• Investigation •

Sensory outcome of exotropia surgery in Thailand: a retrospective multicenter study

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Abstract

● **AIM:** To evaluate the characteristics of exotropia (XT) and motor-sensory outcomes after surgical correction and to determine the factors associated with sensory outcomes of XT surgery.

● **METHODS:** The medical records of all patients that were diagnosed with XT and underwent strabismus surgery in 13 major government hospitals in Thailand; from January 2012 to December 2019, were retrospectively reviewed. Univariable and multivariable logistic regression were performed to identify factors related to binocular vision.

● **RESULTS:** Data of five hundred and thirty-seven patients were analyzed. Two hundred and twenty-six patients were men (42.1%). The median age of onset was 3 years old [Interquartile range (IQR): 1, 8]. The median age at diagnosis was 9.21 years old (IQR; 4.64, 21.06). intermittent exotropia [X(T)] was the most common type (52.1%); 19.5% of the patients had amblyopia. For refractive error, spherical equivalent refraction on right eye (RE) and left eye (LE) were -0.53±2.45 diopters (D) (range -14.88 to +10 D) and -0.48±2.37 D (range -19.50 to +7.75 D), respectively. The mean angle of deviation at distance and near before surgery were 42.06±14.91 prism diopters (PD) and 40.81±16.09 PD, respectively. Follow-up time after first operation was 2.48±2.27y. Four hundred sixty-two patients (86%) needed only one operation and 299 (55.6%) patients had bilateral lateral rectus recession. At final visit, the mean angles of deviation at distance and near decreased to 5.76±8.96 PD and 5.01±8.73 PD, respectively. After surgery, two hundred seventy-three patients (50.8%) were evaluated for binocular function, but the others did not have result. From multivariable logistic regression in 273 patients, the factors related to better binocular function were type of XT which was X(T) [adjusted odds ratio (aOR) 10.35; 95%CI: 4.73, 22.66] compared to constant XT, without amblyopia (aOR 3.97; 95%CI: 1.84, 8.53), underwent only single operation compared with more than 1 operation (aOR 3.80, 95%CI: 1.58, 9.16), the angle of deviation at near in last visit less than 10 PD better than 10–30 PD with aOR 0.42 (95%CI: 0.18, 0.96) and type of refraction revealed isometropia better than anisometropia with aOR 4.13 (95%CI: 1.19, 14.32).

● **CONCLUSION:** The surgical outcomes of XT within one operation in Thailand is 86%. The factors related to achieve binocular function includes type of XT as X(T), without amblyopia, angle of deviation at final visit less than 10 PD, isometropia type of refraction and underwent only one surgical correction.

● **KEYWORDS:** exotropia; intermittent exotropia; sensory outcome

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INTRODUCTION

Strabismus is a common eye problem during childhood, with an estimated global pooled prevalence of 1.93% [95% confidence interval (CI) 1.64%–2.21%]. Ethnicity appears to have effect on heterogeneity in the prevalence of strabismus[1]. Abnormal ocular alignment may be manifest or intermittent presentation; however, it has a direct effect on binocular vision function, leading to strabismic amblyopia, reduced visual function and psychological disabilities. Strabismic amblyopia can be treated successfully with proper management in a golden period of time. The prevalence of strabismus is not significantly different between exotropia (XT) and esotropia (ET). In Asian populations, XT is more common than ET[2-3]. However, report from a tertiary eye care center in India about infantile strabismus demonstrated prevalence of ET was 2-fold higher than XT[4].

XT presentation can be manifested or latent divergent strabismus. Intermittent exotropia [X(T)] is the most common type of divergent strabismus in childhood[3,5-6]. There are multiple modalities of management; including nonsurgical and surgical managements. The indications for surgery in XT comprise of the manifestation of XT more than 50% of waking hours, poor control, decreased stereopsis and cosmetic concerns[6]. Some psychiatric problems from personality can be prevented by early surgical correction of XT. Quality of life is one of the benefits in strabismus surgery but may not be a significant criterion for surgery[7-8].

