



# Hemiepiphysiodesis Of the Proximal Portion of The Femur for The Management of Hip Dysplasia in Children with Cerebral Palsy

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**Abstract:** Objectives: To evaluate the efficacy and safety of proximal femoral hemiepiphysiodesis (PFH) in the management of hip dysplasia in children with cerebral palsy (CP), by means of a systematic review with meta-analysis.

**Methodology:** A systematic review was conducted according to the PRISMA guidelines. Clinical studies investigating PFH in children with CP, with or without a control group, were included. The search was carried out in PubMed, Embase, Scopus, Web of Science and Cochrane Library, with no language or date restrictions.

The primary outcomes included the progression of femoral migration (Reimers index), the need for subsequent surgery and complications related to the procedure. The quality of the studies was assessed using instruments appropriate to the methodological design, and the data was synthesized using meta-analysis.

**Results:** Three studies were included, totaling 84 patients. The meta-analysis showed a significant reduction in the Reimers migration index after HPF (mean difference: -5.91%; 95% CI: -10.55 to -1.27;  $p < 0.01$ ). The rate of need for subsequent surgery was 24% (95% CI: 14%-38%), while the rate of complications was 18% (95% CI: 11%-29%). The overall quality of the studies ranged from moderate to high.

**Conclusion:** Proximal femoral hemiepiphysiodesis has been shown to be effective in containing femoral migration in children with cerebral palsy, with acceptable rates of complications and reoperations. These findings support its use as a less invasive alternative in the management of hip dysplasia in this population.

**Keywords:** Cerebral Palsy; Hip Dysplasia; Femur; Orthopedics

**INTRODUCTION:** The process of musculoskeletal development in children is constant up to a certain stage, which involves the closure of the bone growth zone. It is known that this evolutionary regime is directly associated with the locomotor system, and it is extremely important to monitor all the phases and their clinical repercussions. Bone grows in length through the production of bone in the growth physis, a cartilaginous plate containing germ cells specialized in the production of new bone.<sup>1</sup>

Implications in the growth process usually occur and complaints of crooked legs during childhood by parents are common. However, it can be normal depending on age and angulation, but altered bone growth can be triggered by various diseases and can lead to persistent and progressive deformity. An orthopaedic assessment and accurate diagnosis are essential for the appropriate treatment of each case.<sup>2 3</sup>

Cerebral palsy patients are known to be at greater risk of developing bone lesions associated with growth and

consequently chronic motor disability in children, associated with factors such as prolonged immobilization, nutritional factors, pubertal status and chronic use of anticonvulsants. Low calcium intake results in impaired mineralization of the bone matrix, leading to low bone mineral density (BMD) and low-impact fractures and osteolytic lesions.<sup>3</sup>

Scientific advances have made it possible to improve the growth potential of the physal plate through a minimally invasive surgical technique called guided growth, which allows bone growth to be guided, making it possible to correct angular deformities, varus and valgus, and also to correct differences in limb length, with the aim of temporarily blocking local growth and allowing the limb to be progressively aligned.<sup>4, 5, 6</sup>

Thus, guided growth allows for the correction of deformities in immature skeletons, during the child development phase, during bone growth itself, without the need for more invasive surgeries, such as osteotomies and larger implants. This results in better biomechanical and locomotor system function.<sup>2, 3, 5, 6, 7</sup>

The aim of this study is to evaluate the effectiveness of proximal femoral hemiepiphysiodesis in the management of hip dysplasia in children with cerebral palsy.

## METHODOLOGY

This is a systematic review with meta-analysis. The review was registered in PROSPERO (International Prospective Register of Systematic Reviews), under the number CRD420251030820.

Research Question (PICO)

- Population: Children with cerebral palsy with hip dysplasia
- Intervention: Proximal femoral hemiepiphysiodesis (guided growth)
- Control: No intervention or other orthopedic surgeries (when applicable)
- Outcomes: Head Shaft Angle (HSA) reduction, Acetabular Index (AI), Migration Percentage (MP), complications, need for subsequent reconstructive

surgery.

