Original Article

Incidence and Risk Factors for Hip Displacement in Thai Children with Cerebral Palsy under a 10-Year Surveillance Program: A retrospective analytical study at Queen Sirikit National Institute of Child Health

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ABSTRACT

Objectives: To evaluate the cumulative incidence of significant hip displacement, defined as a migration percentage (MP) > 40% or the requirement for hip reconstructive surgery among children with cerebral palsy (CP) enrolled in a 10-year institutional hip surveillance program, and to identify independent clinical predictors of displacement.

Study design: Retrospective cohort study

Setting: Queen Sirikit National Institute of Child Health

Participants: Children with cerebral palsy (CP) undergoing their first surveillance radiograph with baseline MP ≤ 40.0%.

Methods: This retrospective cohort study at Queen Sirikit National Institute of Child Health, a national tertiary referral center in Thailand (2016 to 2025), analyzed children with CP having baseline MP ≤ 40.0%. The primary outcome was the cumulative incidence of hip displacement (MP > 40% or surgery), estimated using Kaplan-Meier analysis. Multivariable Cox regression was used to identify risk factors, adjusting for Gross Motor Function Classification System (GMFCS) level, CP subtype, and epilepsy.

Results: A total of 265 patients were included. The cumulative incidence of significant hip displacement of the patients progressively increased over time: 17.8% at 2 years of follow-up, 30.5% at 4 years of follow-up, reaching 41.0% at 6 years of follow-up. Among the children who developed significant hip displacement during the surveillance period, the mean age at the time of initial documentation of displacement was 5.0 (SD = 2.2) years. Multivariable analysis identified GMFCS levels IV-V as the strongest independent predictor (adjusted Hazard Ratio [aHR] 3.09; 95% CI: 1.24, 7.70; p = 0.015) compared to levels I-III. Non-spastic CP subtypes were associated with a significantly lower risk (aHR 0.22; p = 0.017) compared to spastic diplegia. Epilepsy was not found to be an independent risk factor after adjusting for motor severity (aHR = 0.76; p = 0.407).

Conclusions: The cumulative risk of hip displacement in this surveillance cohort is high, particularly among children with severe motor impairment (GMFCS IV-V), reaching 41.0% at 6 years of follow-up. These findings underscore the necessity for rigorous, long-term surveillance stratified by GMFCS level and provide crucial data for prognostic counseling to facilitate timely interventions.

Keywords: cerebral palsy, hip displacement, hip surveillance, incidence, risk factors, Gross Motor Function Classification System

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Introduction

Hip displacement is the second most common musculoskeletal deformity in children with cerebral palsy (CP), following equinus,[1-3] with an overall incidence of approximately 35.0% among the entire CP population.[2] If left untreated, this condition typically progresses to hip dislocation[1,4] resulting in severe complications such as chronic pain, scoliosis, impaired function, and a significant deterioration in the quality of life for both the child and their family.[1,2,4,5]

Most children with CP are born with anatomically normal hips. However, spasticity and muscle imbalance around the hip joint create abnormal and uneven forces on the femoral head and acetabulum. These forces stimulate gradual bony remodeling during growth. This phenomenon is often referred to as “silent subluxation” because, in the early stages, there are usually no pain or obvious clinical signs, making early diagnosis difficult when relying solely on physical examination.[1,2,6] Consequently, early diagnosis and monitoring of hip displacement relies on the measurement of the migration percentage (MP) (Reimer’s Migration Percentage/Index). This is a widely accepted, reliable, and commonly used radiological measurement.[2] An MP greater than 30.0% is considered indicative of a hip at risk for dislocation.[2,5]

Over the past 15 years, the role of hip surveillance in children with CP to detect “hips at risk” early has been recognized as a crucial step in preventing hip dislocation.[7] Successful surveillance programs in several countries, including Sweden

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(Cerebral Palsy Follow-Up Program, CPUP), Australia, and Scotland, have demonstrated a significant reduction in the incidence of hip dislocation and the need for salvage surgery.[2,6-9] The most significant clinical factor associated with hip displacement is the functional motor level, classified by the Gross Motor Function Classification System (GMFCS). A linear relationship has been observed between GMFCS level and the risk of hip displacement.[2,3] In addition to GMFCS, previous studies have demonstrated that the presence of epilepsy is highly associated with overall disease severity, while CP topography (subtype) is directly correlated with the risk and progression of hip displacement.[10,11]

Recognizing the importance of surveillance, the Queen Sirikit National Institute of Child Health (QSNICH) implemented the Clinical Practice Guideline for Hip Dysplasia in CP in Thailand in 2016.[12] An effective international standard prevention program consists of surveillance and screening systems, clinical assessment, radiological monitoring, spasticity management, physical therapy, criteria for referral to orthopedic surgeons, and follow-up.[7] A review of the institute's practices indicates that the following components are comprehensively utilized: early hip X-ray screening based on GMFCS risk is conducted together with non-operative treatment, which covers spasticity management, stretching, strengthening exercises, positioning, and the use of orthoses. Following the program's implementation, the rate of radiological screening before age 2 increased from 66.7% in 2015 to 74.1% between 2016 and 2019, and the mean age at first screening significantly decreased. Furthermore, the program demonstrated efficacy in maintaining hip stability, with 84.8% of followed patients maintaining a MP of less than 40.0%.[5] However, while short-term results are promising, there is a lack of long-term data to confirm the program's sustained efficacy in preventing severe hip displacement until skeletal maturity. Additionally, the variation in follow-up durations among patients has not been accounted for, which may lead to an underestimation of the true cumulative risk.

Furthermore, there is a lack of long-term hip surveillance data in Southeast Asia, including Thailand. Outcomes in this region may differ from Western registries due to variations in healthcare resources, delayed referrals, and the recent implementation of national guidelines. Therefore, understanding outcomes in this specific context is crucial.