The standard surgical correction of XT includes bilateral lateral rectus recession (BLRR), bilateral medial rectus resection and unilateral lateral rectus recession & medial rectus resection (URR). The type of surgery and laterality depends on the angle of deviation, age of patient at surgery, visual acuity (VA) and surgeon preference[9]. In general, 1- or 2-muscle surgeries are adequate for correction. However, in very large angle of deviation may require 3- or 4-muscle surgeries. The goal of surgical correction is recovery of binocular fusion, with good motor and sensory outcomes, in which the angle of deviation is within 10 prism diopters (PD) of XT. The benefits of strabismus surgery includes: improved motor function, sensory function, and psychosocial and health-related quality of life. There are multiple, comparable studies regarding the surgical success rates between BLRR and URR; with long-term follow up demonstrating an increasing recurrence rate. The success rate of BLRR varies from 48.9% to 70%, and that of URR from 25.9% to 85%[10-16]; depending on exodeviation type and timing of follow up. Long-term outcome studies revealed no statistically significant difference between BLRR and URR[5,15].

However, reoperation shows an increasing trend by time[17] with reoperation within first year, 3 and 5y of 8.5%, 38.9%, 52.9%, respectively.

This study is a retrospective multicenter review of surgical outcomes of XT in Thailand to evaluate characteristics of XT and motor-sensory outcomes after surgical correction. In addition to determining factors associated with sensory outcome of XT surgery.

PARTICIPANTS AND METHODS

Ethical Approval Ethical approval was obtained from the Research Ethics Committee of King Chulalongkorn Memorial Hospital (COA No.1414/2020), Maharaj Nakorn Chiang Mai Hospital (OPT-2563-07419), Phramongkutklao Hospital Phramongkutklao College of Medicine (S084h64), Ramathibodi Hospital Mahidol University (MURA2020/1345), Siriraj Hospital Mahidol University (COA No.Si 1015/2020), Songklanagarind Hospital Prince of Songkla University (REC 63-363-2-1); Srinagarind Hospital (HE631433), Thammasat University Hospital (MTU-EC-OP-1 127/63), Khon Kaen Hospital (KEXP63049), Lerdsin Hospital (LH631045), Mettapracharak Hospital (COA No.001/2564), Queen Sirikit National Institute of Child Health (REC.113/2563), and Rajavithi Hospital (63142). The study was conducted in accordance with the principles of the Declaration of Helsinki. The informed consent was obtained from the subjects.

Methods The medical records of all patients, diagnosed with XT and having undergone strabismus surgery in 13 major government hospitals in Thailand; from January 2012 to December 2019, were retrospectively reviewed. The sites comprised 8 university hospitals (King Chulalongkorn Memorial Hospital, Maharaj Nakorn Chiang Mai Hospital, Phramongkutklao Hospital Phramongkutklao College of Medicine, Ramathibodi Hospital Mahidol University, Siriraj Hospital Mahidol University, Songklanagarind Hospital Prince of Songkla University, Srinagarind Hospital and Thammasat University Hospital) and 5 tertiary care hospitals under the Ministry of Public Health (Khon Kaen Hospital, Lerdsin Hospital, Mettapracharak Hospital, Queen Sirikit National Institute of Child Health, and Rajavithi Hospital). Patients with restrictive muscular disease, neuromuscular disorder, cranial nerve disorder; delayed development or history of previous muscle surgery at another hospital were excluded. The general data included: age at presentation, age at diagnosis, type of XT, VA, amblyopic status, refractive errors; pre- and post-operative angle of deviation at distance and near, type of surgical correction and sensory outcome. Angle of deviation was assessed by the prism cover test and Krimsky test.

Definition of Terms

Surgical outcome Good surgical outcome was angle of deviation ≤10 PD after surgery. Partial surgical outcome was angle of deviation >10 PD after surgery. Poor surgical outcome was residual XT and reoperation for horizontal muscles.

Visual outcome at the last follow up Good outcome was a best corrected visual acuity (BCVA) ≤20/40 or fusion with stereopsis. Partial outcome was BCVA>20/40 or fusion without stereopsis. Poor outcome was BCVA<20/200.

