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Research Article

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Excessive Smartphone Use May Cause Acute Acquired Comitant Esotropia

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Purpose: To investigate if and how excessive smartphone use is related to the development of acute acquired comitant esotropia (AACE).

Methods: The medical records and history of smartphone use of 26 patients with AACE between February 2016 and October 2017 were retrospectively reviewed. Duration, intensity of smartphone use, angle of esodeviation and treatment outcome were reported. The incidence of AACE in the study period was compared to that of proceeding years.

Results: 20 out of the 26 patients with the diagnosis of AACE used a smartphone for more than 5 hours daily over a period of several months prior to presentation to the hospital. All patients had comitant esotropia with an average angle of 46.48 prism diopters (PD) for distance and 42.08 PD for near; 24 were myopia with spherical equivalent of -4.33 ± 2.63D in the right eyes and −4.13 ± 2.59 D in the left eyes (ranging from -1.50D to -11.00D). All the patients had normal neurologic examination and normal MRI scan. Strabismus surgery were needed for all patients to resolve the esotropia and diplopia.

Conclusion: The number of cases of AACE is in increased significantly in recent two years. Excessive smartphone use may contribute to the development of AACE.

Key words: *Acute esotropia; Smartphone use*

Acute acquired comitant esotropia (AACE) is a rare type of esotropia. [1-4] The prevalence is unknown and it has been infrequently reported in older children and adults. [1-4] The underlying aetiology of the AACE remains inconclusive and the condition is characterized by sudden onset of esotropia without significant refractive errors, or neurological abnormalities. There has been an increased availability and use of smartphones in our normal daily activities both at workplaces and at home. [5,6] With increasing availability of gaming applications and online video streaming services smartphone use can become excessive and addictive especially among young people. [7-9] The excessive use of smart phone has been indicated as a potential cause of AACE by by H. S. Lee. [10] In recent

years we have encountered an increased number of cases of AACE in our hospital. The clinical characteristics, history of smartphone use among the patients diagnosed with AACE over a two year period are reported here.

Methods and Materials

The medical records of patients diagnosed with AACE at the Pediatric Ophthalmology and Strabismus Service of Shanxi Eye Hospital, China between February 2016 and October 2017 were retrospectively reviewed and analyzed.

Inclusion criteria were: (1) acute onset of esotropia with diplopia; (2) esotropia is comitant; (3) corrected visual acuity better than 6/9 in both eyes; (4) 6 months, or longer follow up prior to surgical correction; (5) post-operation follow-up period at least 3 months. Patients with a history of previous strabismus and amblyopia, previous ocular surgery, head trauma, and neurological disease were excluded.

Detailed data on the duration of smartphone use prior to the onset of esotropia, the time of onset and duration of diplopia, esotropia angle at both near and distance fixation, binocular vision status, refractive errors, neuroimaging and clinical outcome were extracted from clinical records. In order to ascertain true increase of AACE in recent years, we calculated the yearly incidence of AACE among all strabismus cases diagnosed in our hospital between the years 2009 to 2017.

This study was approved by the Institutional Review Board of Shanxi Eye Hospital, and the study adhered to the tenets of Declaration of Helsinki. Written informed consent was obtained from all participants and their guardians for their clinical records to be used in this study. SPSS version 18.0 (SPSS Institute Inc., Chicago, IL, USA) was used for statistical analyses.

Results

26 patients (15 males, 11 females) met the inclusion criteria and their results were used for data analysis, their clinical details are shown in table 1. The average age of the patients was 22.5 years old (ranging from 6 to 46 years old). Among these, two cases were with mild hypermetropia; 24 patients were myopic with spherical equivalents of -4.33 ± 2.63D in the right eye and −4.13 ± 2.59 D in the left eye (ranging from -1.50D to -11.00D). Average angle of esotropia was 46.48 prism diopters (PD) for distance and 42.08 PD for near. All 26 patients had normal neurological examinations including normal MRI scan neuroimaging.