This 10-year retrospective study aims to utilize data from the medical records of pediatric patients who underwent their first hip X-ray at the QSNICH between 2016 and 2024. The objectives are to evaluate the cumulative incidence of significant hip displacement, defined as a MP exceeding 40.0% or a requirement for hip reconstructive surgery among children with CP enrolled in a 10-year institutional hip surveillance program. In this study, a MP > 40.0% was selected as the primary endpoint for defining significant hip displacement. This threshold marks the point at which orthopedic evaluation and corrective measures are mandated under the current institutional guidelines. Furthermore, we sought to identify independent clinical predictors of hip displacement, specifically determining the adjusted hazard ratio (aHR) associated with different GMFCS levels, CP subtypes, and the presence of epilepsy, to better understand the long-term risk profile in this population. The findings will help refine the institute's clinical practice guidelines to be more specific and effective.

Methods

Study design

This retrospective cohort study evaluated the incidence and risk factors for hip displacement in children with CP who underwent their first hip X-ray at the QSNICH between 2016 and 2024. The study protocol was approved by the Institutional Review Board (IRB) of the QSNICH (REC No. 008/2569) on February 9, 2026 (Clinical Trial Registration: TCTR20260223011). This study has been reported according to the STROBE (STrengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies.

Participants

The study enrolled patients who underwent their first surveillance radiograph at the Department of Rehabilitation Medicine, QSNICH, Thailand, between January 2016 and December 2024.

The inclusion criteria included the following requirements: (1) a clinical diagnosis of CP of any subtype; (2) undergoing an initial anteroposterior (AP) pelvic radiograph for surveillance enrollment during the study period; and (3) having complete medical records available for analysis, including demographic data, GMFCS level, and radiographic images suitable for measurement. The exclusion criteria included the following: (1) a history of hip or pelvic surgery prior to the initial surveillance radiograph; (2) the presence of other neuromuscular conditions affecting hip pathology, e.g., myelomeningocele or arthrogryposis; and (3) severe hip displacement (MP > 40.0%) detected at the initial baseline assessment.

Data collection and measurement

Data were collected from hospital medical records and the Picture Archiving and Communication System (PACS), including patient characteristics, age at enrollment, history of epilepsy, type of CP, and GMFCS level. Clinical parameters, including the specific CP subtype (spastic, dyskinetic, ataxic, or mixed) and topographical distribution (hemiplegia, diplegia, or quadriplegia), were identified from medical records.

Radiographic assessments conducted during the surveillance period were also reviewed. These assessments included the MP of both hips measured from standard AP pelvic radiographs using Reimers' method.[13] For statistical analysis, only the hip with the higher MP value was selected for each patient. Measurements were performed by experienced rehabilitation physicians using digital tools within the PACS.

The clinical outcome was evaluated based on the progression of hip displacement. The primary endpoint was defined as the occurrence of significant hip displacement, characterized by an MP > 40.0%, or the requirement for hip reconstructive surgery during the surveillance period.

The study enrolled patients who underwent their first surveillance radiograph between January 1, 2016 and December 31, 2024. This enrollment cutoff was selected to ensure that all participants had a potential follow-up period of at least one year. Data collection covered a 10-year period ending on December 31, 2025, and each participant was followed from their enrollment date until the earliest of the following endpoints: December 31, 2025, the occurrence of a primary outcome event, or their last recorded visit in cases of loss to follow-up. The detailed clinical pathway and screening intervals according to our institutional protocol are illustrated in Appendix Figure A1.

Sample size calculation

The sample size was calculated to detect a clinically significant difference in hip displacement outcomes using survival analysis and the Cox proportional hazards model. The calculation was based on a two-sided significance level of 0.05 and a power of 80%. We assumed a HR of 2.5 for patients with severe motor impairment (GMFCS levels IV-V) compared to those with mild to moderate impairment (GMFCS levels I-III).

Based on a presumed sample distribution of 60% for the high-risk group (GMFCS IV-V) and an overall event rate of 22% as reported by Kentish et al.[7], a total of 39 events were required, corresponding to an initial sample size of approximately 178 subjects. To account for a potential dropout rate or incomplete data of approximately 30% based on preliminary institutional data,[5] the final sample size was adjusted to include at least 255 participants.

Outcome

The primary outcome was the cumulative incidence of significant hip displacement or the requirement for hip reconstructive surgery. Significant hip displacement was defined as the first radiographic detection of a MP exceeding 40.0% in either hip, the established clinical threshold for a high risk of dislocation. Surgical intervention was defined as bone reconstructive surgery performed to manage hip displacement.

The secondary outcomes included identifying independent clinical predictors of the primary outcome. Specifically, the study aimed to determine the aHR for different GMFCS levels, CP subtypes, and the presence of epilepsy.

Statistical analysis

Data analysis was performed using standard statistical software (STATA18). Descriptive statistics were used to summarize baseline characteristics and clinical parameters. Continuous quantitative variables were tested for normality. Data are presented as mean (standard deviation, SD). Categorical variables are expressed as frequencies and percentages.

Comparisons of variables between the successful and unsuccessful hip outcome groups were performed. Continuous variables were compared using the Independent t-test. Categorical variables were compared using the X^2 test.

The cumulative incidence of hip displacement was estimated using the Kaplan-Meier method, and differences between groups were compared using the Log-rank test. To identify independent predictors and to control for confounding, a multivariable Cox proportional hazards regression model was employed. Results are reported as aHR with 95% confidence intervals (CI). A p-value of < 0.05 was considered statistically significant.

To handle missing data, a complete-case analysis approach was employed; patients with incomplete baseline medical records or missing key variables were excluded from the final analysis. For the time-to-event analysis, patients who did not experience significant hip displacement or who were lost to follow-up before the end of the study period were right censored at the date of their last clinical or radiographic evaluation.