Successful sensory outcome Binocular vision was fusion and/or stereopsis with the methods depending on each research site.

Statistical Analysis General data were summarized using frequency (%), mean (standard deviation) or median (interquartile range; IQR) and descriptive statistics. Pearson Chi-square was used for identifying variables related to binocular vision. Logistic regression was used to identify variables independently associated with binocular vision. Variables with a $P<0.10$ in univariable analyses were included in the multivariable model. Backward stepwise elimination was used to exclude variables from the model, unless they contributed significantly to the fit of the model; based on likelihood ratio (LR) test. A $P<0.05$ was considered to indicate statistical significance.

RESULTS

We enrolled 537 participants from 584 eligible XT patients; 47 participants were excluded due to restrictive muscular disease, neuromuscular disorder and cranial nerve disorder (Figure 1). Demographic data were shown in Table 1. Two hundred and twenty-six patients were men (42.1%). The median age of onset was 3 years old (IQR 1, 8). The median age at diagnosis was 9.21 years old (IQR 4.64, 21.06). Of the 94 patients in whom the case was recorded as congenital or acquired, 59 were recorded as being congenital. X(T) was the most common type (52.1%), and 19.5% of the patients had amblyopia. Normal VA (≥6/18) before surgery in right and left eye (RE and LE) was 76.5% and 77.3%, respectively. For refractive error, spherical equivalent refraction on RE and LE were -0.53 D (range -14.88 to +10 D, SD 2.45) and -0.48 D (range -19.50 to +7.75 D, SD 2.37), respectively; 33.9% needed glasses correction, and 19.4% participants needed amblyopic treatment with patching. The mean angle of deviation at distance and near before surgery were 42.06±14.91 PD and 40.81±16.09 PD, respectively. Median follow-up time after first operation was 1.92y (0.06, 3.95).

Four hundred and sixty-two participants (86%) required only one operation and 299 patients (55.6%) underwent BLRR (Table 2). At the final visit the average angles of deviation at distance and near decreased to 5.76±8.96 PD and 5.01±8.73 PD, respectively. There were intra- and post-operative complications occurred in 6 cases: 1 case of corneal abrasion, 1 case of diplopia, 3 cases of globe penetration, and 1 case of conjunctival abscess. Table 3 showed the motor outcome and sensory outcome at final visit.

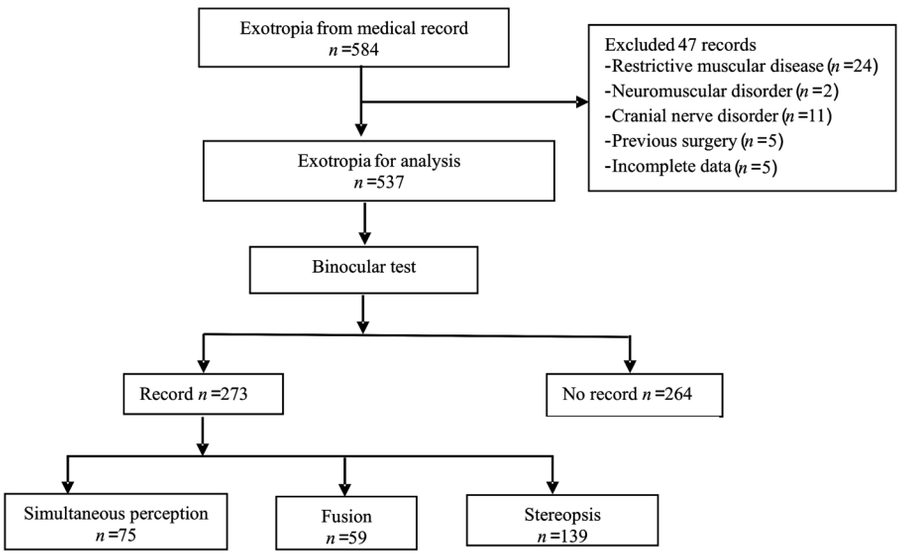

Figure 1 Diagram of surgical patients in the study.

