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Comitant Horizontal Strabismus: an Asian perspective

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Abstract:
Aim: Recent studies suggest that Asian strabismus patterns are different from those in the West. This study aims to determine profile of children with comitant horizontal strabismus in Singapore.
Method: 682 children aged $\leq$ 16 years presenting with strabismus for the first time between 2000 and 2002 were included in this study. The type and size of the squint, visual acuity, refractive error and stereopsis were noted.
Results: 493 children (72%) were exotropic, the majority (92%) of whom had intermittent exotropia, X(T). The divergence excess type X(T) was most common (59.5%) followed by basic (29.0%) and convergence-weakness (11.5%). Children with X(T) demonstrated stereopsis for near in 92% and distance in 50%. Esotropia was present in 191(28%) children (23% infantile and 53% accommodative). Children with infantile esotropia presented significantly younger (2.8y versus 4.5y), had larger squint size (35D versus 26D) and were less hyperopic (+0.78D versus +2.79D). Amblyopia or ocular preference was noted in 50% of children with infantile esotropia, and 43% with accommodative esotropia.
Conclusion: Twice as many Singaporean children presented with exotropia than esotropia. However, within the exotropia and esotropia groups, the distribution and characteristics of various strabismus subtypes bore similar characteristics to those described in the West.

Keywords:
Strabismus, Asia, Esotropia, Exotropia

Introduction

Older Western studies have traditionally suggested that convergent strabismus (esotropia) was twice as common as divergent strabismus (exotropia) [1-5]. Recent studies, however, suggest that the reverse may be true in Asian populations [6,7]. Questions remain whether differences in strabismus are limited to the esotropia:exotropia ratio or whether other differences in clinical and surgical outcomes also exist.

In this study, children presenting with horizontal comitant strabismus were assessed. The types of strabismus and characteristics such as age of onset and presentation, strabismus size and presence of amblyopia or stereopsis were determined.

Methods:

Case-files of all children (aged $\leq$ 16years) presenting for the first time to the Singapore National Eye Centre and KK Women's and Children's hospital between 2000 and 2002 with horizontal comitant strabismus were reviewed retrospectively. Some children may have been seen elsewhere previously, and those who had had past strabismus surgery were excluded from the study. The age of presentation, estimated age of onset of strabismus, gender and race of the children were noted. Strabismus sizes for distance (6 metres) and near (30cm) were measured formally by orthoptists. Measurements from the first formal orthoptic assessment (usually during the first or second visit) were recorded. However, if spectacles were prescribed during this visit, recording were taken from the following visit after at least 6 weeks of spectacle wear. Cover-uncover prism test was performed when possible and Krimsky test when not. The presence of amblyopia (or a strong ocular preference), A/V patterns and dissociated vertical deviations (DVD) were noted. Distance stereoacuity was measured using the Mentor B-VAT II Contour Circles at 6 meters, and near stereoacuity using the Lang Stereotest II or Frisby stereotest. Cycloplegia was achieved with 3 drops of cyclopentolate administered at 5 minutes intervals, 0.5% was used in children <1year, and 1% in older children. Refraction was performed 30 minutes later. Atropine refraction (when required) was done after atropine 1% was administered twice daily for 2-3 days prior to visit. Only cycloplegic or atropine refractions done within one year of presentation were accepted for analysis.

Children with exotropia were divided into those with intermittent exotropia and constant exotopia. Children with intermittent exotropia required to be orthophoric at some time, either for distant or near. Three groups, basic (where distant and near exotropia were within 10PD), divergence excess (where distant exotropia exceeded near exotropia by > 10PD) and convergence insufficiency (where near exotropia exceeded distant exotropia by > 10PD) were identified. Children with a constant exotropia not associated with a visual, syndromic or neurological cause were categorized as having constant idiopathic exotropia. Those with strabismus associated with poor vision, neurological disorders or syndromes were judged to have secondary strabismus.

Children with esotropia included those with infantile, accommodative and constant esotropia. Infantile esotropia was defined as an esotropia with an onset of $\leq$ 6 months of age which changed by < 10PD with full atropine or cycloplegic prescription. Children with accommodative esotropia demonstrated a reduction of $\geq$ 10PD with full atropine or

cycloplegic refraction. After at least 3 months of spectacle wear, those with a final ET ≤ 10PD were deemed to be fully accommodative, whilst those with final ET >10PD were partially accommodative. Children with late onset esotropia which reduced by <10PD to spectacle correction were classified as having acquired non-accommodative esotropia.

