular vision function of 110 seconds using TST). Five patients with cerebral infarction or cerebral breeding were identified (average age 53.6 years; average preoperational angle gaze: near 31.8 ⊿BO, far 39.2 ⊿BO; average preoperational binocular vision of 1000 seconds using TST).

Table1: Number of patients that were followed up

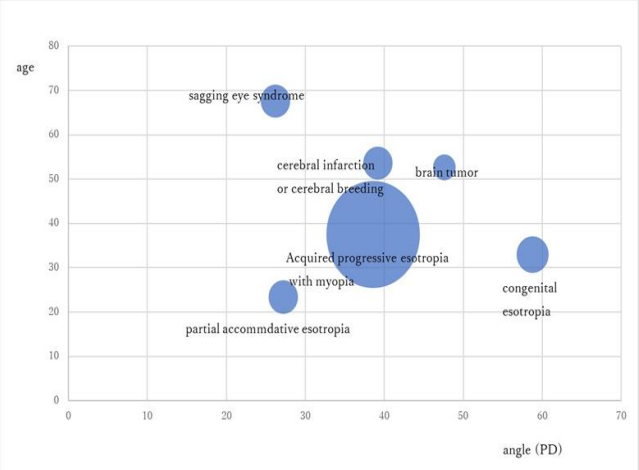
	Preoperation to 6 months	1 year	1.5 year	2 years	3 years	4 years	5 years	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	15 years
Acquired Progressive Esotropia with Myopia	51	29	21	18	15	8	5	4	4	2	2	2	2	2	2	1	1
Congenital Esotropia	6	3	2	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Partial Accommodative Esotropia	5	3	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0
Cerebral Infarction or Cerebral Breeding	5	3	3	3	1	1	1	1	1	1	1	1	1	1	1	0	0
Sagging Eye Syndrome	5	5	3	3	3	2	2	1	1	0	0	0	0	0	0	0	0
Tumor	3	3	3	3	3	2	2	1	1	1	1	1	1	1	1	0	0
Others	30	11	8	7	4	3	1	0	0	0	0	0	0	0	0	0	0
All	105	57	43	38	28	16	11	7	7	4	4	4	4	4	4	1	1

Five patients with SES were identified (average age 67.6 years; average preoperational angle gaze: near 16.2 ⊿BO, far 26.2 ⊿BO; average preoperational binocular visual function of 80 seconds using TST). Three patients with brain tumor (two with a pituitary tumor and one with an auditory nerve tumor) were identified (average age 52.7 years; average preoperational angle gaze: near 47.3 ⊿BO, far 47.7 ⊿BO). Regarding preoperational binocular vision function, one patient lacked retinal correspondence, one exhibited normal retinal correspondence after image testing, and one could perceive Fly protrusion during TST. One patient with a pituitary tumor maintained good eye alignment for 13 years, although developed esotropia again and required a second surgery.

Two patients had sensory esotropia caused by anisometropic amblyopia (average age 17 years; average preoperational angle gaze: near 52.5 ⊿BO, far 40.0 ⊿BO); both had normal retinal correspondence before surgery and this did not change after surgery. Two patients had consecutive esotropia after exotropia surgery (average age 20 years; average preoperational angle gaze: near 47.5 ⊿BO, far 55 ⊿BO); one of them had normal retinal correspondence before surgery and near stereopsis after surgery, whereas the other had abnormal retinal correspondence before surgery and normal retinal correspondence after surgery. One patient had face trauma (age 58 years, preoperational angle gaze: near 14 ⊿BO, far 20 ⊿BO; preoperational binocular vision function of 50 seconds using TST). One patient, aged 15 years, had Duane syndrome (preoperational angle gaze: near 50 ⊿BO, far 65 ⊿BO); the patient had abnormal retinal correspondence before surgery, which did not change after surgery. Twenty-four patients had unknown origin. (Figure 1) presents the characteristics of each type of esotropia.

We performed 23 one-eye medial rectus muscle recessions; 8 one-eye lateral rectus muscle resections; 52 one-eye medial rectus muscle recessions and lateral rectus muscle resections; 8 medial rectus muscle recessions in both eyes; 15 one-eye medial rectus muscle recessions and lateral rectus muscle resections and in the other eye medial rectus muscle recessions; and one medial rectus muscle recession and lateral rectus muscle resection in both eyes. Acquired progressive esotropia with myopia is called crowded eye syndrome, and the length between the posterior globe and the common tendon ring is short Iwasa et al. (2020). Consequently, we prioritized binocular medial rectus muscle recession to widen the space behind the eyeball.