Table 1 Demographic characteristics of XT patients *n* (%)

Characteristics	No. of patients (*n*=537)
Sex	
Male	226 (42.1)
Female	311 (57.9)
Age at onset (y)	
Mean±SD	7.06±10.98
Median (IQR)	3 (1, 8)
At birth	59 (11.2)
Age at diagnosis (y)	
Mean±SD	14.94±14.92
Median (IQR)	9.21 (4.64, 21.06)
At birth	7 (1.3)
Age at first surgery (y)	
Mean±SD	16.69±14.68
Median (IQR)	10.79 (6.67, 22.05)
Age at first surgery (y)	
<5	82 (15.3)
5–9	165 (30.7)
10–20	144 (26.8)
>20	146 (27.2)
Type of XT	
Intermittent XT	280 (52.1)
Constant XT	240 (44.7)
Sensory XT	17 (3.2)
Amblyopia	
Unilateral	102 (19.0)
Bilateral	3 (0.5)
No amblyopia	423 (78.8)
NA	9 (1.7)
VA RE before surgery	
Mild (≥6/18)	411 (76.5)
Moderate (<6/18 to ≥6/60)	46 (8.6)
Severe+blindness (<6/60)	15 (2.8)
Fixed and followed	57 (10.6)
NA	8 (1.5)
VA LE before surgery	
Mild (≥6/18)	415 (77.3)
Moderate (<6/18 to ≥6/60)	42 (7.8)
Severe+blindness (<6/60)	17 (3.2)
Fixed and followed	54 (10)
NA	9 (1.7)
Spherical equivalence RE	
Mean±SD	-0.53±2.45
Median (IQR)	0 (-1, 0.75)
Spherical equivalence LE	
Mean±SD	-0.48±2.37
Median (IQR)	0 (-1, 0.75)
On glasses	
Bifocal	7 (1.3)
Monofocal	175 (32.6)
None	355 (66.1)
Occlusion therapy	
Alternate patching	37 (6.9)
Full time	6 (1.1)
Part time	61 (11.4)
None	433 (80.6)
Refractive error in XT surgery (SE RE)	
<-5.0	24 (4.5)
<-1.0 to -5.0	90 (16.8)
-1.0 to 1.0	278 (51.8)
>1.0 to 5.0	69 (12.7)
>5.0	2 (0.4)
NA	74 (13.8)
Refractive error in XT surgery (SE LE)	
<-5.0	20 (3.7)
<1.0 to -5.0	89 (16.7)
-1.0 to 1.0	285 (53.1)
>1.0 to 5.0	66 (12.3)
>5.0	1 (0.2)
NA	76 (14.0)
Angle of deviation before surgery	
Distant PD	
Mean±SD	42.06±14.91
Median (IQR)	40 (30, 50)
Near PD	
Mean±SD	40.81±16.09
Median (IQR)	40 (30, 50)
Duration of F/U from OP 1 (y)	
Mean±SD	2.48±2.27
Median (IQR)	1.92 (0.06, 3.95)

PD: Prism diopters; SD: Standard deviation; IQR: Interquartile range; XT: Exotropia; NA: Not applicable; SE: Spherical equivalent; RE: Right eye; LE: Left eye; F/U: Follow up; OP: Opreation.

Table 2 Surgical type in XT patients *n* (%)

Type of surgery	1st operation	2nd operation	3rd operation
BLR recession	299 (55.6)	0	0
Monocular recession and resection	129 (24.0)	0	0
3 muscles surgery	44 (8.2)	0	0
BLR recession+oblique muscle	31 (5.8)	0	0
1 muscle (recession or resection)	16 (3.0)	58 (10.8)	7 (1.3)
3 muscles surgery+oblique muscle	7 (1.3)	0	0
URR+oblique or vertical muscle	6 (1.1)	0	0
1 muscle (recession or resection)+oblique or vertical	3 (0.6)	9 (1.7)	0
Only oblique or vertical	2 (0.4)	6 (1.1)	1 (0.2)
Other	0	2 (0.4)[a]	1 (0.2)[b]
No surgery	0	462 (86.0)	528 (98.3)
Total	537 (100)	537 (100)	537 (100)

BLR: Bilateral lateral rectus; URR: Unilateral lateral rectus recession and medial rectus resection. [a]Botulinum A toxin injection, monocular recession and resection another eye; [b]Bilateral resection. XT: Exotropia.