Bias minimization

To minimize bias, we recruited consecutive eligible patients and excluded those with baseline severe displacement (MP > 40.0%) to address selection and prevalence-incidence bias. Measurement bias was reduced by using standardized digital radiographic tools. Multivariable survival analysis was employed to control for confounding, while time-to-event analysis accounted for attrition and censored data.

Results

A total of 334 patients were identified from the medical records. We excluded 22 patients due to incomplete data and 47 patients due to baseline severe hip displacement (MP > 40.0%). Consequently, 265 patients were included in the final analysis. (Figure 1)

The study consisted of 213 patients (80.4%) in the successful outcome group and 52 patients (19.6%) in the unsuccessful outcome group. Among the children who developed significant hip displacement during the surveillance period, the mean age at the time of documented displacement was 5.0 years (SD = 2.2). There were no statistically significant differences between the two groups regarding age at initial X-ray, gender distribution, BMI, history of epilepsy, or the duration of follow-up (p > 0.05). The mean age at enrollment was 34.7 months (SD = 23.2) in the successful group and 31.2 months (SD = 16.1) in the unsuccessful group (p = 0.306).

However, significant differences were observed in functional gross motor severity, CP subtype, and initial radiographic measurements. Patients in the unsuccessful outcome group had a significantly higher proportion of severe motor impairment (GMFCS levels IV-V) compared to the successful group (88.5% vs. 62.0%, p < 0.001). Similarly,

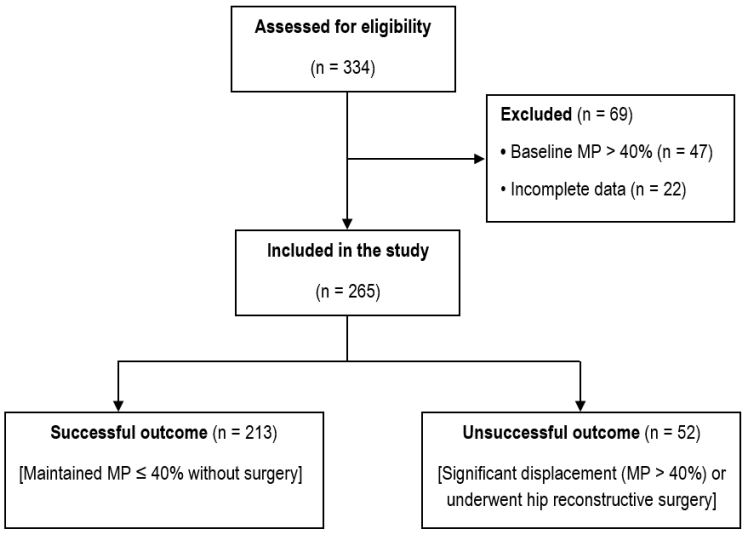

Figure 1. The study flow diagram

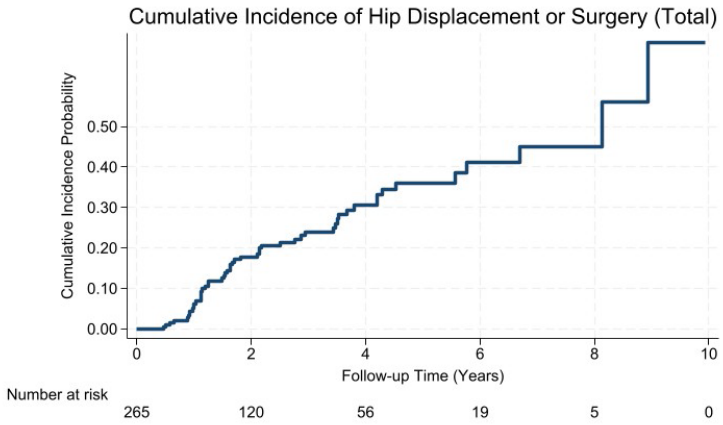

Figure 2. Kaplan-Meier cumulative incidence of significant hip displacement or surgery

the distribution of CP subtypes differed significantly between groups ($p < 0.001$), with spastic quadriplegia being markedly more prevalent in the unsuccessful group (48.1%) compared to the successful group (24.9%).

Regarding radiographic parameters, the unsuccessful group had a significantly higher mean baseline MP than the successful group (29.9% (SD = 9.7) vs. 21.3% (SD = 12.4), $p < 0.001$). Additionally, the annual MP progression rate was notably higher in the unsuccessful group (6.39% per year) compared to the successful group (0.89% per year) (Table 1).

The primary outcome was the cumulative incidence of significant hip displacement (MP > 40.0%) or the requirement for hip reconstructive surgery. Kaplan-Meier analysis demonstrated a progressive increase in the cumulative risk over the surveillance period (Figure 2). The estimated cumulative incidence was 17.8% (95% CI: 12.7%, 24.7%) at 2 years of follow-up and rose to 30.5% (95% CI: 23.3%, 39.3%) at 4 years of follow-up. By 6 years of follow-up, the cumulative incidence reached 41.0% (95% CI: 31.3%, 52.5%), and at 8 years, it was estimated to be 44.9% (95% CI: 33.6%, 58.2%) Kaplan-Meier cumulative incidence (Figure 3) demonstrated distinct risk stratification. Patients with severe motor impairment (GMFCS IV-V) exhibited a steeply rising cumulative incidence curve, diverging sharply from the flat trajectory of those with mild-to-moderate impairment (GMFCS I-III). Similarly, spastic quadriplegia and diplegia showed higher cumulative risks compared to hemiplegia and non-spastic types. In contrast, survival curves for epilepsy overlapped throughout the surveillance period, indicating no significant unadjusted difference.

After adjusting for covariates (Table 3), GMFCS level remained the strongest independent predictor. Children with GMFCS levels IV-V had a three-fold increased risk of hip displacement compared to levels I-III (aHR = 3.09; 95% CI: 1.24, 7.70; $p = 0.015$).