The esotropia: exotropia ratio was calculated. Age, strabismus size and spherical equivalent differences were analysed using the unpaired t-test. Difference in amblyopia, A/V pattern or DVD, stereopsis, astigmatism and anisometropia were analysed using chi-squared test. All statistical analysis was done using Statview version 5.0.1.

Results:

Six hundred and eighty two children presented with horizontal comitant strabismus between 2000 and 2002. The mean age at presentation was 5.3 +/- 3.2 years. In keeping with national ethnic distribution, the ratio of Chinese:Malays:Indians was 82:10:8. The overall esotropia:exotropia ratio was 28:72. The esotropia:exotropia ratios for ethnic Chinese, Malays and Indians were 27:73, 33:67 and 21:79 respectively.

Characteristics of children with comitant exotropia

Seventy-two percent of children presented with exotropia (Table 1). Intermittent exotropia, X(T), comprised 92% of all exotropias. The median age of presentation was 5.2 years. Stereovision was present in 92% for near and 50% for distant. Myopia (ie. spherical equivalent ≤ -0.5D) was present in 43%, whilst 4% were moderately hyperopic (with spherical equivalent ≥ 2D). There was little difference between those with divergent-excess and basic X(T). However, those with convergence-weakness X(T) tended to present later, and were more myopic and astigmatic.

Secondary exotropia was present in 19 children; 12 were associated with visual impairment [dense amblyopia (6), trauma (1), retinoblastoma (1), retinopathy of prematurity (1), retinal dystrophy (1), toxoplasmosis (1), optic neuropathy (1)] and 7 with systemic/neurological impairment [syndrome (2), brain trauma (2), cerebral palsy (3)].

Characteristics of children with comitant esotropia

One hundred and ninety (28%) children presented with esotropia (Table 2). Children with infantile esotropia presented younger (62% before the age of 2 years), had larger esotropia and were less hyperopic than those with accommodative esotropia (Table 2). Myopia (ie. spherical equivalent ≤ -0.5D) was present in 22%, whilst 28% were moderate hyperopes (with spherical equivalent ≥ 2D). At presentation, children with infantile esotropia had similar amounts of amblyopia (or ocular preference), A/V pattern or DVD as accommodative esotropic children.

Children with fully and partially accommodative esotropia had similar ages of presentation, estimated ages of onset and spherical equivalents. Children with partially accommodative esotropia, however, had higher astigmatism. Myopia (ie. spherical equivalent ≤ -0.5D) was present in 5%, whilst 58% of children were moderate hyperopes (with spherical equivalent ≥ 2D). Seventeen percent of children with accommodative

Table 1: Characteristics of Comitant Exotropia (XT)

	Convergence weakness (CW)	Divergence excess (DE)	Basic (B)	*P*	Idiopathic XT	Secondary XT	*P*
Number (% of all XT)	51 (10%)	270 (55%)	132 (27%)		20 (4%)	19 (4%)	
Age of Presentation (yr) (Range)	6.8 +/- 2.8 (0.1-15.0)	5.4 +/- 3.0 (0.2-15.1)	5.6 +/- 3.0 (0.1-15.2)	*P*<0.01 for CW/DE, CW/B	7.1 +/- 3.9 (0.3-14)	5.5 +/- 3.6 (0.3-14.8)	0.19
Estimated age of Onset (yr)							
0 to 2 years	4 (7%)	89 (33%)	33 (25%)		6 (27%)	9 (47%)	
3 to 5 years	29 (58%)	112 (41%)	61 (46%)		4 (23%)	3 (19%)	
6 to12 years	17 (32%)	68 (25%)	38 (28%)		10 (50%)	7 (34%)	0.37
13 to 16 years	1 (2%)	1 (0%)	0 (0%)	<0.01	-	-	
Distant strabismus (PD)* (Range)	14.9 +/- 10.2 (0-57)	29.0 +/- 11.2 (2-66)	27.6 +/- 11.8 (0-60)	*P*<0.001 for CW/DE, CW/B	37.3 +/- 14.4 (8-65)	31.4 +/- 12.0 (8-55)	0.15
Near strabismus (PD)* (Range)	26.1 +/- 12.8 (6-87)	14.0 +/- 10.7 (0-55)	26.7 +/- 11.3 (2-60)	P<0.001 for CW/DE, DE/B	37.5 +/- 11.2 (10-63)	29.3 +/- 12.8 (6-45)	0.04
Presence of							
Distant stereoacuity	10/25 (40%)	53/112 (53%)	29/59 (50%)	0.51	NA	NA	NA
Near stereoacuity	43/47 (94%)	202/216 (94%)	97/107 (90%)	0.47			
Spherical equivalent (D)	-2.4 +/- 3.6	-0.5 +/- 2.4	-0.6 +/- 2.2	*P*<0.001 for CW/DE, CW/B	0.3 +/- 2.5	-1.4 +/- 4.0	0.14
Anisometropia $\geq$ 1D	8/45 (18%)	39/226 (17%)	22/106 (21%)	0.75	6/17 (35%)	11/16 (68%)	0.05
Astigmatism $\geq$ 1.5D	22/45 (50%)	53/226 (23%)	27/106 (25%)	<0.001	6/17 (35%)	10/16 (62%)	0.11
Amblyopia/preference	12 (23%)	55 (20%)	21 (16%)	0.14	6 (30%)	10 (52%)	<0.01
A/V pattern or DVD	12 (23%)	84 (31%)	46 (35%)	0.20	11 (55%)	3(16%)	<0.01

