

Ocular Motor Behavior Monitor in Intermittent Exotropia by Eye Tracker

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Research Article

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Abstract

Purpose: Eye movement in intermittent exotropia (IXT) patients is characterized by variability and uncertainty, however, conventional strabismus inspection methods cannot reflect these important qualities. Here, we sought to study the ocular motor behavior of IXT under different viewing conditions by eye tracker.

Methods: Sixty-one IXT patients (33 males and 28 females) and 15 age-matched control participants were recruited for this study. An eye tracker equipped with a high-speed camera and MATLAB software was employed to monitor and record eye movement as well as eye position in included subjects with 3D shutter glasses at a normal reading distance (57 cm).

Results: By using an eye tracker, our data showed that 90% of the included IXT patients lost their control and showed exotropia in 1.5 ± 2.1 s. The average deviation degree measured by the eye tracker was $32.9 \pm 11.5 \Delta$, ranging from 6 to 50Δ , and reached its maximum deviation degree at $36.9 \pm 12.4 \Delta$, with a mean time of 2 ± 1.5 s. Although a significant difference exists in the strabismus quantification between the prism test and the eye tracker, the test results obtained from these two methods were positively correlated. Moreover, by using the eye tracker, the fixation instability of IXT patients could be easily recorded and analyzed. In addition, the included IXT patients were divided into three types according to their ocular motor behavior as monitored by an eye tracker.

Conclusion: Eye trackers could not only provide continuous, precise and effective strabismus assessments but also analyze ocular motor behavior over a period of time in IXT patients.

Introduction

Intermittent exotropia, the most common type of childhood onset divergent strabismus,¹ occurs in approximately 1% of American children and even more frequently in Asian populations.^{2,3} Intermittent variability and uncertainty have been well recognized as the most extraordinary features of intermittent exotropia. Unlike other concomitant strabismus, which presents with no more than two eye positions, intermittent exotropia patients exhibit varied ocular positions: they are able to maintain eye alignment but easily manifest deviation with diverse exotropia degrees when tired or under stress, during soft-focus, or experiencing illness,⁴ more importantly changing the deviation degree easily at will.^{5,6} Extensive studies have shown that exotropia might be the consequence of convergence dysfunction with or without ocular anatomical abnormalities. However, the mechanisms that trigger the loss of fusion and result in varied axial misalignment in intermittent exotropia have yet to be defined.

Conventional strabismus inspection methods, such as prism, synoptophore, perimeter arc, etc., only evaluate the deviation degree of intermittent exotropia patients at a certain point in time, which can cause errors in intermittent exotropia patient diagnosis, and cannot continuously observe the eye movement patterns in intermittent exotropia patients. The poor control and impaired fixation stability of intermittent exotropia patients^{7,8} creates practical challenges for accurate strabismus assessments by conventional physicians to determine the patient's exodeviation control ability, thus impeding an accurate assessment of the severity and progression of intermittent exotropia. Additionally, continued controversy exists regarding the control quantification of intermittent exotropia patients with conventional inspections. Hence, continuous objective dynamic observations of eye position would help capture the moment when fusion breaks and the eye drifts outward, which might also shed light on the pathological processes of intermittent exotropia.

With an eye tracker, dynamic changes in eye movement over time in intermittent exotropia patients can be easily monitored, and the control ability as well as fixation can be quantified. Eye tracking technology has been continually developed and successfully employed to address various clinical problems in neurodegenerative diseases.^{9,10} It has also been proposed for strabismus examination.^{11,12,13} Schaeffel assessed the Kappa and Hirschberg ratios by using a video gaze tracker.¹⁴ A camera vision system was designed to measure the deviation angle in young children with strabismus and has been proven to be fast and accurate.¹⁵ Moreover, whether dichoptic attentive motion tracking is biased was evaluated in strabismus amblyopia by a dichoptic multiple-object tracking system.¹⁶ Furthermore, the measurement acuity in the deviation degree of strabismus patients has been confirmed with an eye tracker.⁷ However, no thorough research has been conducted on intermittent exotropia patients. With the assistance of an eye tracker device, the different gaze states of the intermittent exotropia patients and their conversion process can be

accurately and continuously recorded, which might provide ophthalmologists with a better understanding of intermittent exotropia
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To achieve a more comprehensive strabismus evaluation in intermittent exotropia patients, a desktop eye movement recorder (SR Eyelink1000) equipped with a high-speed digital camera and well-designed automated system was employed to monitor ocular motor behavior and assess the exodeviation degree of intermittent exotropia patients over a continuous period of time. This study presents an approach that might facilitate exploring the neural mechanisms underlying intermittent exotropia and provides a more objective and comprehensive examination basis for the diagnosis and treatment of patients with intermittent exotropia.