NO.	Age (years)	VA (logMAR)		Wearing spectacles	Duration of esotropia (months)	Refraction (SE) (D)		Deviation, Near/ Distant(PD)	
		UCVA (Rt/ Lt)	BCVA (Rt/Lt)			Right	Left	Preoperative (ET)	Postoperative (ET, XT, Ortho)
1	6	0.2/0.2	0.0/0.0	-	6	+0.75	+0.75	80/80	ET=2 /ET=2
2	18	0.7/0.6	0.0/0.0	+	18	-7.75	-7.50	60/60	ET=3 /ET=3
3	17	0.9/0.9	0.0/0.0	+	12	-5.00	-4.25	30/30	ET=1/ET=2
4	20	1.0/1.0	0.0/0.0	-	24	-3.75	-4.25	20/30	ET=1/ET=2
5	20	1.0/1.0	0.0/0.0	+	36	-4.25	-4.25	74/74	ET=4/ET=5
6	13	0.7/0.6	0.0/0.0	-	6	-3.50	-3.00	60/60	ET=2/ET=2
7	15	1.3/1.0	0.0/0.0	-	48	-4.25	-3.75	70/80	ET=3/ET=5
8	46	1.0/0.9	0.1/0.1	+	18	-4.50	-4.25	40/50	ET=2/ET=3
9	21	0.5/0.5	0.0/0.0	-	6	-4.00	-4.50	30/40	Ortho/ET=1
10	30	0.5/0.5	0.0/0.0	-	6	-1.50	-1.50	15/20	Ortho/ET=1
11	31	1.0/0.6	0.0/0.0	-	6	-2.25	-1.00	25/25	ET=3/ET=3
12	17	0.6/0.6	0.0/0.0	-	48	-8.00	-7.25	50/80	Ortho/ET=5
13	26	1.0/1.0	0.0/0.0	+	6	-6.75	-7.00	60/60	ET=2/ET=3
14	24	0.7/0.8	0.0/0.0	-	6	-4.50	-5.25	12/12	XT=2/XT=2
15	19	0.9/1.0	0.0/0.0	+	6	-8.50	-7.75	50/40	ET=2/ET=2

16	17	0.6/0.7	0.0/0.0	+	24	-3.75	-4.00	50/50	XT=3/XT=2
17	37	0.0/0.0	0.0/0.0	-	6	+0.25	+0.25	30/50	Ortho/ET=5
18	34	0.7/0.7	0.0/0.0	+	24	-5.00	-5.00	10/20	Ortho/ET=2
19	21	0.4/0.6	0.0/0.0	-	48	-2.75	-2.75	25/25	Ortho/Ortho
20	32	1.4/1.4	0.1/0.1	+	24	-11.00	-10.75	16/16	XT=2/XT=2
21	17	0.9/0.9	0.0/0.0	-	6	-6.00	-5.75	60/80	ET=2/ET=4
22	23	0.9/0.9	0.0/0.0	-	60	-4.25	-4.25	40/40	XT=2/XT=2
23	25	0.8/0.7	0.0/0.0	-	36	-5.25	-4.00	60/50	ET=4/ET=3
24	11	0.7/0.6	0.0/0.0	-	6	-2.50	-2.25	60/60	ET=4/ET=4
25	30	0.6/0.6	0.0/0.0	+	12	-2.50	-2.50	40/50	ET=2/ET=4
26	15	0.4/0.3	0.0/0.0	-	24	-2.00	-1.50	45/60	ET=2/ET=5

("+"= regularly wearing glasses; "-" = no wearing glasses or no wearing glasses regularly ; VA = visual acuity; UCVA = uncorrected visual acuity; BCVA = best corrected visual acuity; Rt = right; Lt =left; SE=Spherical Equivalent; D = diopter; PD = prism diopter; ET = esotropia; XT = exotropia; Ortho = Orthophoria)

Table 1: *Clinical characteristics of patients with acute acquired comitant esotropia (data).*

Smartphone use: 20 of 26 cases (76.92%) were identified as excessive smartphone users (smartphone use was more than five hours per day on average for more than four consecutive months prior to the development of esotropia). Six cases from the 20 excessive smartphone users used their smartphone for more than 8 hours daily prior to onset of strabismus & diplopia. Five of the 6 remaining cases (19.23%) didn't use their smartphones during the preceding months prior to their presentation though two of the five were in their third year of junior high school and the remaining three were at their third year of their senior high school. These five students were engaged in intensive daily studies in preparation for their entrance examinations into senior high school, or university. (Table 2) One of those 6 cases used the smartphone for less than 3 hours daily.

Course of presentation: For all 26 patients, time of onset of esotropia was within 48 months prior to presentation to our hospital. (Table 3)

Compliance to glasses wearing: 14 cases did not usually wear glasses, despite having significant myopic refractive errors. 10 cases (41.67%) wore glasses full time during waking hours.

Surgical treatment outcome: All 26 cases showed no resolution of esotropia after at least 6 months follow up after initial diagnosis and required surgical correction of their esotropia and diplopia. Except case 11, all other 25 cases only needed one surgical procedure to achieve satisfactory ocular alignment. (Table 1)

Incidence of AACE: The number of cases of AACE had been increasing markedly from 2014 and more rapidly in recent two years. (Table 4)

	Smartphone use per day (hours)					Duration of smartphone use(months)				
	5~8	>8	>2h	No use	Total	4~6	7~9	9~12	12~24	Total
Number of cases	14	6	1	5	26	4	9	5	2	20
Constituent ratio%	53.8	23.2	3.8	19.2	100	20	45	25	10	100