Regarding CP subtypes (reference: spastic diplegia), non-spastic CP was associated with a significant 78% risk reduction (aHR = 0.22; 95% CI: 0.07, 0.76; $p = 0.017$). Notably, the elevated risk for spastic quadriplegia seen in univariate analysis lost statistical significance in the adjusted model (aHR = 1.44; $p = 0.306$), suggesting that the risk is largely mediated by motor severity rather than the subtype itself.

Moreover, multivariable analysis demonstrated that epilepsy is not an independent risk factor for hip displacement.

Table 1. Baseline characteristics and outcomes of patients with cerebral palsy, stratified by hip surveillance outcome

Variables	Successful hip outcome (n = 213)	Unsuccessful hip outcome (n = 52)	*p*-value
Age at first X-ray (month)[1]	34.7 (23.2)	31.2 (16.1)	0.306[a]
Gender[2]			
Female	101 (47.7)	25 (48.1)	0.932[b]
Male	112 (52.6)	27 (51.9)	
BMI (kg/m^2)[1]	15.95 (5.84)	15.79 (3.24)	0.858[a]
GMFCS level[2]			
I-III	81 (38.0)	6 (11.5)	< 0.001[b]
IV-V	132 (62.0)	46 (88.5)	
CP type[2]			
Spastic quadriplegia	53 (24.9)	25 (48.1)	< 0.001[b]
Spastic diplegia	86 (40.4)	23 (44.2)	
Spastic hemiplegia	24 (11.3)	1 (1.9)	
Non-spastic	50 (23.5)	3 (5.8)	
Epilepsy[2]			
Yes	92 (43.2)	27 (51.9)	0.256[b]
No	121 (56.8)	25 (48.1)	
Baseline MP (%)[1]	21.3 (12.4)	29.9 (9.7)	< 0.001[a]
MP progression rate (%/year)	0.89	6.39	
Time to follow-up (year)[1]	2.18 (2.34)	2.44 (1.91)	0.459[a]

[1]Mean (SD), [2]Number (%); [a]Independent t-test, [b]X2-test, MP, migration percentage; ; BMI, body mass index; GMFCS, Gross Motor Function Classification System; CP, cerebral palsy

Table 2. Cumulative incidence of hip displacement at specific follow-up intervals

Time after first X-ray (years)	No. at risk	Cumulative incidence (95% CI)
0	265	-
2	120	17.8% (12.7, 24.7)
4	56	30.5% (23.3, 39.3)
6	19	41.0% (31.3, 52.5)
8	5	44.9% (33.6, 58.2)
10	0	-

The aHR of 0.76 (95% CI: 0.40, 1.45; $p = 0.407$) substantiates that seizure history does not confer additional risk when controlling for motor function.

Discussion

This 10-year retrospective cohort study evaluates the cumulative incidence and risk factors for hip displacement among children with CP enrolled in a surveillance program at a national tertiary referral center. To our knowledge, this is one of the first studies in Southeast Asia to report long-term hip surveillance outcomes using survival analysis. The principal finding is that the cumulative risk of significant hip displacement (MP > 40.0%) or the need for reconstructive surgery increases progressively, reaching 41.0% at 6 years of follow-up. Consistent with global literature, the severity of motor impairment (GMFCS levels IV-V) was identified as the most robust independent predictor. The lack of an independent association for epilepsy in our multivariable model is likely due to its strong correlation with higher GMFCS levels, which represent overall disease severity. This collinearity may explain why our findings differ from previous studies,[11] where epilepsy might have appeared significant in univariate analyses or in cohorts with different distributions of disease severity.

The cumulative incidence of hip displacement in this study (41.0% at 6 years of follow-up) is higher than figures reported from population-based surveillance programs in developed countries, such as Sweden (CPUP) and Australia.[2,14,15] However, it is important to note that our study defined the outcome as significant displacement (MP > 40.0%), capturing hips at risk rather than only those that had fully dislocated. Furthermore, unlike major population-based cohorts that report cumulative incidence by patient age[16], our study used 'follow-up duration' as the primary time axis. This approach was strategically selected to evaluate the surveillance program's operational effectiveness in the real world. Because children in our setting entered surveillance at highly variable ages due to delayed referrals, analyzing incidence by follow-up duration practically illustrates the progression risk after entering the system. While this methodology limits direct graphical comparisons with age-based incidence curves, a descriptive comparison reveals similar underlying trends. Consistent with established cohorts, we observed that MP gradually increased across all severity levels during the initial 2 to 4 years of follow-up. Subsequently, progression tended to stabilize in patients with milder CP, whereas those with GMFCS levels IV-V continued to experience MP progression, albeit at a shallower slope over time.