* Measurement taken from first formal orthoptic assessment (usually during first or second visit). If spectacles were prescribed during these visits, the measurement performed after at least 6 weeks of spectacle wear was taken.

Table 2: Characteristics of Comintant Esotropia (ET)

	Infantile ET	Accommoda-tive ET	*P*	Fully Accommoda-tive ET	Partially Accommoda-tive ET	*P*	Acquired non-accommodative ET	Secondary ET
Number (% all ET)	45 (23%)	101 (53%)		57 (30%)	44 (23%)		32 (17%)	12 (6%)
Age of Presentation (yrs) (Range)	2.8 +/- 3.1 (0.2 - 15.2)	4.4 +/- 2.5 (0.4-13.1)	<0.001	4.5 +/- 2.8 (0.4-13.1)	4.3 +/- 2.0 (0.4-11.0)	0.64	4.6 +/- 2.4 (0.7-12.0)	5.8 +/- 4.3 (0.6-13.1)
Estimated age of Onset 0 to 2 years 3 to 5 years 6 to12 years	 45 (100%) - -	 34 (33%) 55 (55%) 12 (12%)	 <0.001	 20 (35%) 31 (54%) 6 (10%)	 14 (32%) 24 (54%) 6 (14%)	 0.86	 17 (53%) 12 (37%) 3 (10%)	 6 (50%) 4 (33%) 2 (17%)
Distant strabismus (PD)* (Range) Near strabismus (PD)* (Range)	34.0 +/- 18.1 (8-103) 35.0 +/- 19.2 (10-113)	17.7 +/- 14.8 (0-59) 25.8 +/- 12.3 (2-59)	<0.001 <0.001	13.2 +/- 13.7 (0-59) 23.0 +/- 12.3 (2-59)	25.3 +/- 14.2 (0-55) 29.7 +/- 11.2 (8-55)	<0.001 <0.01	32.3 +/- 16.0 (2-80) 35.4 +/- 15.3 (14-80)	35.0 +/- 16.2 (8-72) 36.7 +/- 15.6 (14-72)
Presence of Distant stereoacuity Near stereoacuity	 0/3 (0%) 0/13 (0%)	 4/9 (44%) 12/56 (20%)	 0.15 0.06	 4/7 (57%) 12/32 (36%)	 0/2 (0%) 0/24 (0%)	 0.15 <0.001	 NA	 NA
Spherical equivalent(D) Anisometropia $\geq$ 1D Astigmatism $\geq$ 1.5D	0.78 +/- 3.45 6/36 (16%) 8/36 (22%)	2.75 +/- 2.67 23/92 (25%) 19/92 (20%)	<0.001 0.31 0.84	2.4 +/- 2.7 12/49 (24%) 6/49 (12%)	3.1 +/- 2.5 11/43 (25%) 13/43 (30%)	0.21 0.90 0.02	1.8 +/- 1.7 11/32 (34%) 6/32 (18%)	2.0 +/- 2.0 7/12 (41%) 0/12 (0%)
Amblyopia/preference A/V pattern or DVD	23 (51%) 8 (17%)	43 (42%) 18 (17%)	0.35 0.51	21 (37%) 7 (12%)	22 (50%) 12 (27%)	0.18 0.08	17 (53%) 4 (12%)	7 (58%) 0 (0%)

* Measurement taken from first formal orthoptic assessment (usually during first or second visit). If spectacles were prescribed during these visits, the measurement performed after at least 6 weeks of spectacle wear was taken.

esotropia presented before the age of 2 years, of which 53% had esotropia ≥ 30PD and 24% had spherical equivalents < 2D at presentation.