Methods

Patient Recruitment

This research was reviewed by an independent ethical review board and conforms with the principles and applicable guidelines for the protection of human subjects in biomedical research. This study was approved by the national ethics committee at Zhongshan Ophthalmic Center. Sixty-one patients (33 male and 28 female) diagnosed with intermittent exotropia by professors at the Zhongshan Ophthalmic Center and 15 age-matched control participants were recruited for this study. All subjects and their legal guardians were given the details of the study content in oral as well as written form and signed an informed consent form voluntarily. The included subjects had an average age of 15, ranging from 7 to 22, had a corrected distance visual acuity (CDVA) better than 16/20, and presented with no ocular or systemic illness other than intermittent exotropia and refractive errors. All procedures were performed in strict accordance with the Declaration of Helsinki.

Patient examinations

Standard ocular examinations were performed for all subjects, including corrected distance visual acuity (CDVA), slit-lamp exam, fundus exam, optometry test and conventional strabismus evaluation by synoptophore, perimeter arc, and prism alternate cover tests. The inclusion criteria of this study were as follows: 1) congenital intermittent exotropia diagnosed by professor Daming Deng from the Zhongshan Ophthalmic Center. The patients showed intermittent divergent misalignment, and their diagnosis was made by using the prism cover test; 2) presented with no ocular or systemic illness other than intermittent exotropia and refractive errors; 3) had a corrected distance visual acuity (CDVA) better than 16/20 in Snellen acuity; 4) no history of any ocular surgery; 5) ability to fix and absent diplopia, vertical strabismus and nystagmus; 6) the squint of the visual field arc was less than 30°, and the squint of the prism was less than 50△; and 7) more than 7 years old and could understand and cooperate with relevant inspections.

Apparatus

An Eyelink1000 eye tracker (SR Research Ltd.) was employed to monitor eye movement and position in the present study.¹⁸ This desktop eye tracking system is mainly composed of an infrared light transmitter, a high-speed camera, a computer and record-analysis software, which allows efficient, accurate and convenient eye tracking assessment. Moreover, no device was required to be worn by the included subjects, which was compatible with glasses or contact lenses and kept subjects undisturbed during the test.

Vision stimuli were displayed on an ASUS 3D monitor (VG278, 144-Hz refresh rate, 1920*1080 resolution, Taiwan) using MATLAB (Kanata, ON, Canada) and PsychToolbox. Subjects held a fixed head position that was stabilized in a chin/forehead rest and a sight level in the center of a monitor screen, viewing the screen through NVIDIA 3D VISION LCD shutter glasses (Santa Clara, CA, USA) at a distance of 57 cm.

Eye track assessment

After obtaining the consent forms, the subjects were scheduled with conventional strabismus evaluation and eye track assessment on separate days. Clinical data were obtained and collected. Conventional strabismus evaluations, including synoptophore, perimeter arc, and prism alternate cover tests, were carried out by the same experienced examiner for all subjects according to standard procedures.

For eye track assessments, the eye movements of all subjects were monitored under the best corrected vision in the same examination room with adequate lighting by the same technician to ensure uniformity. At the beginning of each inspection, the subject's eye position was calibrated by using a nine-point calibration method. Briefly, after fixation of the subject's head position, one eye was covered, and the tracker monitored the eye movement of the other eye. Nine stationary calibration points arranged in a 3*3 square array was randomly projected on the screen one by one. The subject was instructed to track the visual target that appeared, and audio feedback was given after each trial. This detection was repeated multiple times until both eyes passed the calibration test.

After calibration, subjects performed the target tracking task in the following four visual situations: simultaneous binocular gaze, right eye gaze, left eye gaze and binocular separation. During monocular gaze, the gaze target of one eye was blocked by 3D split glasses, leaving the other eye to gaze. In addition, 3D splitting glasses were used to force the eyes to fixate on different fixation targets during binocular separation. The gaze target was displayed in the center of the computer screen, one second at a time, and then again at 0.4-second intervals to stimulate the subject to concentrate on the gaze. The duration of each experiment was 2 minutes, and then the subject rested and changed the gaze to continue the examination.

Statistical Methods

The clinical data are presented as the mean \pm standard deviation (SD), and normality was tested by the Shapiro–Wilk test. Data that were normally distributed were analyzed with paired t-tests and ANOVA; otherwise, they were analyzed with nonparametric statistics. The strabismus angle evaluated by different methods was compared by using ANOVA. The fixation ability results were analyzed by using Mann–Whitney U tests. The correlation between three types of intermittent exotropia subjects defined by eye tracker and conventional intermittent exotropia classification was analyzed by Spearman's correlation test. All statistical analyses were performed with SPSS Statistics 19 (SPSS Inc., Chicago, IL). A P-value less than 0.05 was considered statistically significant.