Table 3 Details of post-operative outcome and sensory outcome

Parameters	*n* (%)
Binocular function after surgeries	
Simultaneous perception	75 (14.0)
Fusion	59 (11.0)
Stereopsis	139 (25.9)
NA	264 (49.1)
Angle of deviation after surgery at last visit	
Distant PD	
Mean±SD	5.76±8.96
Median (IQR)	0 (0, 10)
Near PD	
Mean±SD	5.01±8.73
Median (IQR)	0 (0, 8)
BCVA last (in better eye)	
≥6/18	517 (96.3)
<6/18 to ≥ 6/60	7 (1.3)
<6/60	0
Fixed and followed	9 (1.7)
NA	4 (0.7)
BCVA last (in worse eye)	
≥6/18	460 (85.7)
<6/18 to ≥6/60	37 (6.9)
<6/60	27 (5.0)
Fixed and followed	9 (1.7)
NA	4 (0.7)
Visual outcome at last visit	
Good	507 (94.4)
Partial	18 (3.4)
Poor	0
NA	12 (2.2)
Alignment	
Ortho	309 (57.5)
XT	195 (27.9)
ET	33 (6.1)

NA: Not applicable; SD: Standard deviation; IQR: Interquartile range; BCVA: Best corrected visual acuity; XT: Exotropia, ET: Esotropia.

After surgery, 273 (50.8%) patients were evaluated for binocular function, but the others did not have a result (Table 4).

Table 5 showed univariable logistic regression and multivariable logistic regression in 273 patients to identify the factors related to develop binocular function.

In univariable logistic regression, the factors related to binocular development were age at 1st eye muscle surgery between 5 and 9 years old with odds ratio 6.63 (95%CI: 2.93, 14.98) compared to older than 20 years old. Normal VA in worse eye better than blindness odds ratio 27.71 (95%CI: 6.00, 127.98); pre-op angle of deviation less than 50 PD and final visit angle of deviation less than 10 PD.

For multivariable logistic regression, the factors related to binocular development were X(T) with adjusted odds ratio (aOR) 10.35 (95%CI: 4.73, 22.66) compared to constant XT, without amblyopia with aOR 3.97 (95%CI: 1.84, 8.53), underwent single operation compared to more than 1 operation with aOR 3.80 (95%CI: 1.58, 9.16), final visit angle of deviation at near less than 10 PD with aOR 0.42 (95%CI: 0.18, 0.96) and isometropia with aOR 4.13 (95%CI: 1.19, 14.32).

DISCUSSION

Intermittent XT was the most common type (52.1%), with strabismic amblyopia being recorded in 19.5%. The successful surgical outcomes with one operation, second and third operations were 86.0%, 98.3%, 100%, respectively. The operations of 1st operation were: BLRR, URR, BLRR and 1 medial rectus resection, unilateral lateral rectus recession, the others accounted for 55.6%, 24.0%, 8.2%, 3.0% and 9.2%, respectively: 273/537 (50.84%) patients had information about test of binocular visual function. Successful sensory outcome (fusion and/or stereopsis) was achieved in 198/273 (72.5%). The factors related to achieve binocular function includes type of XT as X(T), without amblyopia, angle of deviation at final visit less than 10 PD, isometropia type of refraction and underwent only one surgical correction. The study

Table 4 Clinical characteristics of 273 patients with binocular function after surgeries

