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Original Article

Possible Linkage Between Visual and Motor Development in Children With Cerebral Palsy

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ABSTRACT

AIM: The purpose of this study was to examine ophthalmic disorders associated with neurological disorders in children with cerebral palsy. **METHODS:** Children clinically diagnosed as cerebral palsy with supportive abnormal magnetic resonance imaging results were included in this prospective study. All participants were recommended to have comprehensive ophthalmic exams. To assess motor function, the Gross Motor Function Classification System and the Gross Motor Function Measure were used. To assess motor and cognitive function, the Bayley Scales of Infant Development-II was used. **RESULTS:** Forty-seven children completed all the evaluations and the data were analyzed. Ametropia was seen in 78.7% and strabismus was seen in 44.7% of the 47 children. When subjects were divided into severely impaired and mildly impaired groups based on Gross Motor Function Classification System level, ametropia was more prevalent in the severely impaired than the mildly impaired (95.8% versus 60.9%, $P < 0.05$). According to quantitative analysis, the severity of gross motor impairment correlated with the degree of refractive error in the subjects older than 36 months ($r = -0.65$ for the Bayley Scales of Infant Development-II motor scale, $P < 0.05$). **INTERPRETATION:** Based on these findings, children with cerebral palsy with poor gross motor function have a high possibility of severe refractive disorder that becomes evident from 36 months after birth. These results suggest that brain injury and impaired motor development negatively affect ophthalmic development. Hence, an ophthalmic examination is recommended for young children with cerebral palsy to start early management.

Keywords: cerebral palsy, gross motor, refractory error, correlation

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Introduction

Cerebral palsy represents a group of posture and motor development disorders caused by brain insult during the fetal and infant periods.[1] Many associated disorders, such as seizure, cognitive impairment, and perceptual disorders, were known to add functional deficit in daily lives in victims of cerebral palsy.[2] Ophthalmic disorders are the most frequently associated problem in cerebral palsy[3,4] and may also influence the patient's developmental process. The related pathognomonic disorders are presented as refractive errors and strabismus.[5-7]

Because ophthalmic disorders and neurological deficits in cerebral palsy have a high possibility of being related, several studies have investigated the correlation between neurological impairment and ophthalmic disorders. One study reported that there is no association between the severity and the degree of refractive error in cerebral palsy.[8] On the contrary, a cross-sectional study of 50 children with cerebral palsy showed children with severe cerebral palsy were at greatest risk for high myopia, absence of binocular fusion, dyskinetic strabismus, and severe gaze disorders.[9] The other showed an association between motor and intellectual impairment with accommodative function.[10] Another study that showed a correlation between ophthalmic impairment and motor

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disorders in very low-birth-weight adolescents.[11] Among the possible neurological sequelae, motor impairment is always the main area of concern because it determines the functional limitation of children with cerebral palsy.

Until now, research on the ophthalmic disorders in children with cerebral palsy showed limited aspects of development. Clear diagnosis using strict criteria, including brain-imaging data, was not provided, especially for cerebral palsy patients.[5-7] There are still unidentified situations that mimic clinical manifestation of cerebral palsy.[12] Moreover, the subjects were older than age 4 years in most of the studies.[3,5,6,10,11] Thus, we cannot determine the association between ophthalmic and motor system development. A few reports suggested that fixation of refractive error occurred between ages 2.5 and 3 years.[13,14] No studies have taken age into consideration neurodevelopment with respect to ophthalmic function in neurologically impaired children. Last, to examine a relationship between two different systems, it is necessary to use continuous variables. Up to the present, relevant studies that assessed vision categorized subjects only into three or four groups of motor impairment and lacked quantitative determinants of functional impairment.[8-11]

Thus, we intended to investigate the possible linkage of ophthalmic and motor development in children with cerebral palsy by assessing the relationship between severity of neurological disorders and degree of ophthalmic disorders. This was investigated through comprehensive ophthalmic examinations and standardized function measures. Age was also considered an important factor in the relationship between ophthalmic function and motor development; therefore, we analyzed the relationship according to age.