Figure 1: Characteristics of patients with each etiology.

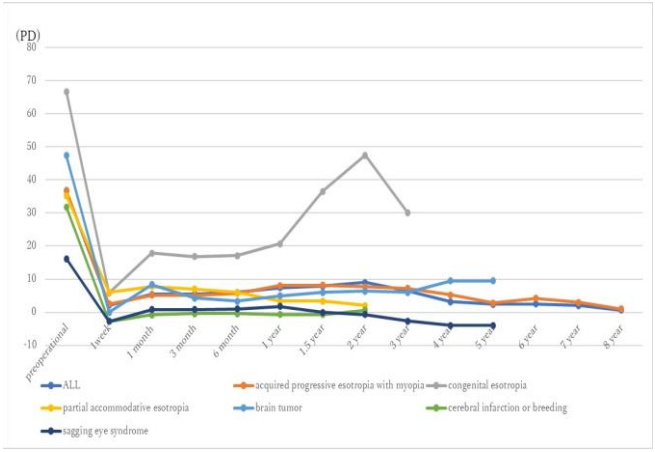


Babble size is the number of patients. The horizontal axis is the average esotropia angle, and the vertical axis is the average age.

The overall course of eye position before and after surgery was highly adequate (Figure 2). Four patients needed esotropia surgery again. The etiologies were pituitary tumor, unknown origin adult-onset, unknown origin child-onset, and acquired progressive esotropia with myopia. We included the eye position course before the second surgery. Figure 2 shows that most of the postoperative course of esotropia surgery for adults was favorable. Particularly, the course of acquired progressive esotropia with myopia, partial accommodative esotropia, and SES was highly favorable. The eye position course for the patient with congenital esotropia was likely to be esotropia again.

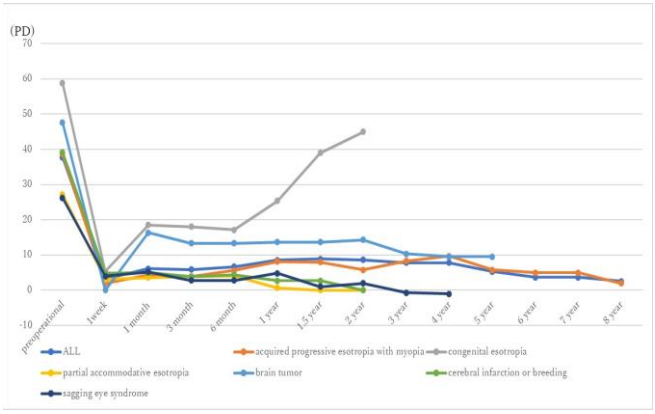
Figure 2: Eye position course for each type of esotropia tested by APCT.

Figure 2A



(a) Eye position course for each type of esotropia tested using the APCT. The fixation point is 30 cm from the patient's nose.

Figure 2B



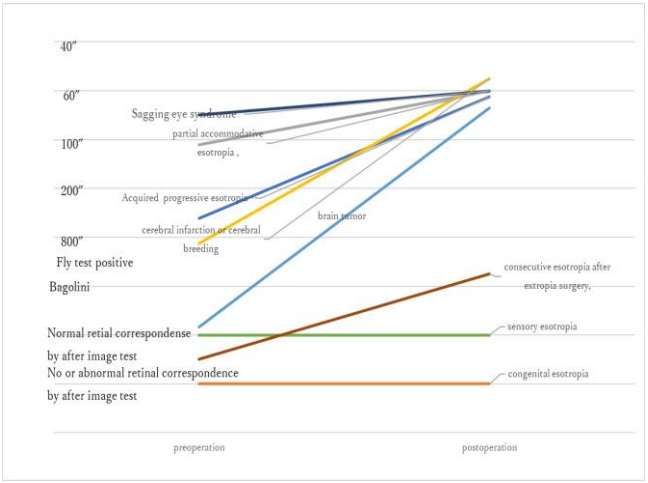
(b) Eye position course for each type of esotropia tested using the APCT. The fixation point is 5 m from the patient's nose.

The preoperational strabismus angle is the average of two or three APCTs.

We tested for at least 1 week, 1 month, 3 months, or 6 months. Many patients were followed up for longer.

We assessed the change in binocular vision function for each cause of esotropia (Figure 3). The patients with acquired progressive esotropia with myopia, partial accommodative esotropia, and SES exhibited weak stereopsis before surgery and achieved strong stereopsis after surgery. The patients with congenital esotropia and sensory esotropia had no stereopsis before or after surgery.