Results

1. Clinical Characteristics of the intermittent exotropia Patients

This study was conducted between July 2017 and December 2019 at Zhong Shan Ophthalmic Center. During that period of time, 61 patients (33 male and 28 female) diagnosed with intermittent exotropia by Pro. Deng, along with 15 age-matched control subjects, were included in this study. The basic clinical information of all subjects included in this study is presented in Table 1. The average patient age was 15.47 ± 7.41 years, ranging from 7 to 36 years. The average onset age was 11.35 ± 6.37 years, ranging from 5 to 25 years. The manifest spherical equivalent (SE) was -1.25 ± 0.85 diopter (D), ranging from -4.25 D to +1.50 D. The corrected distance visual acuity (CDVA) of all subjects was better than 16/20 (snellen). The average AC/A was 4.30 ± 0.23 . The intermittent exotropia severity of subjects evaluated by the Revised Newcastle Control Score (RNCS)¹⁹ was 5.3 ± 2.9 . The IOP of all patients was within the normal range (13.2 ± 1.7 mmHg). Moreover, no fundus abnormality was observed in any of the subjects. In addition, the dominant eye of intermittent exotropia patients was measured by the card-hole method. Among the 61 patients, 40 patients had dominant right eyes, and the other patients had dominant left eyes.

2. Deviation degree evaluation by both conventional and eye tracker qualification in intermittent exotropia patients

Conventional strabismus quantification included synoptophore, perimeter arc, and prism alternate cover tests. First, we evaluated the accuracy and reliability of the eye tracker in measuring the deviation angle in intermittent exotropia patients by comparing its strabismus results with those of conventional assessment. For comparative analysis, the results of the prism strabismus inspection were converted according to $1^\circ = 1.75\Delta$.

As seen in Table 2, the data obtained from the prism and alternate cover tests show that the average deviation degree of these 61 intermittent exotropia patients was $31.1 \pm 11.4\Delta$ at 33 cm, ranging from 8Δ to 50Δ , and 30.3Δ at 5 m, ranging from 10Δ to -50Δ . In addition, the synoptophore tests showed a $26.1 \pm 12.8\Delta$ deviation degree, ranging from 0- 50Δ , in the included intermittent exotropia patients. The perimeter arc showed a near value of $32.6 \pm 7.8\Delta$, ranging from 0Δ to 30Δ , and $31.6 \pm 7.0\Delta$ at 5 m, ranging from 5Δ to -50Δ .

With the assistance of data view software, the eye position data recorded by SR Eyelink1000 were organized into coordinate values. The coordinates on the X-axis represent the deviation degree of intermittent exotropia patients. The maximum and average values were taken into analysis. As shown in Table 2, the mean deviation degree for all subjects was $32.9 \pm 11.5 \Delta$, ranging from 6Δ to 50Δ . The maximum deviation degree was approximately $36.9 \pm 12.4 \Delta$ (95% CI: 6.5 to 51). Moreover, the correlation analysis (Figure 1) showed that the deviation degree monitored by the eye tracker is positively correlated with that measured by the prism and alternate cover test. However, there is a significant difference in the strabismus results quantified by these two methods.

3. Fixation ability in intermittent exotropia patients evaluated by eye tracker

We also monitored the fixation ability of intermittent exotropia patients with the SR Eyelink1000. The steady fixation (more than 500 milliseconds) was captured and recorded for 2 min by the video tracker of the SR Eyelink1000 and presented as data points (Figure 2). The subjects' fixation ability was evaluated by the ellipse area that contained 95% data points. The logarithm of the smallest ellipse areas was used for statistical analysis with the Wilcoxon rank test. Our data showed that in normal subjects, the fixation ability was stable under binocular fixation, monocular fixation or binocular dichoptic fixation, presenting a small ellipse area (Table 3). However, unsteady gaze ability was observed in both eyes of the intermittent exotropia patients, especially under binocular dichoptic viewing situations: the mean ellipse area was 4.36 log units (95% CI) in fixating eyes and 4.78 log units (95% CI) in deviating eyes. It is obvious that the fixated eyes were much more stable than the deviated eyes in intermittent exotropia patients ($*P < .05$), though they were more variable than both eyes in normal subjects ($*P < .05$).

4. Classification of intermittent exotropia subjects based on eye tracker analysis

After the head position was fixed, the subjects were instructed to gaze the viewing target that flickered in the center of the computer screen. Fig. 3 presents the eye movement recordings of an intermittent exotropia patient by SR Eyelink1000 under four visual situations: simultaneous binocular gaze, right eye gaze, left eye gaze and binocular dichoptic gaze.

The test stability has been verified in normal subjects, showing great test-retest reliability (data not shown). When under binocular fixation, only 59.3% included intermittent exotropia subjects shows exotropia, and the average time beginning to lose control and showing exotropia was 4.1 ± 10.8 s, ranging from 0 to 59.1s, and reached their maximum deviation degree at 39.6 ± 45.1 s, ranging from 0 to 110.5s (Table 4). When under binocular dichoptic conditions, up to 83.7% intermittent exotropia subjects shows exotropia, the average time beginning to lose control and showing exotropia was 4.6 ± 8.9 s, ranging from 0 to 30.2s, and reached its maximum deviation degree at 51.4 ± 45.3 s, ranging from 21.1 to 112.8s (Table 4).