Methods

Participants

After approval from the Institutional Review Board at the CHA Bundang Medical Center for this prospective study, 67 children between ages 1 and 7 with suspected cerebral palsy were recruited between May 2010 and November 2011. For proper diagnosis, brain magnetic resonance imaging (MRI) was an absolute necessity for all participants. Participants submitted past MRI results to the research team, whereas those without prior MRI were assessed with T2-weighted brain imaging with diffusion tensor imaging. In addition, a detailed history and neurological examinations including tests of muscle strength and spasticity were performed. Clinically apparent cerebral palsy was diagnosed by significant delay in motor development, abnormal patterns of posture and movement, and abnormal muscle tone determined by a specialist of pediatric rehabilitation medicine. Any histories suggestive of brain insults were used as reference to decide enrollment into this study. We enrolled patients who had intracerebral lesions in their MRI. If the lesion was not observed, only those with definite history of brain injury were included to avoid any chances of enrolling global developmental delay without cerebral palsy. Cerebral palsy types were classified as spastic, ataxic, and dyskinetic. The dyskinetic type was subclassified according to the presence of choreoathetosis and dystonia.[1]

Ophthalmic evaluations were recommended for all subjects regardless of ophthalmic symptoms. Children who refused ophthalmic examination or MRI were excluded from this study. The parents of all participants provided written informed consent before participation in the study.

Functional evaluation

The Gross Motor Function Measure-88 (GMFM-88)[15] and the Bayley Scales of Infant Development-II (BSID-II)[16] were assessed for all participants. Gross Motor Function Classification System (GMFCS) was applied to classify the children by severity of gross motor impairment[17]; those classified at levels IV and V were defined as severely impaired, and those at levels I-III were defined as the mildly impaired. Other tools including the Gross Motor Performance Measure[18] for quality of motor ability assessment and the Quality of Upper Extremity Skills Test (QUEST)[19] for fine motor ability assessment were also conducted for applicable patients.

The GMFM is the most commonly used scoring system to evaluate gross motor function in children with cerebral palsy and includes 88 items categorized as “lying and rolling,” “sitting,” “crawling and kneeling,” “standing and walking,” and “running and jumping.”[15] The GMFCS is a five-level ordinal scale—from level I as best function to level V as worst function—that describes the gross motor function of children with cerebral palsy. Classifications are made in the following age categories: before the second birthday, between the second and fourth birthdays, between the fourth and sixth birthdays, and between the sixth and twelfth birthdays (Table 1).[17] The BSID-II is a standard measurement that assesses cognition, perception, language, and fine and gross motor development of infants,[16] and consists of three domains: motor scale, mental scale, and behavior scale. The BSID-II motor scale measures gross and fine motor development and the BSID-II mental scale measures cognitive and perceptual development. For quantitative analysis, the raw scores of the motor and mental scales were used. The Gross Motor Performance Measure evaluates gross motor performance for dissociated movement, coordination, alignment, weight shift, and stability in cerebral palsy.[18] The QUEST evaluates quality of upper extremity function in four domains: dissociated movement, grasp, protective extension, and weight bearing.[19]

Evaluation reliabilities used in the study were verified through the reliability tests. For GMFM (101 subjects, 10 raters), inter-rater intraclass correlation coefficients were 0.996-0.998[20]; for BSID-II subscales (50 patients, 10 raters), the inter-rater intraclass correlation coefficients were 0.983-0.996.[21] For the Gross Motor Performance Measure, intraclass correlation coefficients ranged from 0.863 to 0.929.[22]

Ophthalmic assessment and definition of ophthalmic disorders

Comprehensive ophthalmic examinations were performed by a pediatric ophthalmologist at the study institution with minimal extraneous auditory or ophthalmic background stimuli.

The alternative cover test was used to identify the type of strabismus, and the Hirschberg and Krimsky tests were used in uncooperative patients. The alternative cover prism test was used at near and far distances to measure the angle of strabismus. The presence of gaze disorders including amblyopia, nystagmus, and tendency to gaze up was also identified. Cycloplegic refraction with retinoscopy was used to measure the refractive error. Cyclopentolate (1%) and tropicamide (0.5%) mixed with phenylephrine eye drops were instilled for cycloplegia. Ophthalmoscopic observations were also performed to examine the vitreal media, fundus, optic nerve, blood vessels, and macula.

Ophthalmic abnormalities were classified into three domains: ametropia, strabismus, and fundus abnormalities. Ametropia, a synonym for refractive errors, was divided into hyperopia, myopia, and astigmatism according to the spherical equivalent (SE). A higher absolute value of SE indicates more refractive errors. In this study, hyperopia was defined as more than 1.50 diopter (D) for either side of the eyes, whereas myopia was defined as less than −1.50 D for either side of the eyes.[23] Astigmatism indicated more than 1.50 D cylindrical for either side of the eyes.[23]

TABLE 1.
Gross Motor Function Classification Scale Levels[31]

Levels	Characteristics
Level I	Walks without limitations
Level II	Walks with limitations
Level III	Walks using a hand-held mobility device
Level IV	Self-mobility with limitations; may use powered mobility
Level V	Transported in a manual wheelchair

Level characteristics represent general headings for each level.