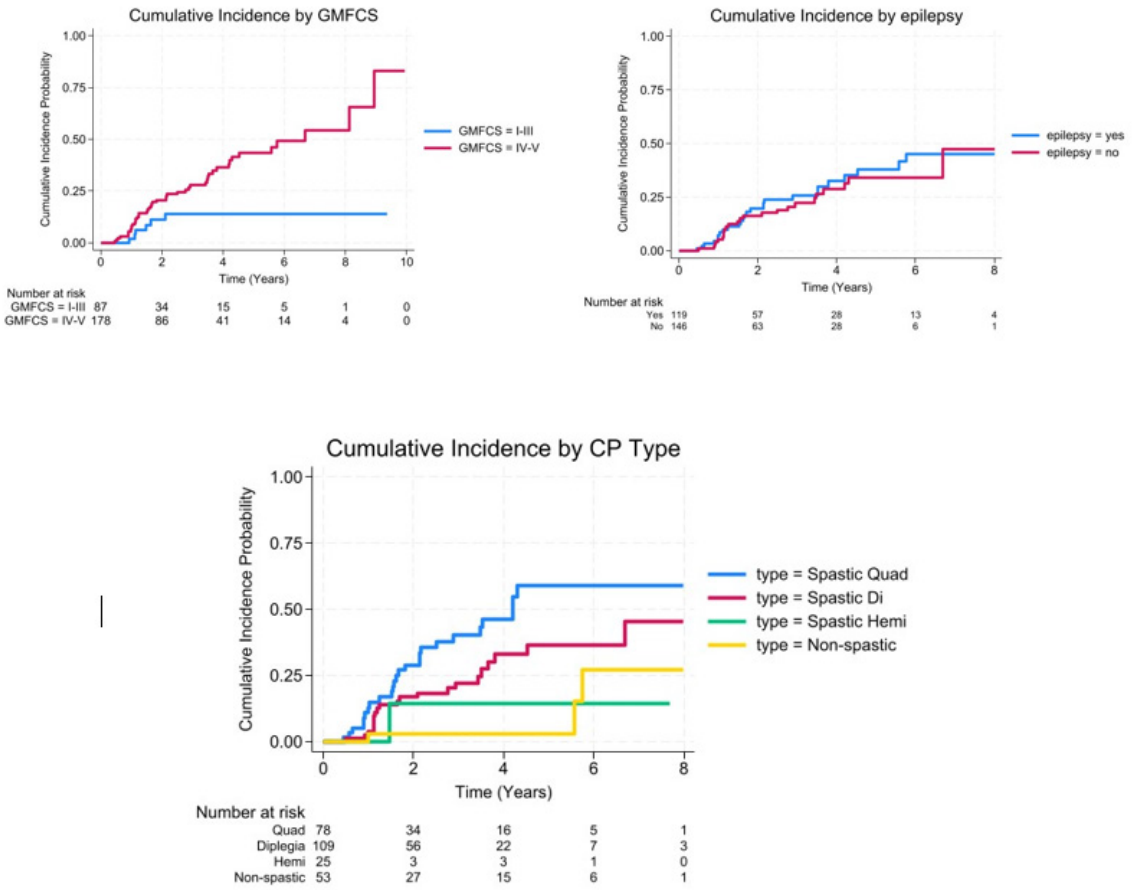

Figure 3. Kaplan-Meier cumulative incidence of significant hip displacement. (A) Stratification by GMFCS level showing rapid risk divergence, with significantly higher incidence in levels IV-V (red) compared to I-III (blue). (B) Stratification by epilepsy status shows overlapping curves, indicating no significant difference in risk. (C) Stratification by CP subtype: Spastic Quadriplegia (blue) and Diplegia (red) demonstrate the highest progression rates compared to Hemiplegia (green) and Non-spastic types (yellow).
GMFCS, Gross Motor Function Classification System; CP, cerebral palsy

Table 3. Multivariable Cox proportional hazards regression analysis of risk factors for significant hip displacement

Variables	Total N	Events (n)	Adjusted HR (95% CI)	*p*-value
GMFCS				
I-III	87	6	1.00 (Ref)	0.015*
IV-V	178	46	3.09 (1.24, 7.70)	
Epilepsy				0.407
Yes	119	27	0.76 (0.40, 1.45)	
No	146	25	1.00 (Ref)	
CP type				
Spastic quadriplegia	78	25	1.44 (0.72, 2.90)	0.306
Spastic diplegia	109	23	1.00 (Ref)	
Spastic hemiplegia	25	1	0.53 (0.07, 4.08)	0.544
Non-spastic	53	3	0.22 (0.07, 0.76)	0.017*

GMFCS, Gross Motor Function Classification System; CP, cerebral palsy

When compared to the natural history of the disease, which represents data collected before surveillance programs were common, our rates align with the 35.0% to 60.0% incidence typically seen in non-ambulatory populations.[17-19] It should be noted that while previous studies typically defined hip displacement at an MP threshold of approximately 30.0%, our study used a slightly higher institutional cut-point of MP > 40.0%.

Compared to our institution's preliminary study during the initial program implementation (from 2015 to 2019), which reported short-term success with 84.8% of patients maintaining hip stability (MP < 40.0%) over a mean follow-up of

1.89 years[5], the current 10-year analysis reveals a contrasting reality. We found that the cumulative risk of significant displacement progressively rose to 41.0% at 6 years of follow-up. This discrepancy highlights that short-term evaluation may lead to an underestimation of risk due to the silent, progressive nature of hip displacement. Consequently, these findings reinforce the necessity of strict, long-term surveillance until skeletal maturity, rather than relying solely on early-stage stability.

The higher incidence observed in our study compared to Scandinavian registries can be attributed to the nature of our institution. As a national tertiary referral center, we likely manage a population with greater disease complexity and comorbidity compared to community-based registries.[20] Furthermore, many patients in our setting may present with established contractures or delayed enrollment, which accelerates the progression of hip migration despite non-operative management.[19] Specifically, although our institutional guidelines recommend initiating baseline radiographic screening at 18 months of age, the mean age at the first screening radiograph in our cohort was more than 30 months. This reflects a substantial delay in real-world enrollment compared to established surveillance programs in developed countries, where baseline evaluations are typically initiated and consistently performed between 12 and 24 months of age.[19-21]

Another contributing factor to the high incidence observed in this study may be the inconsistency of follow-up visits. In our real-world practice, some patients are lost to follow-up for extended periods and only return when they become symptomatic or when the hip is already significantly displaced. This lack of continuous monitoring means that the opportunity for early, less invasive intervention is missed, leading to a higher rate of severe displacement upon return. Therefore, future research should aim to identify and collect data on the specific factors contributing to loss to follow-up such as socioeconomic barriers, geographic distance from healthcare facilities, and caregiver burden. Understanding these factors is crucial for developing targeted strategies to improve long-term adherence to the surveillance program.