Characteristics	Simultaneous perception (*n*=75)	Fusion (*n*=59)	Stereopsis (*n*=139)	*P*
Sex				0.575
Male	25 (33.3)	21 (35.6)	56 (40.3)	
Female	50 (66.7)	38 (64.4)	83 (59.7)	
Age at first surgery (y)				<0.001
<5	12 (16.0)	9 (15.3)	18 (12.9)	
5–9	10 (13.3)	18 (30.4)	59 (42.5)	
10–20	22 (29.3)	15 (25.4)	43 (30.9)	
>20	31 (41.4)	17 (28.8)	19 (13.7)	
Type of XT				<0.001
Intermittent XT	15 (20.0)	42 (71.2)	102 (73.4)	
Constant XT	53 (70.7)	17 (28.8)	36 (25.9)	
Sensory XT	7 (9.3)	0	1 (0.7)	
All amblyopia				<0.001
No amblyopia	42 (56.0)	52 (91.2)	117 (85.4)	
Amblyopia	33 (44.0)	5 (8.8)	20 (14.6)	
BCVA before (better eye)				0.578
Mild (≥6/18)	64 (85.3)	52 (91.2)	124 (89.9)	
Moderate (<6/18 to ≥6/60)	2 (2.7)	2 (3.5)	2 (1.5)	
Severe+blindness (<6/60)	1 (1.3)	0	0	
Fixed and followed	8 (10.7)	3 (5.3)	12 (8.7)	
BCVA before (worse eye)				<0.001
Mild (≥6/18)	38 (50.7)	50 (87.7)	112 (81.2)	
Moderate (<6/18 to ≥6/60)	16 (21.3)	4 (7.0)	12 (8.7)	
Severe+blindness (<6/60)	13 (17.3)	0	2 (1.4)	
Fixed and followed	8 (10.7)	3 (5.3)	12 (8.7)	
Refractive error in XT surgery (SE RE)				0.322
<-5.0	7 (11.1)	2 (5.1)	6 (4.3)	
<-1.0 to -5.0	10 (15.9)	5 (12.8)	25 (17.9)	
-1.0 to +1.0	39 (61.9)	24 (61.5)	82 (58.9)	
>+1.0 to +5.0	6 (9.5)	7 (18.0)	26 (18.7)	
>+5.0	1 (1.6)	1 (2.6)	0	
Refractive error in XT surgery (SE LE)				0.350
<-5.0	6 (9.5)	1 (2.6)	5 (3.6)	
<-1.0 to -5.0	11 (17.5)	6 (15.4)	31 (22.3)	
-1.0 to +1.0	40 (63.5)	25 (64.1)	75 (54.0)	
>+1.0 to +5.0	6 (9.5)	7 (17.9)	27 (19.4)	
>+5.0	0	0	1 (0.7)	
Deviation before surgery				0.085
Distant PD				
≤30	22 (29.7)	22 (37.3)	46 (33.1)	
>30–50	35 (47.3)	28 (47.5)	80 (57.5)	
>50	17 (23.0)	9 (15.3)	13 (9.4)	
Near PD				0.016
≤30	24 (32.0)	21 (35.6)	52 (37.4)	
>30–50	33 (44.0)	28 (47.5)	77 (55.4)	
>50	18 (24.0)	10 (16.9)	10 (7.2)	

Table 4 Clinical characteristics of 273 patients with binocular function after surgeries (Continued)