Acquired non-accommodative esotropias comprised 17% of comitant esotropia. These children presented significantly later than children with infantile esotropia, and had larger amounts of esotropia than children with accommodative esotropia.

Secondary esotropias were associated with visual impairment in 6 children [optic nerve abnormalities (2), ocular trauma (2), congential cataract (1), congenital nystagmus (1)] and systemic/neurological impairment also in 6 children [syndrome (2), developmental delay/cerebral palsy (3), head trauma (1)].

Discussion

As in studies from Hong Kong and Japan, Singaporean children presenting with horizontal comitant strabismus were 2.5 times more likely to be exotropic than esotropic (Table 3) [6,7]. This is a direct opposite to figures quoted the United States and Australia [1-5]. Yu et al and Matsuo et al also noted that the esotropia:exotropia ratio appears to be decreasing over time [6,7]. The declining rate of hyperopia in Asian populations has been proposed as a reason for this changing trend [5,6,7,8].

Table 3: Comparison with other studies

	Govindan et al (2005) Greenberg et al (2006)	Robaei et al (2005)	Yu et al (2002)	This Study	
Study design	Population, USA	Population, Australia	Clinic, Hong Kong	Clinic, Singapore	
Study population	Children ≤ 19 yrs (n 509 with strabismus)	Schoolchildren aged 7 yrs (n 1739, 48 with strabismus)	All ages (n 2704) XT: all ages ET: Children ≤ 19 yrs	Children ≤16 yrs (n 682)	Children ≤ 7 yrs (n 494)
Exotropia (XT)					
. Intermittent	71%*	93%	69%	92%	93%
. Constant	na	7%	32%	4%	3%
. Secondary	23%†	na	na	4%	4%
Esotropia (ET)					
. Infantile	8.1%	na	2%§	23%	25%
. Accommodative	46.5%	34%	48%§	53%	53%
-Fully	- 36.4%			- 20%	29%
-Partially	- 10.1%			- 33%	24%
. Acquired	16.6%	na	25%§	17%	16%
. Secondary	17.9%†	na	na	6%	5%
XT: ET ratio	35 : 65	35 : 65‡	71 : 29‡	72: 28	67 : 33

* Intermittent X(T) includes subjects with convergence insufficiency
† Includes combination of central nervous system and sensory disorders
‡ after removal of microstrabismus, vertical and incomitant strabismus
§ estimated from graph (1999-2001). Further 20% had microesotropia.

The Singapore population with its mix of Chinese, Indian and Malay races provides an opportunity to study strabismus in an Asian context. Together, the two large public ophthalmology and paediatric hospitals in this study deals with 60-70% of the children in Singapore. Since travel is rarely a problem, and as there are few practices offering paediatric services on the island, and because parents often sought multiple clinical opinions, few referral biases existed. Care, however, needs to be taken whilst interpreting the results from a retrospective clinic based study as children presented only when strabismus was noticed, or when a parent deemed it necessary to seek an ophthalmological opinion. Indeed, although 62% of children with infantile esotropia presented before 2 years of age, one presented as late as 15 years. Parental inertia, the lack of knowledge amongst general health practitioners, and the mistaken diagnosis of pseudo-esotropia all contribute to this late presentation. The strabismus profile obtained may therefore only be a rough estimation of the incidence of strabismus within the population. For example, secondary strabismus associated with ocular abnormalities (such as retinal dystrophies or glaucoma) or with neurological or syndromic conditions may be under-estimated simply because these children are less likely to present to pediatric ophthalmologists. Govindan et al and Greenberg et al attempted to overcome this by actively reviewing case-files of a wide range of ophthalmic subspecialities which may account for the higher percentage of secondary strabismus in their studies (Table 3) [3,4]. Likewise, the higher rates of secondary exotropia in Yu et al's study may be due to their inclusion of adult patients. Some researchers have suggested that if only young children (eg. $\leq$ 7 years) are considered, the esotropia:exotropia differences may not be so marked [7,8]. However, when we subtract older children from our study, this only had a slight effect on the esotropia:exotropia ratio (Table 3).