Figure 3: Binocular vision function for each type of esotropia pre- and post-operatively.

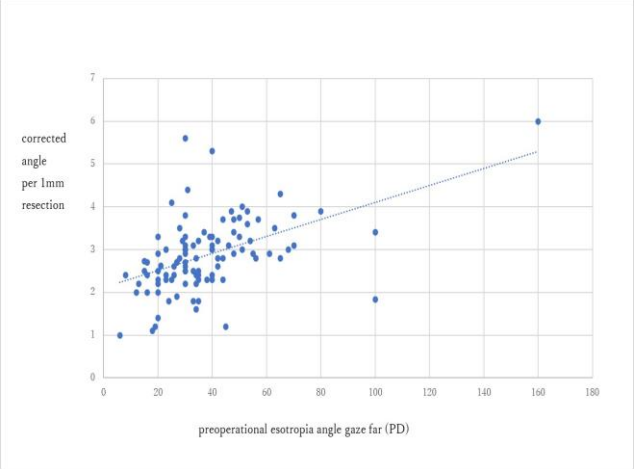


In graph creation, we assigned the number 16 to stereopsis of binocular parallax for 40 seconds. The numbers 15, 14, 13, 12, 11, 10, 9, and 8 were assigned to 50, 60, 80, 100, 140, 200, 400, and 800 seconds, respectively. Number 7 was assigned to recognize Fly protrusion. Number 6 was assigned to the simultaneous view center cross of Bagolini. Number 4 was assigned to the simultaneous view center cross of the afterimage test. Number 2 was assigned to only one line of the afterimage test or two lines abnormally crossed.

We performed major amblyoscopes before and after surgery in 51 patients. Among those, 19 patients did not have gross stereopsis as tested using TST horsefly (stereoscopic parallax of 3000 seconds) even after correction using prism lenses. Among these 19 patients, nine were able to perceive the depth in major amblyoscope, and after surgery, stereopsis was tested using TST. In the major amblyoscope, an image can be presented in front of the patient's fovea, making it easy to detect the remaining binocular vision function. Even without near stereopsis using TST, if a patient has depth perception with a major amblyoscope, nearby stereopsis may emerge when the eye position is corrected.

We surveyed the relationship between the corrected alignment angle per 1 mm of muscle movement and the esotropia angle before surgery (Figure 4). The corrected alignment angle (PD) per 1 mm of muscle recession or resection was calculated as follows: 0.02×esotropia angle gaze far + 2.1.

Figure 4: Relationship between the corrected alignment angle per 1 mm muscle moved and the esotropia angle before surgery.



The horizontal axis is the preoperational esotropia angle tested using the APCT fixation point 5 m from the patient's nose. The vertical axis is the corrected esotropia angle per 1 mm muscle replacement.

DISCUSSIONS

Since the COVID-19 pandemic, the development of esotropia due to the increase in the use of digital devices such as smartphones has become a hot topic Iimori et al. (2022). Of the 105 patients in this study, eight (average age, 21.9 years) self-reported that their time spent on digital devices increased and the onset of esotropia was imminent. We encouraged those patients to reduce their time spent using digital devices. After 6 months or more of follow up, we performed surgery to correct the misalignment angle.

This study evaluated large-angle esotropia necessitating surgery, with acquired progressive esotropia with myopia accounting for 48.6% of the cases. In this study, SES accounted for 4.8% of the cases; this percentage is relatively low because SES is often associated with cyclo-vertical strabismus and, in some cases, surgery on the inferior oblique muscle or superior rectus muscle, an exclusion criterion, is necessary. Many cases could not be classified regarding the disease cause due to deceased parents of the patients and unclear patient recollection.

The analysis of binocular vision function indicated patients with acquired progressive esotropia with myopia, cerebral infarction or cerebral breeding, and brain tumors initially had normal binocular vision function. Subsequently, deterioration occurred as they became unable to fuse both eyes. When misalignment is corrected by surgery, patients regain the ability to fuse, restoring their stereopsis. After an abrupt onset at approximately 3 months of age, the critical period for stereopsis development in humans consists of a rapid period of maturation until 8–18 months of age, followed by ongoing gradual improvement until at least 3 years of age Fawcett et al. (2005), Braddick et al. (1980), Fox et al. (1980), Braddick et al. (1996).

