Introduction

Congenital cataract is one of the most common causes of congenital visual disability. The loss of adequate stimuli during a very sensitive period of time in a child’s visual development causes permanent visual impairment.

A child with dense bilateral congenital cataract, that is not treated during the first 3 months of its life, will almost certainly develop anomalies in its motility (nystagmus), its visual development will be impeded and its visual acuity will seldom rise above 0.2 (Fig 1a).

Several studies1-3 have shown that early surgical treatment of children with dense bilateral congenital cataract, which have not developed nystagmus, followed by careful amblyopia treatment and a thorough follow-up of visual development, leads to good visual acuity in most cases, compared with those children with dense bilateral congenital cataract (Fig 1b). However, there are findings that claim that the factors mentioned above are not prognostically significant in visual outcome and the development of nystagmus in these children4,5.

In children with congenital cataract that develop nystagmus, the nystagmus changes with age and visual acuity in a way that has been difficult to describe and define in an unambiguous manner. In this study eye movements in children with congenital cataract were registered with a personal computer and an eye-tracking device in order to obtain quantitative eye movement and foveation data.

Methods

The eye movements were recorded with an i486DX PC equipped with the Ober2 parallel infra-red eye movement system (Permobil Medtech, Inc., Woburn, MA). Eye movements are measured using goggles, with an array of pulsed light emitting infra-red diodes along with an array of photo-detectors, by rim-detection using the infra-red limbal reflection technique. Horizontal and vertical eye movements of both eyes are measured simultaneously. Data was recorded with a sampling rate of 120 Hz.

Spectral analysis methods were implemented in order to obtain frequency information and for correlation analysis. Foveation was evaluated using a method developed by Dell’Osso et al.6 The foveation window used in the analysis was defined by a velocity component of ± 3 °/sec and a positional component of ± 0.5°. As additional 1.3° was added to the foveation window to compensate for the actual size of the viewed target.

Recorded data was converted from Ober2 to text format and transferred to a Macintosh computer. Calculation and analysis was performed with Matlab 4.2c1 (The MathWorks Inc., Natick, MA). Velocity data was acquired by numerical derivation of positional data. Frequency analysis was performed by taking the Fast Fourier Transform of the positional data. Cross-correlation coefficients of right and left eye velocity data were computed to yield measures of eye movement similarities.

Phase-plane portraits of eye position vs. velocity were constructed in order to analyze foveation.

Results

Phase-plane portraits of the horizontal trajectories of the left and right eye respectively of a 14 year old girl are presented in Fig 2a-e. The frequency of the ocular tremor is clearly seen in the power spectrum plots (Fig 1a-c). Visual acuity was 0.2 (20/100) (OD) and 0.2 (20/100) (OS), foveation times were (1 sec interval) 0.95 sec (OD) and 1 sec (OS), and the crosscorrelation coefficient = 0.32.

Phase-plane portraits of the horizontal trajectories of the left and right eye respectively of a 12 year old boy, are presented in Fig 3a-e. The high velocity loops are the fast phases of the jerk nystagmus which move the eyes to the foveation window. The decelerating leftward slow phase moves the eyes away from the foveation windows. The jerk nystagmus gives rise to a peak in the power spectrum plots (Fig 1a-c). Visual acuity was 0.4 (20/50) (OD) and 0.1 (20/200) (OS), foveation times were (1 sec interval) 0.2 sec (OD) and 0.15 sec (OS), and γ = 0.92.

Discussion

The changes of the nystagmus that occur both over time and due to surgery in children treated for congenital cataract are difficult to describe in quantifiable terms. So far we have relied upon qualitative assessments of longitudinal changes of nystagmus and other motility disturbances, assessments that have been difficult to evaluate.

We have developed a quantitative method that will allow us to follow and characterize changes in motility with age and visual acuity development in children with congenital cataract. Thus far measurements have been done on children aged 1.5 years an older, and we are continuing our effort to examine even younger children in order to be able to differentiate among children at risk of developing nystagmus.

References