This study confirms GMFCS level as the strongest predictor of hip displacement, consistent with global consensus.[2,17,22,23] Children with GMFCS levels IV-V face a three-fold increased risk (aHR 3.09), a relationship driven by delayed weight-bearing and muscle imbalance.[13] This analysis also indicates that non-spastic forms carry a significantly lower risk (78.0% reduction) compared to spastic diplegia, consistent with the Victorian Cerebral Palsy Register.[17] Notably, spastic quadriplegia was not an independent predictor in the multivariate model, suggesting that its high raw incidence is driven primarily by the associated GMFCS V status rather than topography.[22]

The strength of this study lies in its long-term follow-up (up to 10 years) and the use of survival analysis (Cox proportional hazards model), which accounts for variable follow-up times and censored data, providing a more accurate estimate of risk than simple cross-sectional prevalence used in many previous hospital-based studies. However, this study has limitations. First, the single-center design may limit generalizability to the broader community CP population, as our tertiary center likely manages more severe cases. Second, we did not evaluate the impact of pelvic obliquity or scoliosis, which are known to correlate with hip displacement.[24,25] Third, due to sample size constraints within specific subgroups, we dichotomized GMFCS levels into I-III and IV-V to ensure the statistical reliability of our multivariable model. We acknowledge that this broad categorization may mask subtle differences in hip displacement risk between adjacent GMFCS levels and reduce the granularity of our clinical risk estimates. Fourth, an important limitation concerns the interpretation of unadjusted baseline comparisons, like those presented in Table 1. Because follow-up duration varied substantially across participants, some patients classified as “successful” simply may not have been followed long enough to experience significant displacement. While our Cox regression appropriately accounts for this time-to-event data, there was still a substantial reduction in the number of patients at risk at later time points (e.g., years 6 to 8) due to right-censoring and loss to follow-up. This reduction inherently increases the uncertainty of our long-term cumulative incidence estimates.

To assess potential attrition bias, we compared baseline characteristics of patients who remained in the study with those of patients who were lost to follow-up (Appendix Table B1). Reassuringly, there were no significant differences in major clinical severity indicators, including GMFCS levels and epilepsy. However, patients who were retained in the program tended to be older at their initial X-ray and had slightly higher baseline MP, suggesting that those with more concerning initial clinical presentations were more likely to remain under long-term observation.

These findings highlight the urgent need to strengthen our national hip surveillance program. Although the institute’s 2016 protocol aligns with general screening principles, the high cumulative incidence observed in this study suggests that current surveillance intensity and intervention thresholds may be insufficient for high-risk populations (GMFCS IV-V). Specifically, reducing surveillance frequency to once a year after age 7 may miss rapid deterioration during the prepubertal growth spurt. Furthermore, the referral threshold of MP > 40.0% may preclude the opportunity for less invasive preventive surgery. Therefore, we recommend intensifying the protocol by maintaining 6-monthly surveillance for GMFCS IV-V until skeletal maturity and lowering the surgical referral threshold to allow for timely preventive interventions.

Crucially, the cumulative incidence and HR derived from this study serve as vital tools for prognostic counseling. Providing parents with evidence-based, time-specific risks facilitates informed and shared decision-making. Clear communication

of these figures, such as the 41.0% risk by 6 years or the three-fold increase in risk for GMFCS IV-V, can improve compliance with monitoring schedules and set realistic surgical expectations. Proactive communication and targeted monitoring of these vulnerable groups could help effectively prevent hip dislocation rather than merely documenting its progression.

Conclusion

The cumulative incidence of significant hip displacement was high in this study (41.0% at 6 years of follow-up). While higher GMFCS levels (IV-V) are the strongest independent predictors of hip displacement, having a non-spastic CP subtype acts as a significant independent protective factor. These findings highlight the critical need for structured, GMFCS-stratified surveillance. Furthermore, the results provide clinicians with robust evidence for prognostic counseling, facilitating more effective communication of time-specific risks to parents. This is essential for ensuring long-term adherence to monitoring protocols and preventing the progression to painful dislocations.

Conflicts of interest disclosure

The author confirms that there are no conflicts of interest related to the manuscript.

Generative AI declaration

During the preparation of this work, the author used Gemini to improve language and grammar. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the publication's content.

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Data availability

Research data are not shared.

Author declaration

The Principal Investigator is the sole author of this manuscript. The author was responsible for all aspects of the research, as defined by the CRediT taxonomy.

Supplementary materials

The following supporting information can be downloaded at: Supplementary file.