Patients with partial accommodative esotropia had an onset of strabismus after the peak of the critical period for the development of stereopsis between 2 and 4 years of age. The patients included in this study were properly treated with prism-added hyperopia glasses since they were children and had stereopsis before surgery. Among the six patients with congenital esotropia in this study, although one underwent surgery as an infant, esotropia remained. The other patients had no treatment before they visited our hospital. Early surgery (6–24 months) is recommended to achieve gloss stereopsis Simonsz et al. (2005). Hence, all our patients with congenital esotropia had a rack of retinal correspondence.

The instructions for the amount of extraocular muscle movement based on the esotropia angle are detailed in Binocular vision and ocular motility. Theory and management of strabismus Gunter et al. (1996).

However, we wanted a standard for surgery in adults with large-angle esotropia. Based on experience, when the misalignment angle is large, the amount of eye position correction per 1 mm increases.

In this study, the follow-up period depended on patient will and differed among them (Table 1), which might have caused some bias regarding the eye position course for each type of esotropia tested using APCT (Figure 2). However, according to the results of this research, for each etiology, it can be possible to describe patient statuses before surgery concerning the degree of maintenance for the improved eye position and predictions of improvement for binocular vision function in the case of surgery.

CONCLUSIONS

The patients with sensory esotropia and congenital esotropia could not acquire binocular vision function. However, most patients with other types of esotropia could improve binocular vision function. To enhance binocular vision function, the angle at which both eyes can see should be fixed, either surgically or with prism correction.

ABBREVIATIONS

⊿BO: Prism base out

APCT: alternate prism cover test

SES: Sagging eye syndrome

TST: Titmus stereo test

DECLARATIONS

Ethics approval and consent to participate

This study was approved by the 52nd Inoue Memorial Hospital Ethics Committee on November 1, 2023 and adhered to the tenets of the Declaration of Helsinki. Before surgery, all participants provided informed consent; parents or legal guardians provided consent for the four participants under the age of 16 years.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

The authors declare that they have no funding.

Authors' contributions

All authors contributed to the study conception and design. AY, TI, KW, and YK performed the esotropia operations. AY collected the data. The first draft of the manuscript was written by AY and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We thank Dr. Naoya Fujimoto, Dr. Hiroko Kuga, and Dr. Shoko Oiwa as former co-workers for operating together and discussing treatment. We thank Editage for English language editing.

REFERENCES

1.Godts D, Mathysen DG. 2013 Nov. Distance esotropia in the elderly. Br J Ophthalmol. 2013 Nov;97(11):1415-9.

2.Chaudhuri Z, Demer JL. 2013 May. Sagging eye syndrome. Connective tissue involution as a cause of horizontal and vertical strabismus in older patients. JAMA Ophthalmol. 131(5):619-25.

3.Kawai M, Goseki T, Ishikawa H, et al. 2018 Nov. Causes, background, and characteristics of binocular diplopia in the elderly. Jpn J Ophthalmol. 62(6):659-666.

4.Zheng K, Han T, Han Y, et al. 2018 Feb 20. Acquired distance esotropia associated with myopia in the young adult. BMC Ophthalmol. 18(1):51.

5.Yokoyama A, Kuga H, Fujimoto N, et al. 2018. A long-term evaluation of esotropia surgery for adults. Folia Japonica de Opthalmologica. Clin. 11:194-9.

6.Iwasa M, Wakakura M, Kohmoto H et al. 2020 Jul 16. Clinical Features of Crowded Orbital Syndrome on Magnetic Resonance Imaging. Neuroophthalmology. 45(2):87-91.

7.Iimori H, Suzuki H, Komori M, et al. 2022 Jan. Clinical findings of acute acquired comitant esotropia in young patients. Jpn J Ophthalmol. 66(1):87-93.

8.Fawcett SL, Wang YZ, Birch EE. 2005 Feb .The critical period for susceptibility of human stereopsis. Invest Ophthalmol Vis Sci. 46(2):521-5.

9.Braddick O, Atkinson J, Julesz B, et al. 1980 Nov 27. Cortical binocularity in infants. Nature. 288(5789):363-5.

10.Fox R, Aslin RN, Shea SL, et al. 1980 Jan 18. Stereopsis in human infants. Science. 207(4428):323-4.

11.Braddick O. 1996. Binocularity in infancy. Eye (Lond). 10 (Pt 2):182-8.

12.Simonsz HJ, Kolling GH, Unnebrink K. 2005 Dec. Final report of the early vs. late infantile strabismus surgery study (ELISSS), a controlled, prospective, multicenter study. Strabismus. 13(4):169-99.

13.Gunter K, von Noorden MD, Campos E. 1996.Binocular vision and ocular motility. Theory and management of strabismus. 5th ed. Bayer College of Medicine.Houston, Texas: Mosby.