Risk factors for hip dislocation in dyskinetic cerebral palsy

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Abstract

Purpose: To investigate the risk factors for hip displacement in patients with dyskinetic cerebral palsy (DCP).

Methods: We evaluated 81 patients with DCP, 45 males and 36 females, aged 10–22 years, risk factors for hip displacement were evaluated using multivariate logistic regression analysis with primary brain lesions, Gross Motor Function Classification System (GMFCS) level, gestational age, birth weight, Cobb’s angle, and complication of epilepsy as independent factors. Hip displacement was defined as migration percentage >30%. Primary brain lesions were classified into globus pallidus (GP), thalamus and putamen (TP), and others using brain magnetic resonance imaging (MRI). Perinatal and clinical features were compared between patients with GP lesions and those with TP lesions.

Results: Hip displacement was observed in 53 patients (67%). Higher GMFCS levels (p = 0.013, odds ratio [OR] 2.6) and the presence of GP lesions (p = 0.04, OR 16.5) were independent risk factors for hip displacement. Patients with GP lesions showed significantly higher GMFCS levels, more frequent hip displacement, and lower gestational age and birth weight than those with TP lesions.

Conclusion: Primary brain lesion location may be an important factor in predicting hip displacement among patients with DCP. Appropriate risk assessment using brain MRI may contribute to the early detection and intervention of hip displacement because brain lesion location can be assessed during infancy before GMFCS level is decided.

Keywords
chronic bilirubin encephalopathy, dyskinetic cerebral palsy, hip dislocation, pallidum, MRI

Introduction

Cerebral palsy (CP) encompasses several permanent movement disorders caused by non-progressive disturbances in the developing fetal or infant brain and is clinically characterized by abnormal posture and insufficient muscle tone regulation. There are four major types of CP: spastic (76–80% of cases), dyskinetic (2–14% of cases), ataxic (<2% of cases), and mixed type (<2% of cases). The dyskinetic types are mostly caused by lesions in the bilateral deep grey matter, such as the thalamus and putamen (TP) and globus pallidus (GP).

The prevalence of hip dislocation was reported to be 15–35% in patients with CP of all types and 10–48% in those with dyskinetic cerebral palsy (DCP). Hip displacement or dislocation often results in the destruction of the hip joint cartilage, causing pain in the hip and limitations in range of motion. Subsequently, patients are unable to sit or receive sufficient care, and the quality of life (QOL) of both patients and caregivers declines. Hence, early diagnosis and treatment of hip displacement are important for the prevention of future QOL deterioration.

It is difficult to predict hip dislocation in patients with DCP as compared to those with spastic CP because the posture and laterality of patients with DCP are not always...
fixed, and their muscle tone fluctuates with changes in mood and/or circumstances. There are many reports regarding the risk factors for hip dislocation in patients with spastic CP, but only a few reports exist on the risk factors for hip dislocation or displacement in patients with DCP. The purpose of this study was to investigate the risk factors for hip displacement among patients with DCP with reference to the location of their brain lesions.

Materials and methods

Patients

We recruited patients with DCP who visited the rehabilitation/orthopedic clinic of our institution between April 2006 and December 2019. All patients were diagnosed by a pediatric neurologist based on the Surveillance of Cerebral Palsy in Europe.15 The inclusion criteria were as follows: over 2 years of follow-up, age ≥10 years at the latest follow-up, and complete clinical information including hip and spine radiographs and brain magnetic resonance imaging (MRI). All patients received physical therapy, and orthoses were prepared and adjusted to encourage hip abduction with use of orthoses in the patients. X-rays were assessed annually, and patients who received surgical treatment, including soft tissue release or osteotomies, were excluded from the study when the operation was performed.

Methods

Migration percentage (MP) for the hip joint and Cobb’s angle for scoliosis were measured using plain anteroposterior radiographs at the latest follow-up. Hips with an MP > 30% were considered as having a high risk of hip displacement.16 The location of the primary brain lesion was evaluated by pediatric neurologists and classified into GP, TP, or others using brain MRI. The typical GP and TP lesions are shown in Figure 1. Gestational age, birth weight, and complication of epilepsy were recorded retrospectively from the patients’ medical charts.