References

1. Li J, Ganjwala D, Johari A, Miller S, Schaeffer EK, Mulpuri K, et al. Hip surveillance for children with cerebral palsy: a survey of orthopaedic surgeons in India. Indian J Orthop [Internet]. 2022 Jan [cited 2026 Jan 14];56(1):58-65. Available from: https://pubmed.ncbi.nlm.nih.gov/35070143/ doi:10.1007/s43465-021-00432-3
2. Shore B, Spence D, Graham HK. The role for hip surveillance in children with cerebral palsy. Curr Rev Musculoskelet Med [Internet]. 2012 Jun [cited 2026 Jan 15];5(2):126-34. Available from: https://pubmed.ncbi.nlm.nih.gov/22430862/ doi:10.1007/s12178-012-9120-4
3. Aroojis A, Mantri N, Johari AN. Hip displacement in cerebral palsy: the role of surveillance. Indian J Orthop [Internet]. 2021 Jan [cited 2026 Jan 12];55(1):5-19. Available from: https://pubmed.ncbi.nlm.nih.gov/33569095/ doi:10.1007/s43465-020-00162-y
4. Bugler KE, Gaston MS, Robb JE. Hip displacement in children with cerebral palsy in Scotland: a total population study. J Child Orthop [Internet]. 2018 Dec [cited 2026 Jan 17];12(6):635-9. Available from: https://pubmed.ncbi.nlm.nih.gov/30607212/ doi:10.1302/1863-2548.12.180106
5. Lomaneenoparat R. Results of hip subluxation prevention program in cerebral palsy children at Queen Sirikit National Institute of Child Health. J Dept Med Serv [Internet]. 2023 Jan-Mar [cited 2026 Jan 17];48(1):12-9. Available from: https://he02.tci-thaijo.org/index.php/JDMS/article/view/257269
6. Huser A, Mo M, Hosseinzadeh P. Hip surveillance in children with cerebral palsy. Orthop Clin North Am [Internet]. 2018 Apr [cited 2026 Jan 17];49(2):181-90. Available from:https://pubmed.ncbi.nlm.nih.gov/29499819/ doi:10.1016/j.ocl.2017.11.006
7. Kentish M, Wynter M, Snape N, Boyd R. Five-year outcome of state-wide hip surveillance of children and adolescents with cerebral palsy. J Pediatr Rehabil Med [Internet]. 2011 [cited 2026 Jan 17];4(3):205-17. Available from:https://pubmed.ncbi.nlm.nih.gov/22207097/ doi:10.3233/PRM-2011-0176
8. Wordie SJ, Robb JE, Hägglund G, Bugler KE, Gaston MS. Hip displacement and dislocation in a total population of children with cerebral palsy in Scotland: status after five years' hip surveillance. Bone Joint J [Internet]. 2020 Mar [cited 2026 Jan 17];102-B(3):383-7. Available from:https://pubmed.ncbi.nlm.nih.gov/32114804/ doi:10.1302/0301-620X.102B3.BJJ-2019-1203.R1
9. Gordon GS, Simkiss DE. A systematic review of the evidence for hip surveillance in children with cerebral palsy. J Bone Joint Surg Br [Internet]. 2006 Nov [cited 2026 Jan 17];88-B(11):1492-6. Available from:https://pubmed.ncbi.nlm.nih.gov/17075096/ doi:10.1302/0301-620X.88B11.18114
10. Hagglund G, Lauge-Pedersen H, Wagner P. Characteristics of children with hip displacement in cerebral palsy. BMC Musculoskelet Disord [Internet]. 2007 Oct [cited 2026 Jan 17];8:101. Available from:https://pubmed.ncbi.nlm.nih.gov/17963501/ doi:10.1186/1471-2474-8-101
11. Lindgren AM, Asma A, Rogers KJ, Miller F, Shrader MW, Howard JJ. Hip displacement after triradiate closure in ambulatory cerebral palsy: who needs continued surveillance? J Pediatr Orthop [Internet]. 2024 Nov [cited 2026 May 17];44(10):601-7. Available

from: https://pubmed.ncbi.nlm.nih.gov/39099047/ doi:10.1097/BPO.0000000000002783
12. Thamphunanon V, editor. Clinical Practice Guideline for Hip Dysplasia in Cerebral Palsy: Management Program in QSNICH. 1st ed. Bangkok: Queen Sirikit National Institute of Child Health, Department of Medical Services, Ministry of Public Health; 2016.
13. Reimers J. The stability of the hip in children: a radiological study of the results of muscle surgery in cerebral palsy. Acta Orthop Scand Suppl [Internet]. 1980 [cited 2026 Feb 16];184:1-100. Available from:https://pubmed.ncbi.nlm.nih.gov/6930145/ doi:10.3109/ort.1980.51.suppl-184.01
14. Hägglund G, Alriksson-Schmidt A, Lauge-Pedersen H, Rodby-Bousquet E, Wagner P, Westbom L. Prevention of dislocation of the hip in children with cerebral palsy. Bone Joint J [Internet]. 2014 Nov [cited 2026 Jan 18];96-B(11):1546-52. Available from:https://pubmed.ncbi.nlm.nih.gov/25371472/ doi:10.1302/0301-620X.96B11.34385
15. Wynter M, Gibson N, Willoughby KL, Love S, Kentish M, Thomason P, et al. Australian hip surveillance guidelines for children with cerebral palsy: 5-year review. Dev Med Child Neurol [Internet]. 2015 Sep [cited 2026 Feb 18];57(9):808-20. Available from:https://pubmed.ncbi.nlm.nih.gov/25846730/ doi:10.1111/dmcn.12754
16. Larnert P, Risto O, Hagglund G, Wagner P. Hip displacement in relation to age and gross motor function in children with cerebral palsy. J Child Orthop [Internet]. 2014 Apr [cited 2026 May 12];8(2):129-34. Available from:https://pmc.ncbi.nlm.nih.gov/articles/PMC3965763/ doi:10.1007/s11832-014-0570-7
17. Soo B, Howard JJ, Boyd RN, Reid SM, Lanigan A, Wolfe R, et al. Hip displacement in cerebral palsy. J Bone Joint Surg Am [Internet]. 2006 Jan [cited 2026 Feb 18];88(1):121-9. Available from:https://pubmed.ncbi.nlm.nih.gov/16391257/ doi:10.2106/JBJS.E.00071
18. Scrutton D, Baird G. Surveillance measures of the hips of children with bilateral cerebral palsy. Arch Dis Child [Internet]. 1997 Apr [cited 2026 Feb 5];76(4):381-4. Available from:https://pubmed.ncbi.nlm.nih.gov/9166039/ doi:10.1136/adc.76.4.381
19. Rutz E. Are hips stable in children with cerebral palsy? Dev Med Child Neurol [Internet]. 2012 Oct [cited 2026 Feb 18];54(10):878. Available from:https://pubmed.ncbi.nlm.nih.gov/22881187/ doi:10.1111/j.1469-8749.2012.04380.x
20. Dobson F, Boyd RN, Parrott J, Nattrass GR, Graham HK. Hip surveillance in children with cerebral palsy: impact on the surgical management of spastic hip disease. J Bone Joint Surg Br [Internet]. 2002 Jul [cited 2026 Feb 18];84-B(5):720-6. Available from:https://pubmed.ncbi.nlm.nih.gov/12188492/ doi:10.1302/0301-620x.84b5.12398
21. Australian National Hip Surveillance Working Group. Australian hip surveillance guidelines for children with cerebral palsy 2020 [Internet]. Melbourne: Australasian Academy of Cerebral Palsy and Developmental Medicine (AusACPDM); 2020 Nov [cited 2026 Feb 10]. Available from:https://www.oceaniaacademy.org/wp-content/uploads/2020/12/200240-Hip-survey-A5-booklet-WEB.pdf
22. Pruszczynski B, Sees J, Miller F. Risk factors for hip displacement in children with cerebral palsy: systematic review. J Pediatr Orthop [Internet]. 2016 Sep [cited 2026 Jan 18];36(6):629-33. Available from:https://pubmed.ncbi.nlm.nih.gov/26090973/ doi:10.1097/BPO.0000000000000577
23. Elkamil AI, Andersen GL, Hägglund G, Lamvik T, Skranes J, Vik T. Prevalence of hip dislocation among children with cerebral palsy in regions with and without a surveillance programme: a cross sectional study in Sweden and Norway. BMC Musculoskelet Disord [Internet]. 2011 Dec [cited 2026 Feb 18];12:284. Available from:https://pubmed.ncbi.nlm.nih.gov/22177473/ doi:10.1186/1471-2474-12-284
24. Terjesen T, Vinje S, Kibsgard T. The relationship between hip displacement, scoliosis, and pelvic obliquity in 106 nonambulatory children with cerebral palsy: a longitudinal retrospective population-based study. Acta Orthop [Internet]. 2024 Feb [cited 2026 Feb 15];95:55-60. Available from:https://pubmed.ncbi.nlm.nih.gov/38288626/ doi:10.2340/17453674.2024.39915
25. Pountney TE, Mandy A, Green E, Gard PR. Hip subluxation and dislocation in cerebral palsy: a prospective study on the effectiveness of postural management programmes. Physiother Res Int [Internet]. 2009 Jun [cited 2026 Feb18];14(2):116-27. Available from:https://pubmed.ncbi.nlm.nih.gov/19194957/ doi:10.1002/pri.434