As shown in Fig. 4, the eye position was recorded as dots: red dots represented the eye position of the right eyes, and green dots represent those of the left eyes. According to the eye position distribution characteristics under binocular dichoptic monitoring by the SR Eyelink1000, the included intermittent exotropia patients could be classified into three categories as follows: A) relatively good control ability and exhibits exotropia only in monocular visual situations; B) weak control and exhibits exotropia in all four visual situations; and C) sporadic control and exhibits changeable eye position. Accordingly, we evaluated the severity of exodeviation degree of intermittent exotropia subjects in these three categories by using a well-recognized clinically significant grading method for the severity of intermittent external squint, the Revised Newcastle Control Score (RNCS).¹⁹ Our data shown that type A patients scored lowest (2.6 ± 1.6), and type B patients scored highest with most unstable intermittent exotropia condition (7.9 ± 1.0 , $*P < .05$), suggesting that the classification based on eye tracker could reflect the severity of intermittent exotropia in strabismus patients.

Moreover, we further analyzed and summarized the binocular visual function of these three types of intermittent exotropia as categorized by the eye tracker. The disease course, AC/A, stereopsis, fusion function, strabismus degree and monocular suppression condition were analyzed. All clinical information is presented in Table 5. Unfortunately, no significant differences in these data were observed among the three types of intermittent exotropia subjects.

Discussion

Intermittency and variability have been characterized as the most extraordinary clinical features of intermittent exotropia ; however, conventional strabismus inspection methods cannot reflect these important qualities well.^{20,21,22} Here, our data suggest

that an automatic eye tracking system can monitor eye movement dynamically in intermittent exotropia patients continuously and effectively. And on this basis, intermittent exotropia patients would be classified into three categories, not only provide ophthalmologist with supplemental information of intermittent exotropia, but also guide clinician with intervention strategy.

In intermittent exotropia patients, the deviation degree does not always match their control ability^{23,24}, and their control ability often vary over the course of a day, indicating that a single observation is inadequate for intermittent exotropia strabismus assessment.^{23,25} While, conventional strabismus examinations can only present the eye position at a certain point in time. More importantly, a covering test is usually needed to induce ocular misalignment, thereby failing to reflect the necessarily daily state of intermittent exotropia patients. Whilst, eye tracker allows a continuous and intuitive observations of eye movement in intermittent exotropia patients, under different viewing situations while they are not disturbed, providing a more objective strabismus inspection result. Besides, most of the conventional strabismus test results may be discrepant for different observers, as experienced examiners and cooperative patients are both necessary for reliable results. It is likely that a well-designed eye tracker could address this issue; however, its clinical appliance needs further investigation, and its process warrants deeper optimization.

Monitoring ocular motor behavior may provide plenty information that gives us some primitive understanding of the neural basis of intermittent exotropia. Economides et al. analyzed eye movements recorded by eye trackers in intermittent exotropia patients when fusion loss occurs and concluded that fusion loss is not affected by visual feedback in intermittent exotropia.¹⁷ Incomitance in approximately 40% of intermittent exotropia subjects was observed by using a video eye tracker.²⁶ Moreover, horizontal changes in the binocular coordination smooth pursuit of intermittent exotropia patients during pre- and postsurgical strabismus correction were investigated by an eye tracker.²⁷ Here, the intermittent exotropia subjects shown varied control ability during different gazing situation, with poorest control ability under binocular dichoptic conditions as more than 80% subjects showing exotropia. Moreover, the average time began to lose control and show exotropia as well as the time reaching their maximum deviation degree were recorded, reflecting gaze instability and poor control in intermittent exotropia. There are several control rating methods applied in the current clinical diagnoses; however, their reliability remains controversial. Eye trackers might provide a new objective approach to quantify the control ability of intermittent exotropia patients.

In addition, the included intermittent exotropia patients were divided into three types based on the eye position distribution under dichoptic viewing conditions and their intermittent exotropia severity was evaluated by using a well-recognized clinically significant grading method, the Revised Newcastle Control Score (RNCS) squint. Our data shown that this classification reflects the control ability and stability degree of intermittent exotropia patients, providing surgeons with a more intuitive assessment of the severity and progression of an intermittent exotropia patient's condition, which might have more guiding significance for clinical strategy decisions. However, due to the relatively small sample size or the inclusion standard bias of the enrolled subjects (patients that too young, or with mild strabismus or displayed a great degree of deviation were not included), no obvious correlations between eye movement distribution drawn by the eye tracker in the dichoptic state with age, AC/A, and vision function were observed in subjects of these three groups. Hence, in our future study, more intermittent exotropia subjects will be recruited, and a retrospective analysis of intermittent exotropia patients in a long-term follow-up will be conducted to further confirm the value of eye trackers in the daily clinical treatment of intermittent exotropia.