In the primary analysis, the presence of a GP lesion, Gross Motor Function Classification System (GMFCS) level, gestational age, birth weight, Cobb’s angle, and complication of epilepsy were used as independent variables in multiple logistic regression analysis. As a secondary analysis, GMFCS level, gestational age, birth weight, and onset age of hip displacement were compared between 32 patients with GP lesions and 42 patients with TP lesions. The age of onset of hip displacement was also compared between the GP (64 hips) and TP (84 hips) groups.

Statistical analyses

In the primary analysis, multivariate logistic regression analysis was performed to elucidate the independent risk factors for hip displacement. In the secondary analysis, the

Results

A total of 81 patients (male: 45; female: 36) with DCP met the inclusion criteria. Demographic characteristics of the participants are summarized in Table 1. The average age at the last follow-up was 14.3 years (range: 10–22 years), and the average follow-up period was 9.4 years (range: 2–19 years). Brain MRI, conducted earlier than the age of 18 months, revealed that the primary brain lesions were located in the GP in 32 patients, TP in 42 patients, and other locations in seven patients. Sixty-eight patients (84%) were classified as GMFCS level IV or V.

Fifty-three patients had hip displacements. Multiple logistic regression analysis revealed that the presence of GP lesion (odds ratio [OR] 16.5, p = 0.04) and higher GMFCS level (OR 2.6, p = 0.01) were independent risk factors for hip displacement (Table 2). The distribution of GMFCS levels in the GP group was significantly poorer than that in the TP group (p < 0.001), and the prevalence of hip displacement was significantly higher in the GP group (67.2%) than in the TP group (46.4%) (p = 0.013). However, the age of onset of hip displacement was not significantly different between the two groups (p = 0.17). Gestational age and birth weight were significantly lower (p < 0.001) in the GP group than in the TP group (Table 3).

Figure 1. Exemplary images of primary brain lesion.

Primary brain MRIs of patients with DCP were mostly classified into two types: globus pallidus (GP) or thalamus and putamen (TP) (T2-weighted axial images). The left image shows bilateral pallidal lesions (filled arrowheads) of a 10-month-old patient with DCP. The right image shows bilateral lateral thalamic lesions (arrows) and posterior putaminal lesions (open arrowheads) of a 5-year-old patient with DCP.
GMFCS: Gross Motor Function Classification System.

Table 1. Clinical information of patients with dyskinetic cerebral palsy.

| Sex, n (%) | GMFCS level, n (%) | Mean age at the first consultation, y (range) | Mean gestational age, w (range) | Mean birth weight, g (range) | Primary brain lesion, n (%) | Hip displacement, n (%), total | Scoliosis*, n (%) | Onset age of hip displacement (y)* | Gestational age (w)* | Birth weight (g)* |
|------------|-------------------|---------------------------------------------|-------------------------------|----------------------------|---------------------------|-----------------------------|-----------------|-------------------------------|-------------------|-----------------|
| Male       | 45 (55.6)         | 3.7 (1–13)                                  | 34.0 (23.6–41.3)              | 2055 (544–4215)             | Thalamus and putamen      | 53 (66.7)                     | 18 (22.2)       | 5.3 ± 3.2                      | 27.8 ± 2.7        | 1029 ± 354      |
| Female     | 36 (44.4)         | 13.2 (10–22)                                |                               |                             | Globus pallidus            | 29 (35.8)                     | 15 (18.5)       | 39 (11.1)                      | 35.3 ± 2.8         | 3278 ± 565      |
|            |                   |                                             |                               |                             | Others                     | 9 (11.1)                     |                 |                               |                   |                 |

Table 2. Multivariate risk analysis for hip displacement among patients with dyskinetic cerebral palsy (case analysis).

| p-value | OR   |
|---------|------|
| Presence of GP lesion | 0.04  | 16.5   |
| GMFCS level | 0.01  | 2.6    |
| Sex (Female) | 0.47  | 0.7    |
| Gestational age | 0.48  | 1.1    |
| Birth weight | 0.42  | 1.0    |
| Scoliosis (Cobb’s angle) | 0.35  | 1.0    |
| Complication of epilepsy | 0.22  | 0.4    |

GP: globus pallidus. GMFCS: Gross Motor Function Classification System.