While identifying whether a child has an exotropia or esotropia was relatively easy, categorizing strabismus into their various sub-types and performing accurate orthoptic measurements in very young or un-cooperative children could be difficult. Compliance with treatment might be variable and since the diagnosis was occasionally based on a response to spectacle or amblyopia treatment, it might be delayed or missed in some cases. Children with early onset accommodative esotropia may be inadvertently placed in the infantile group and children with presumed acquired non-accomodative esotropia may actually have infantile or decompensated accommodative esotropia. Similarly, children with constant exotropia may actually have poorly controlled or be decompensated intermittent exotropia and children with dense intractable amblyopia within the secondary strabismus groups may in fact have strabismus that preceded amblyopia.

Even though the esotropia:exotropia ratio in Singaporean children was markedly different from that in the West, it is interesting to note that the proportions of various strabismus subgroups approximated of Western populations (Table 3). As in the West, the majority of our children with esotropia had accommodative esotropia, while the majority of children with exotropia had an intermittent exotropia (Table 3) [3,4, 9,10].

Intermittent exotropia, X(T), was the single commonest form of strabismus in our study with divergent excess X(T) appearing to occur most frequently. However, some basic-

type X(T) may have been inadvertently classified as divergent excess X(T) since children were not routinely patched to eliminate tenacious proximal fusion. There were few differences between children with basic and divergent excess X(T) but those with convergence-weakness X(T) presented later and tended to be more myopic and astigmatic. It is interesting to speculate whether a reduction in accommodative stimuli in myopic children predispose them to develop convergence-weakness X(T) over time.

Amongst our esotropic children, half were accommodative whilst one-quarter were infantile. Determining if a young child (aged < 2 years) has an infantile esotropia or accommodative esotropia is one of the challenges pediatric ophthalmologist face. As in Western studies, infantile esotropes in this study presented earlier, had larger strabismus size and tended to be less hyperopic [2,11]. However, 17% of children with accommodative esotropia presented before 2 years of age and some had a large angle esotropia (53%) or milder hyperopia (24%) at presentation (ie. characteristics similar to children with infantile esotropia). Furthermore, 5% of children with accommodative esotropia were myopic, a finding also noted in other studies [2,12]. All this suggests that it may be difficult to predict whether a child has infantile or accommodative esotropia based on age of onset, strabismus size or refractive error alone. A trial of spectacles (even in myopic children) may be necessary before a definite diagnosis can be made.

Having determined that a child has an accommodative esotropia, a further clinical challenge lies in predicting whether the esotropia would be fully or partially accommodative. The findings in this study suggest that there was little difference between the two groups at presentation, the only variation being that those with partially accommodative esotropia were more astigmatic (27% vs 12 %, Table 2).

There was also a notable portion of our children (17%) with acquired non-accommodative esotropia. Recent studies suggest that this form of strabismus may be more common than previously thought, comprising 10.4 to 16.6% of all esotropia [4,13]. Mohney described these children as typically presenting between 2-5 years with a small angle esotropia which responded well to surgery [13]. In our study, children with acquired non-accommodative esotropia presented over a wide age-range, with estimated onset most commonly being < 5 years, and moderate size esotropia. It is possible that some of these children actually had an infantile esotropia (which their parents failed to recognize earlier) or a decompensated accommodative esotropia as Baker & Park noted that 50% of children with accommodative esotropia who initially responded to spectacles became non-accommodative over time [14].

Children with strabismus are well known to be at greater risk of amblyopia than children without strabismus, amblyopia being reported to be as high as 48% in some studies [2,5]. In our study, 50% with esotropia and 20% of children with exotropia were amblyopic or had a strong ocular preference, and children with infantile, partially accommodative and secondary esotropias appeared to be at greater risk. Stereopsis was, as expected, better in children with intermittent exotropia and fully accommodative esotropia (ie. in children with periods of orthophoria).

In conclusion, exotropia is more common that esotropia in Singaporean children. However, within the exotropia and esotropia groups, the proportions and characteristics of various subgroups bear similar characteristics to that in the West.

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