Furthermore, a direct view of the changeable misalignment can be easily observed by eye tracker, hence both the average and maximum deviation degrees can be recorded, which is unavailable by conventional methods. Moreover, these deviation results show good comparative with that of conventional strabismus assessments, indicating its effectiveness in measuring deviation degree. Unsurprisingly, though comparative, there is a significant difference in the deviation degree measured by the prism test and the eye tracker. Four reasons might explain this discrepancy. First, unlike the prism test only detects the strabismus at a certain point in time, the eye tracker incorporates the recorded deviation degree of intermittent exotropia patients within a period of time through the course of a single day into the analysis. Second, the eye tracker records the eye movement and position of subjects viewing a fixing target at a median distance of 57 cm, a commonly used reading distance, under a natural gaze state. The viewing condition for the subjects receiving the prism alternate cover test is different. Third, the deviation degree obtained from the eye tracker reflected a more objective result, as the prism test can interfere by the subjectivity of examiners. Additionally, the eye tracker monitors the eye movement of subjects under a normal state, while the prism test assessment needs the help of a

cover test. Fourth, it is normal to have differences between the data measured by the two different inspection methods, including the errors generated in unit conversion ($1^\circ = 1.75\Delta$). However, further investigation is warranted.

In conclusion, the eye tracker provides a new approach to intuitively monitor changeable ocular motor behavior in intermittent exotropia patients under various viewing conditions over a period of time continuously and effectively, and category them to reflect the strabismus severity, which might shed some light on the pathological basis and innervation strategy of intermittent exotropia. However, to further define the value of eye trackers in clinical treatment, more investigations and repeated data collections at different time periods are warranted.

Declarations

Availability of data and materials

The datasets used and analyzed for the present study are available from the corresponding author.

Authors' contributions

XC, ZC, YL, ZL, DD collected and analyzed the data. XC, DD and MY interpreted the data. XC, ZC and MY were the major contributors in writing the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

All research methods are in accordance with the tenets of the Declaration of Helsinki and approved by the ethics committee board of the University of Miami. All subjects were recruited voluntarily and were informed about the purposes, methods, and the potential risks of the study. A signed consent form was obtained from each volunteer.

Consent for publication

All study subjects gave informant consent.

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Tables

Table 1: Demographics of the IXT patients in the study.

Characteristic	Mean ± Standard Deviation (SD)
Patients	61
Sex	33 males and 28 females
Age (years)	15.47±7.41 years (range 7 to 36 years)
Onset age(years)	11.35±6.37 years (range 5 to 25 years)
Spherical equivalent (D)	-1.25±0.85D (range -4.25D to +1.50D)
logMAR UDVA	1.32±0.68
logMAR CDVA	-0.08±0.07
AC/A	4.30±0.23
Intraocular pressure (mmHg)	13.2±1.7mmHg

LogMAR = logarithm of the minimal angle of resolution.

Table 2: Strabismus angle of the IXT participants

	Prism Δ		Arc perimeter (deg)		Synoptophore Δ	Eye tracker Δ	
	near	far	near	far		mean	max
Average	31.1±11.4	30.3±11.4	32.6±7.8	31.6±7.0	26.1±12.8	32.9±11.5	36.9±12.4
Range	8-50	10-50	0-30	5-30	0-50	6-50	6.5-51

Table 3: Bivariate contour ellipse area (BCEA)

Fixation target	Normal	IXT patients	
		Fixation eye	Fellow eye
Binocular	3.12±0.41	3.81±0.51	
Monocular	3.57±0.35	3.87±0.32	4.57±0.36
Dichoptic	3.56±0.33	4.36±0.53	4.78±0.37

Table 4: The time deviation appearing and to the peak

Fixation condition	Extropia	Deviation appearing		Time for largest angle (s)
			time (s)	
Binocular	59.3%	mean	4.1±10.8	39.6±45.1
		range	0-59.1	0-110.5
Dichoptic	83.7%	mean	4.6±8.9	51.4±45.3
		range	0-30.2	21.1-112.8

Table 5: Strabismus analyze of the three eye motion types in IXT patients

Type	Number	Age (years)	Time (years)	AC/A	Stereopsis	Strabismus angle (Δ)	RNCS
A	10 (16.3%)	20 \pm 6.9	8.7 \pm 3.5	3.33 \pm 0.23	80	31.0 \pm 13.7	2.6 \pm 1.6*
B	22 (36.1%)	14.9 \pm 6.4	6.9 \pm 3.0	5.26 \pm 0.13	80	32.5 \pm 9.6	7.9 \pm 1.0*
C	29 (47.5%)	13.7 \pm 6.8	7.2 \pm 4.1	4.33 \pm 0.23	40	29.2 \pm 12.8	5.5 \pm 1.9*