Table 2: *Smartphone use and duration of smartphone use in study subjects.*

	Age(years)					Course(months)			
	<10	11~20	21~30	>30	Total	6-12	12-24	24-48	Total
Number of cases	1	12	8	5	26	13	9	4	26
Constituent ratio%	3.8	46.2	30.8	19.2	100	50	34.6	15.4	100

Table 3: *Age and Course distribution of 26 cases.*

	2009	2010	2011	2012	2013	2014	2015	2016	2017
Number of cases with AACE	1	2	2	2	2	4	5	9	19
Number of all cases with strabismus	720	1055	1403	1484	1354	1384	1374	1264	1256
Constituent ratio of AACE%	0.14	0.19	0.14	0.13	0.15	0.29	0.36	0.71	1.51

Table 4: *Number of cases with AACE and Constituent ratio from the year 2009 to 2017.*

Discussion

AACE was a rare type of esotropia seen in routine ophthalmic practice and a few of cases reported had been found to be related to intracranial tumors, or other central nervous system diseases such as demyelinating diseases. [11-13] In 1958, Burian and Miller firstly summarized the features of AACE. [1] AACE has been defined in three types: Swan type, Franceschetti type and Bielschowsky type: (1) Swan type: Esotropia is caused by the disruption of fusion, especially by loss of vision in one eye or monocular occlusion; (2) Burian-Franceschetti: Esotropia is characterized by a minimal amount of hypermetropia. No underlying cause of the strabismus can be found, although this type of esotropia is often associated with physical or psychological stress; (3) Bielschowsky type: Esotropia occurs in adolescents and adults. These patients are myopic with varying degrees and show a constant esodeviation at distant and at near fixation. [3, 4] The etiology mechanism of Bielschowsky type AACE is thought to be excessive near work because of uncorrected myopia. Balance between converging and diverging of the eye can be broken by reading printed materials or sewing excessively close to the eye. Subsequent the increase in tonus of the medial rectus muscles can lead to development of esotropia. [3]

All 26 cases with acute onset of comitant esodeviation showed no clinical evidence of paralysis of the extraocular muscles. Among the 26 cases, 24 cases presented with myopia, while only 2 cases had mild hypermetropia.

According to Bielschowsky uncorrected myopia was the main cause of this form of acute esotropia. In our current study, 14 of 24 patients with myopia (58.33%) didn't wear glasses regularly and they were likely to have Bielschowsky type AACE. 10 of 24 patients (41.67%) with myopic refractive error in our study, who wore glasses regularly, were inconsistent to any of the above three types of AACE described. One common observation was the excessive near visual activities engaged by all our cases, especially the use of smartphones among all those cases prior to the development of AACE. Therefore, we may deduce that AACE could be caused by excessive near work regardless of whether or not one wears glasses regularly for individuals with myopic refractive error.

Excessive smartphone use of more than five hours per day, was a predominant observation among majority of the subjects (20/26) in our study. The other five subjects, although did not engage in excessive smartphone use in the course of undertaking intensive studies for preparation of higher school, or university entrance examinations. It is conceivable that prolonged near visual activities using smartphone may have contributed to the increase of AACE cases.

The number of AACE cases diagnosed in our hospital has increased by 10 fold from the years 2009 to 2017. Smartphone distribution has dramatically increased all over the world including China in the past decade, especially in the past five years. [5,6] We strongly suspect that the rapid increase of the availability of smartphones and its use in recent years have contributed to this trend. (Table 4)

A survey about smartphone addiction conducted by the National Information Society Agency from Korea in 2012 showed that addiction rates were highest in teenagers, which illustrated adolescents were more vulnerable to smartphone addiction. [7-9] While in our study 20 cases were at ages of 11 to 30 years old, (Table 3) our study also shows teenagers and individuals with more severe addiction are more susceptible to AACE.

In 2016, Lee, et al. showed that abstaining from smartphone usage can decrease the degree of esodeviation in AACE patients. [10] However, we did not advise our patients to reduce the smartphone use as part of the management strategy of their AACE due to late awareness of Lee's research. We propose that education about abstinence of smartphone use may be necessary and be an useful step prior to surgical treatment in these patients.

It is possible recovered abducens nerve paralysis could be the cause of the acute esotropia in some of our cases. However the lack of systemic illness and normal neuroimaging with MRI scan made this unlikely to be the cause. This study is limited due to the retrospective nature. The absolute causation of smartphone use and AACE can only be proven by a controlled prospective study.

With the increasing use of smartphones and tablets in modern life, more and more work is being done through a small screens at a close distance. The habit of long-time sustained near work on these devices may increase the risk of inducement of AACE.

Acknowledgements

Data Availability

The data used to support the conclusions of this study are available from the corresponding author upon request.

Disclosure

The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript. Yan Wu and Shuan Dai are co-first authors.

Conflicts of Interest

The authors declare no conflicts of interest regarding the content, or publication of this paper.

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