Appendix A. The Clinical Practice Guideline for Hip Dysplasia in Cerebral Palsy, Queen Sirikit National Institute of Child Health, Thailand, 2016

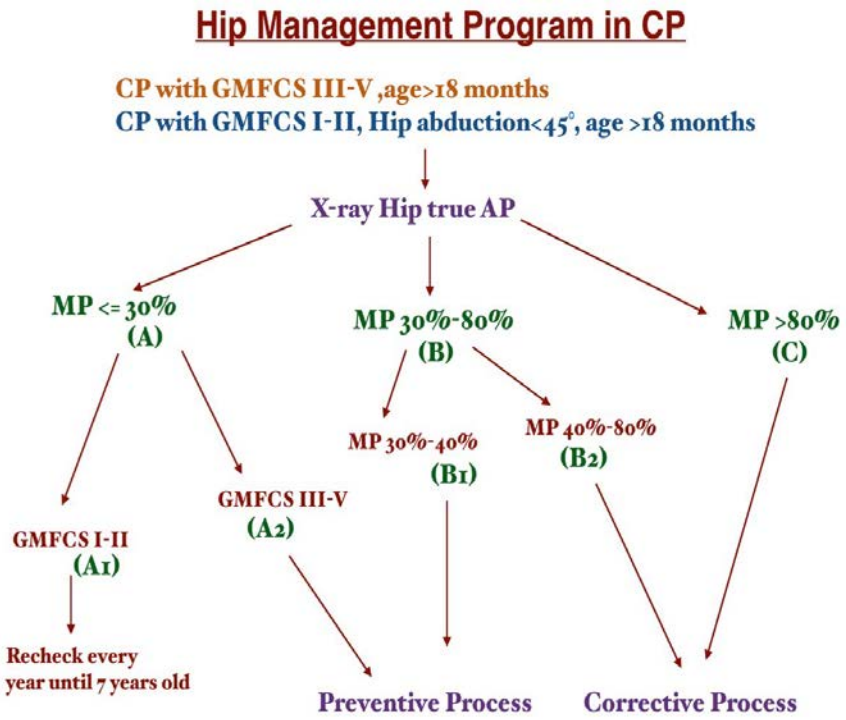

Figure A1. Algorithm for the screening and management of hip displacement in children with cerebral palsy, Queen Sirikit National Institute of Child Health, Thailand, 2016

Appendix B: Supplementary table

Table B1. Comparison of baseline characteristics between patients who completed follow-up and those lost to follow-up.

Variables	Completed follow-up (n = 126)	Loss to follow-up (n = 139)	*p*-value
Age at first X-ray (month)[1]	39.9 (28.4)	28.6 (11.8)	< 0.001[a]
Gender[2]			
Female	63 (50.0)	63 (45.3)	0.447[b]
Male	63 (50.0)	76 (54.7)	
BMI (kg/m^2)[1]	16.15 (7.19)	15.70 (3.06)	0.496[a]
GMFCS level[2]			
I-III	37 (29.4)	50 (36.0)	0.253[b]
IV-V	89 (70.6)	89 (64.0)	
CP type[2]			
Spastic quadriplegia	45 (35.7)	33 (23.7)	
Spastic diplegia	56 (44.4)	53 (38.1)	0.006[b]
Spastic hemiplegia	6 (4.8)	19 (13.7)	
Non-spastic	19 (15.1)	34 (24.5)	
Epilepsy[2]			
Yes	61 (48.4)	58 (41.7)	0.274[b]
No	65 (51.6)	81 (58.3)	
Baseline migration percentage (%)[1]	24.6 (12.3)	21.6 (12.3)	0.049[a]

[1]Mean (SD), [2]Number (%), [a]Independent t-test, [b]X^2-test

BMI; body mass index; GMFCS, Gross Motor Function Classification System; CP, cerebral palsy