Figures

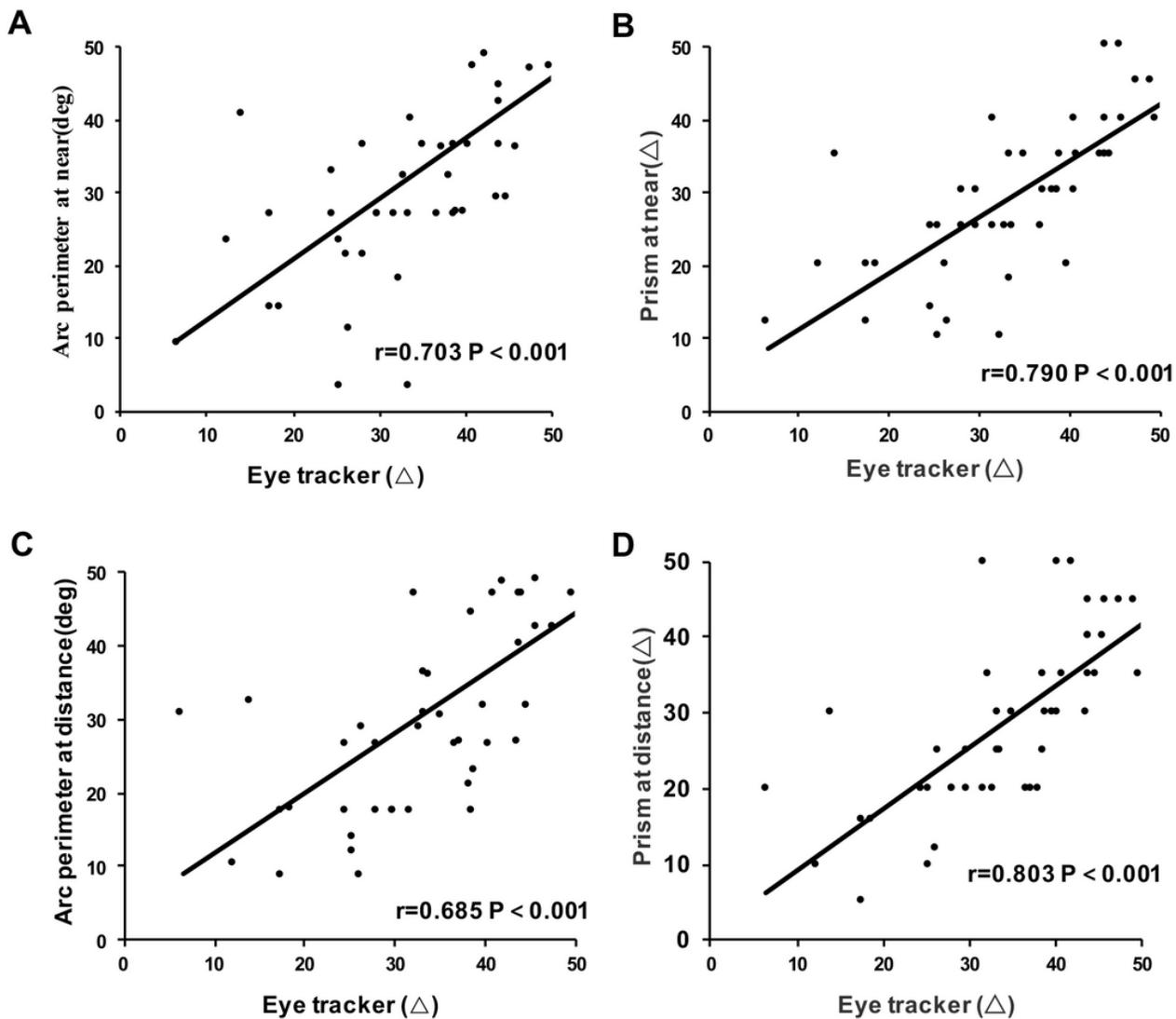


Figure 1

Correlation analysis of deviation degree monitored by eye tracker, prism and alternate cover test. A, Deviation degree at near (33cm) monitored by eye tracker is positively correlated with that of measured by alternate cover test. B, Deviation degree at near

(33cm) monitored by eye tracker is positively correlated with that of measured by prism. C, Deviation degree at distance monitored by eye tracker is positively correlated with that of measured by prism. D, Deviation degree at distance monitored by eye tracker is positively correlated with that of measured by alternate cover test.