Table 3. Comparison between the GP and TP groups.

| GMFCS level | p-value |
|-------------|---------|
| I / II / III | 0.013  |
| IV / V      | 0.013  |
| Prevalence of hip displacement | 0.001  |
| Onset age of hip displacement | 0.17   |
| Gestational age | 0.001  |
| Birth weight | < 0.001 |

*Results are expressed as average ± standard deviation.

Discussion

CP is an umbrella term that covers various types of movement disorders with different etiologies and outcomes. Because it is necessary to restrict the CP type and etiology to predict outcomes more accurately, we included only patients with DCP and expanded the risk factor candidates to include perinatal factors and primary brain lesions. To the best of our knowledge, this is the first study to investigate the prevalence and risk factors of hip displacement, specifically in patients with DCP. Low gross motor function (high GMFCS level) is considered the risk factor for hip dislocation among patients with CP of all types.6,16 Similar results were found in this study confined to patients with DCP, and patients with GP lesion were more likely to experience hip displacement than those with other lesions.

Primary brain lesions with DCP, and patients with GP lesion were more likely to experience hip displacement than those with other lesions. Secondary analysis showed that the GP group had significantly higher GMFCS levels and prevalence of hip displacement than the TP group. Recently, bilirubin encephalopathy in very premature infants has received increasing recognition as an etiological determinant of...
Indeed, most patients in the GP group in this study were very premature and of very low birth weight. Recent advances in perinatal medicine might help improve the survival ratio of very premature infants, which resulted in the increased number of patients with DCP who had GP lesions.

The primary brain lesion is determined using MRI before 18 months of age, whereas the GMFCS level is usually ascertained after 2 years of age. Risk evaluation via brain MRI can facilitate earlier prediction of the future development of hip displacement among patients with DCP. It suggests that for patients in the GP group, shortening follow-up periods from a young age and providing early surgical treatment to prevent hip displacement improve the QOL of patients and caregivers.

In this study, the prevalence rate of bilateral hip displacement was 40.7% and that of unilateral hip displacement was 25.9% (Table 1), which is similar to that of the spastic type. This may be caused by the fact that the muscle tone of the whole body in DCP is stronger than in the spastic type, although there is an asymmetric posture in both types.

Scoliosis was not related to hip displacement. The mean age of 13.2 years at the latest follow-up in this study was considered to be too young to develop scoliosis. A longer follow-up period may be necessary to examine the relationship between hip displacement and scoliosis in patients with DCP. Furthermore, a history of epilepsy was also not related to hip displacement. While epilepsy may affect activity and participation, it appears to have no relationship with the fixed posture that leads to contracture.

A major limitation of this study was selection bias. We recruited participants from our rehabilitation and orthopedic clinic, and our hospital is a central hospital for CP in West Japan. Therefore, participants tended to have relatively severe motor impairment and a high need for hip surgery. Indeed, there was only one patient with GMFCS level III and no patients with levels I or II in the GP group. Another limitation was that although all patients received physical therapy and used orthoses, the frequency, treatment methods, and orthoses usage time varied among them. This non-uniformity between the two groups may have influenced hip displacement.

Conclusion
Our results revealed that GP lesion was specific to very premature infants and was a significant risk factor for hip displacement among patients with DCP. Not only the GMFCS level but also a thorough assessment of primary brain lesion location and perinatal history should be considered for the early detection of hip displacement.

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Author contributions
KO: data acquisition, analysis and interpretation of data, drafting and critical revision, and final approval of the article.
YK, TS, HA: design, data acquisition, analysis and interpretation of data, drafting and critical revision, and final approval of the article.

Declaration of conflicting interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval and informed consent
All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the ethics committee of Omichikai Medical Corporation.