Characteristics	Simultaneous perception (*n*=75)	Fusion (*n*=59)	Stereopsis (*n*=139)	*P*
Number of surgeries				0.020
1 operation	56 (74.7)	53 (89.8)	126 (90.7)	
2 operations	18 (24.0)	6 (10.2)	12 (8.6)	
3 operations	1 (1.3)	0	1 (0.7)	
Number of surgeries				0.004
1 operation	56 (74.7)	53 (89.8)	126 (90.7)	
2–3 operations	19 (25.3)	6 (10.2)	13 (9.3)	
Deviation after surgery at last visit				
Distant PD				0.207
<10	48 (64.0)	44 (74.6)	100 (72.0)	
10–30	24 (32.0)	15 (25.4)	38 (27.3)	
>30	3 (4.0)	0	1 (0.7)	
Near PD				
<10	49 (66.2)	44 (74.6)	111 (79.9)	0.015
10–30	20 (27.0)	15 (25.4)	27 (19.4)	
>30	5 (6.8)	0	1 (0.7)	
BCVA last (better eye)				
Mild (≥6/18)	72 (96.0)	58 (100)	139 (100)	0.093
Moderate (<6/18 to ≥6/60)	2 (2.7)	0	0	
Severe+blindness (<6/60)	0	0	0	
Fixed and followed	1 (1.3)	0	0	
BCVA last (worse eye)				
Mild (≥6/18)	49 (65.4)	58 (100)	135 (97.1)	<0.001
Moderate (<6/18 to ≥6/60)	13 (17.3)	0	3 (2.2)	
Severe+blindness (<6/60)	12 (16.0)	0	1 (0.7)	
Fixed and followed	1 (1.3)	0	0	
Alignment last				
Ortho	36 (48.00	34 (57.6)	79 (56.8)	0.442
XT	32 (42.7)	20 (33.9)	54 (38.9)	
ET	7 (9.3)	5 (8.5)	6 (4.3)	
Different refractive error				
<0.25	50 (79.4)	34 (84.2)	123 (88.5)	
0.25 to <0.50	2 (3.2)	4 (10.3)	9 (6.5)	
≥0.50	11 (17.5)	1 (2.5)	7 (5.0)	0.014
Different refractive error				
Isometropia	52 (82.5)	38 (97.4)	132 (95.0)	
Anisometropia	11 (17.5)	1 (2.6)	7 (5.0)	0.004

BCVA: Best corrected visual acuity; XT: Exotropia; ET: Esotropia; PD: Prism diopters; Isometropia: Different of sphere <0.50 D or different of cylinder <0.50 D or spherical equivalent <0.50 D; Anisometropia: different of sphere ≥0.50 D or different of cylinder ≥0.50 D or spherical equivalent ≥0.50 D; SE: Spherical equivalent; RE: Right eye; LE: Left eye.

showed X(T), constant XT, sensory XT accounted for 52.1%, 44.7%, and 3.0%, respectively. Previous studies[2,18] reported prevalence of X(T) as 71.3%–92%, which was higher than this study. Generally, constant XT had developed from X(T), due to progressive weakness of accommodation day after day. In cases of X(T), an early operation, before the deviation has not turned to constant XT, may be enhance binocular vision. Previous studies[2,19] reported that 14.3%–20% of cases of XT had strabismic amblyopia, which was similar to this study (19.5%). The importance priority of management in XT is to concern regarding amblyopia treatment before early surgery. Considering type of surgical correction in XT, the 1st procedure

Table 5 Factors related to binocular vision

Characteristics	Binocular visual function			Binocular visual function		
	Odds ratio (95%CI)	*P* (Wald-test)	*P* (LR-test)	Adjusted odds ratio (95%CI)	*P* (Wald-test)	*P* (LR-test)
Age at first surgery (y)						
>20	1[a]					
10–20	2.27 (1.14, 4.51)[b]	0.019	<0.001	NS		
5–9	6.63 (2.93, 14.98)[c]	<0.001				
<5	1.94 (0.84, 4.45)[a,b]	0.119				
Type of XT						
Constant XT	1[a]			1[a]		
Sensory XT	0.14 (0.02, 1.20)[a]	0.073	<0.001	0.24 (0.02, 2.38)[a]	0.222	<0.001
Intermittent XT	9.60 (4.99, 18.46)[b]	<0.001		10.35 (4.73, 22.66)[b]	<0.001	
All amblyopia						
Amblyopia	1			1		
No amblyopia	5.31 (2.86, 9.87)	<0.001	<0.001	3.97 (1.84, 8.53)	<0.001	<0.001
BCVA before surgery (in worse eye)						
≥6/18	1[a]					
<6/18 to ≥6/60	6.5 (1.26, 33.58)[b]	0.025				
<6/60	27.71 (6.00, 127.98)[c]	<0.001	<0.001	NS		
Fixed and followed	12.19 (2.19, 67.94)[b,c]	0.004				
Angle of deviation before surgery (PD)						
At distant						
>50	1 [a]					
>30–50	2.38 (1.14, 4.99)[b]	0.021	0.058	NS		
≤30	2.39 (1.08, 5.29)[b]	0.032				
At near						
>50	1 [a]					
>30–50	2.86 (1.36, 6.05)[b]	0.006	0.018	NS		
≤30	2.74 (1.25, 6.01)[b]	0.012				
Number of surgeries						
2–3 operations	1			1		
1 operation	3.20 (1.58, 6.46)	0.001	0.001	3.80 (1.58, 9.16)	0.003	0.003
Angle of deviation after surgery (PD)						
At distant						
<10	1					
10–30	0.74 (0.41, 1.32)	0.303	0.082	NS		
>30	0.11 (0.01, 1.09)	0.060				
At near						
<10	1[a]			1[a]		
10–30	0.66 (0.36, 1.24)[a]	0.197	0.006	0.42 (0.18, 0.96)[b]	0.039	<0.001
>30	0.06 (0.007, 0.55)[b]	0.013		0.02 (0.002, 0.27)[c]	0.003	
Anisometropia power						
≥0.50	1	0.002	0.004	1	0.025	0.022
<0.50	4.50 (1.72, 11.77)			4.13 (1.19, 14.32)		