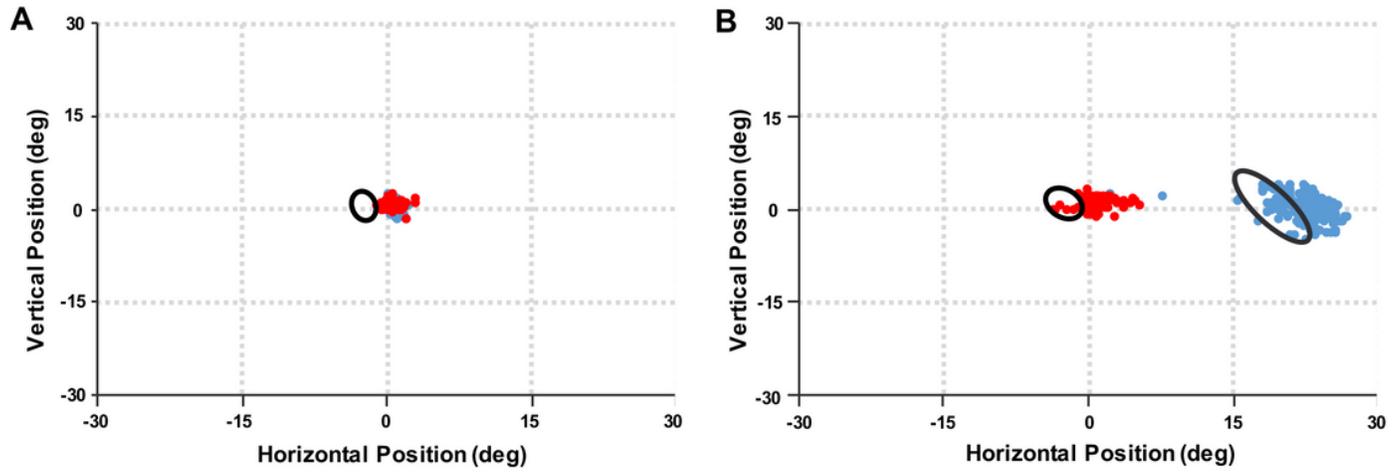


Figure 2

The fixation during 2 minutes recorded by the video tracker. A, Normal subjects shown steady fixation. B, The intermittent exotropia patients shown oscillating gaze. (right eye: blue dots, left eye: red dots)

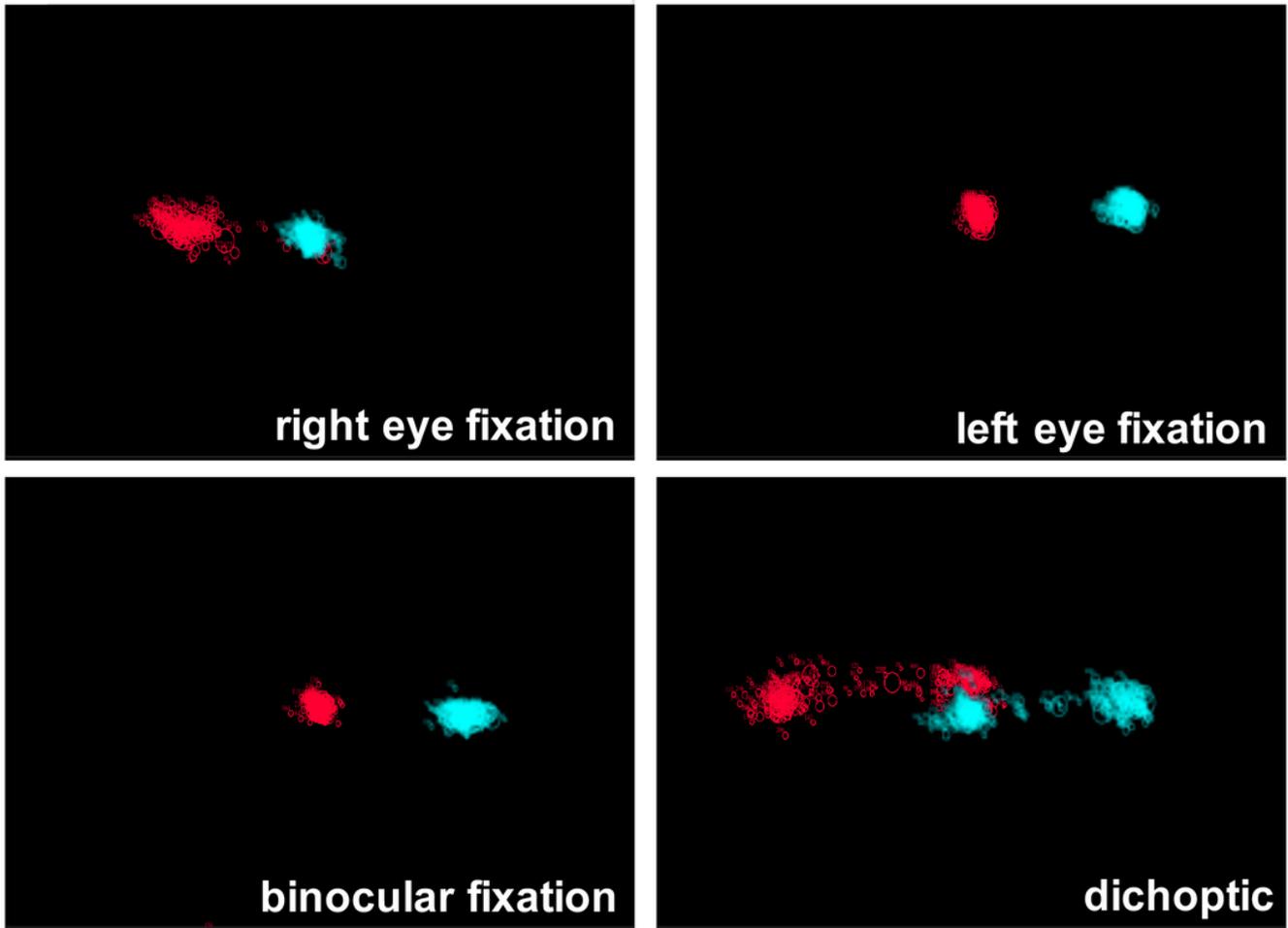


Figure 3

Eye movement of an intermittent exotropia patient. A, Eye movement under simultaneous binocular gaze. B, Eye movement under right eye gaze. C, Eye movement under left eye gaze. D, Eye movement under binocular dichoptic. (right eye: blue dots, left eye: red dots)