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References
1. Bax M, Goldstein M, Rosenbaum P, et al. Proposed definition and classification of cerebral palsy. Dev Med Child Neurol 2005; 47: 571–576.
2. Yeargin-Allsopp M, Van Naarden Braun K, Doernberg NS, et al. Prevalence of cerebral palsy in 8-year-old children in three areas of the United States in 2002: a multisite collaboration. Pediatrics 2008; 121: 547–554.
3. Abel MF and Damiano DL. Cerebral palsy. In: Sponseller PD (ed) Orthopaedic knowledge update. Pediatrics 2. Rosemont: American Academy of Orthopaedic Surgeons, 2002, pp. 233–247.
4. Howard J, Soo B, Graham HK, et al. Cerebral palsy in Victoria: motor types, topography, and gross motor function. J Pediatr Child Health 2005; 41: 479–483.
5. Rice J, Russo R, Halbert J, et al. Motor function in 5-year-old children with cerebral palsy in the South Australian population. Dev Med Child Neurol 2009; 51: 551–556.
6. Soo B, Howard JJ, Boyd RN, et al. Hip displacement in cerebral palsy. J Bone Joint Surg Am 2006; 88: 121–129.
7. Terjesen T. The natural history of hip development in cerebral palsy. Dev Med Child Neurol 2012; 54: 951–957.
8. Hagglund G, Alriksson-Schmidt A, Lauge-Pedersen H, et al. Prevention of dislocation of the hip in children with cerebral palsy: 20-year results of a population-based prevention program. Bone Joint J 2014; 96-B: 1546–1552.
9. Wordie SJ, Robb JE, Hagglund G, et al. Hip displacement and dislocation in a total population of children with cerebral palsy in Scotland. Bone Joint J 2020; 102-B: 383–387.
10. Bugler KE, Gaston MS and Robb JE. Hip displacement in children with cerebral palsy in Scotland: a total population study. J Child Orthop 2018; 12: 635–639.

11. Hagglund G, Lauge-Pedersen H and Wagner P. Characteristics of children with hip displacement in cerebral palsy. BMC Musculoskelet Disord 2007; 8: 101.

12. Moreau M, Drummond DS, Rogala E, et al. Natural history of dislocated hip in spastic cerebral palsy. Dev Med Child Neurol 1979; 21: 749–753.

13. Huser A, Mo M and Hosseinzadeh P. Hip surveillance in children with cerebral palsy. Orthop Clin North Am 2018; 49: 181–190.

14. Monbaliu E, Himmelmann K, Lin JP, et al. Clinical presentation and management of dyskinetic cerebral palsy. Lancet Neurol 2017; 16: 741–749.

15. Cans C, Dolk H, Platt MJ, et al. Recommendations from the SCPE collaborative group for defining and classifying cerebral palsy. Dev Med Child Neurol 2007; 109: 35–38.

16. Pruszczynski B, Sees J and Miller F. Risk factors for hip displacement in children with cerebral palsy: systematic review. J Pediatr Orthop 2016; 36: 829–833.

17. Kitai Y, Hirai S, Okuyama N, et al. Diagnosis of bilirubin encephalopathy in preterm infants with dyskinetic cerebral palsy. Neonatology 2020; 117: 73–79.

18. Reid SM, Daigia CD, Ditchfield MR, et al. Grey matter injury patterns in cerebral palsy: associations between structural involvement on MRI and clinical outcomes. Dev Med Child Neurol 2015; 57: 1159–1167.

19. Morioka I, Nakamura H, Koda T, et al. Current incidence of clinical kernicterus in preterm infants in Japan. Pediatr Int 2015; 57: 494–497.

20. Okumura A, Kidokoro H, Shoji H, et al. Kernicterus in pre-term infants. Pediatrics 2009; 123: e1052–e1058.

21. Rodby-Bousquet E, Czuba T, Hagglund G, et al. Postural asymmetries in young adults with cerebral palsy. Dev Med Child Neurol 2013; 55: 1009–1015.