Binocular vision: Fusion and/or stereopsis. The a, b, c values in column not having a superscript in common differ significantly (P<0.05). NS: Non significantly (P>0.05); BCVA: Best corrected visual acuity; XT: Exotropia; ET: Esotropia; PD: Prism diopter; LR: Likelihood ratio test; CI: Confidence interval.

is usually BLRR, followed by URR. This study found post operative alignment as orthotropia, residual XT, consecutive ET (over correction) were 57.5%, 27.9%, and 6.1%, respectively. Different outcomes in previous report[20], showed an overcorrection of 21% at 6mo follow-up, which is more than this study. Success rates of BLRR varied from 50%–70% and URR varied from 30%–85%[10-15], depending on exodeviation type and timing of follow up. This current study showed good surgical outcomes with one operation as high as 86%, which was not different from previous reports[10-15].

The benefits of surgical treatment in XT patients were: recovery of alignment, motor function, sensory function

and psychosocial and health-related quality of life. The data showed that surgery in cases of XT provided improvement of sensory outcome, and the benefits for strabismus patients to lead a normal life, with good visual outcome[21] up to adulthood[20,22]. Previous studies[23-24] have shown good outcomes related to motor realignment before age 7, and a duration of XT or X(T) of less than 5y. Good visual outcome and binocular visual function in this study was achieved in 94.4% and 72.5% of cases, respectively; whereas, previous studies[2,17,25] have reported about 71.0%–92% of cases.

Surgical intervention between 5 and 9 years old was better than over 20 years old, with odds ratio 6.63 (95%CI: 2.93, 14.98). Surgical outcomes were also better in those younger than 5 years old, which may be due to the high sensitivity for restorability of binocular visual function. In young children that developed early, constant XT might be susceptible to permanent disruption of binocular vision that had been reported in this prospective study[26]. However, age at surgery was not revealed in multivariable logistic regression, due to young cases tending to be X(T) compared with older patients; additionally, most sensory XT were older patients. In cases of X(T) turning to constant XT had time for developing binocular vision before decompensating, until showing XT. Thus, time and health for binocular vision development will explain why X(T) patients, those without amblyopia, and isometropia patients had binocular vision. The earlier the retrieved motor outcome, the better improvement of visual outcomes[27]. Previous studies[26-31] showed the factors positively related to binocular vision are younger age at surgery, X(T), good preoperative stereopsis, binocular development and no amblyopia. However, negative factors were early onset of strabismus (within 6 months of age), ET, larger preoperative deviation (>45 PD), older age at surgery, no preoperative binocular vision and amblyopia.

There are some limitations in this study, such as an incompletement of data due to it being a retrospective study design, with analyzed patients no significant or slightly were tolerable distribution XT and preoperative angle of deviation. There were also differences in VA measurements and orthoptic examination due to this being a multicenter study. Furthermore, the follow-up times were varied.

In conclusion, the surgical outcomes of XT within one operation in Thailand was 86%. The factors related to achieve binocular function includes type of XT as X(T), without amblyopia, angle of deviation at final visit less than 10 PD, isometropia type of refraction and underwent only one surgical correction.

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