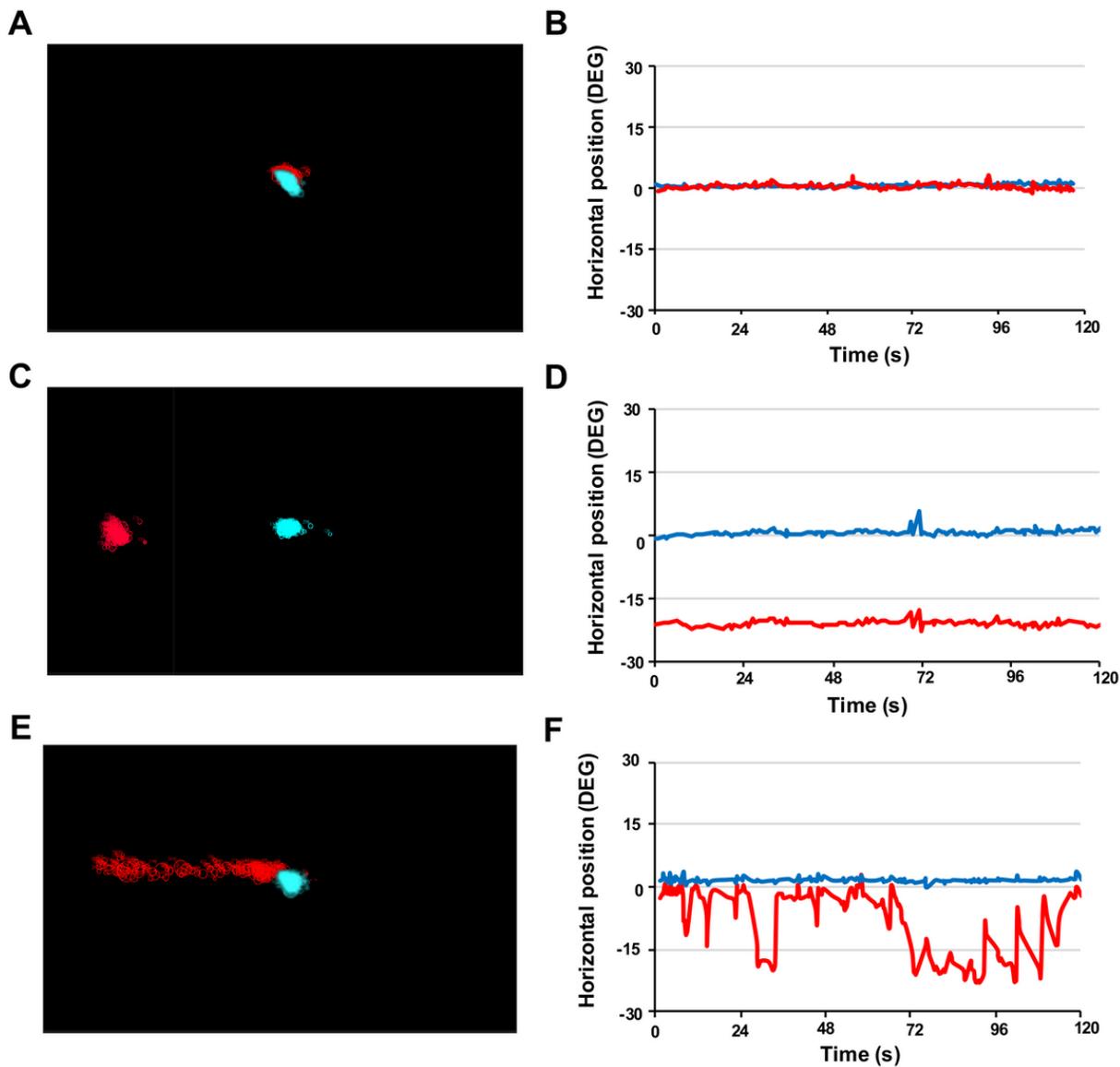


Figure 4

Intermittent exotropia classification based on eye movement pattern. A, Showing relatively good control ability and exhibit exotropia only in monocular visual situation. B, Showing poor control and exhibit exotropia in all four visual situations. C, Showing sporadic control and exhibit changeable eye position. (right eye: blue dots and lines, left eye: red dots and lines)