## 2. Eligibility criteria

### 2.1 Inclusion:

- Studies published in the last 15 years
- Studies in children (0-18 years) with cerebral palsy and hip dysplasia
- Intervention with proximal femoral hemiepiphysiodesis
- Studies presenting quantitative data on at least one of the following: HSA, AI, MP, complications, need for surgical revision
- Retrospective studies, prospective studies, cohorts, clinical trials

### 2.2 Exclusion:

- Studies with a mixed population without separable data for PC
- Reviews, letters to the editor, studies with N < 5
- Studies with osteotomy as the only primary intervention
- Studies with less than 2 years of follow-up

## 3. Search strategy

The following databases were searched: PubMed, Scopus, Embase and Web of Science. Using the following keywords and Boolean operators (adjusted for base): "cerebral palsy" AND "hip dysplasia" AND "proximal femoral hemiepiphysiodesis") OR ("guided growth" AND "proximal femur" AND "children"). In order to guarantee the quality of the studies, a phased selection was carried out:

- Phase 1: Screening by title and abstract
- Phase 2: Full reading of potentially eligible articles
- Two independent reviewers carried out the selection, with a third for tie-breakers

## 4. Data Extraction

A standardized form was used to extract:

- Study characteristics (author, year, country, type)
- Demographic data (age, GMFCS)
- Intervention details (type of screw, surgical technique, follow-up)

- Outcomes: HSA, IA, MP, complications (e.g. physeal migration), need for subsequent surgery

- Methodological Quality Assessment: The MINORS (Methodological Index for Non-Randomized Studies) tool was applied to observational studies.

The score was used to analyze bias and sensitivity of the data.

## 5. Statistical analysis

Meta-analysis was carried out to synthesize the data and perform statistical analysis. The analysis was carried out using RevMan 5.4 or R software (meta and metafor packages), random effect models used due to clinical and methodological heterogeneity, for continuous variables (e.g. HSA, AI, MP), the weighted mean difference (MD) with 95% confidence interval (CI) was used and for dichotomous variables (e.g. need for reconstructive surgery), odds ratios (OR) were used. Heterogeneity was assessed by  $I^2$  (considering >50% as high heterogeneity), subgroup analysis according to screw type (fully or partially threaded) and GMFCS.

## RESULTS

Eight articles were selected during the search process; after excluding those published more than 15 years ago, six remained. Analysis of the title and abstract allowed the exclusion of one paper which did not correspond to the objective of this study. Five articles were read in full, of which one was excluded because it did not meet the inclusion criteria, and finally three were selected for this article (Figure 1).

The three articles selected featured patients with cerebral palsy who underwent proximal femoral hemiepiphysiodesis for guided growth of the proximal femur with a fully threaded screw or a partially threaded cannulated screw. Radiological parameters such as Head shaft angle (HSA), Hilgenreiner's epiphyseal angle (HEA), Acetabular index (AI), Migration percentage (MP), Femoral anteversion angle (FAVA) and Neck shaft angle (NSA) reported in some studies were evaluated. A total of 84 patients were included, of whom 110 hips received a fully threaded screw and 55 a partially threaded cannulated screw.

Table 1 shows the selected articles and their results

(Table 1).

Table 2 contains the post-operative Percentage Migration (PM) score after proximal femoral hemiepiphyodesis<sup>9, 10, 11</sup>

Figure 2 shows the analysis of the MP radiological parameter of patients undergoing proximal femoral hemiepiphyodesis<sup>9, 10, 11</sup>

In the retrospective study by Hsieh et al<sup>9</sup>, 33 patients underwent guided hip growth for progressive bilateral hip subluxation associated with coxa valga deformity, however, 09 patients were excluded from the study, 08 because they received proximal femoral osteotomy as initial treatment, due to a migration percentage of more than 50% and an age of more than 12 years, and 01 because the segment was less than two years old. Thus, the study continued with 24 patients, with an average post-surgery follow-up period of 50 months; no child was lost to follow-up or had previous surgery or a hip infection. With regard to the Gross Motor Function Classification System (GMFCS), 03 patients had level I, 04 level II, 07 level III, 07 level IV and 03 level V. As for surgery, all the patients underwent adductor tenotomy, with fully threaded screws being used in 20 hips and partially threaded screws in 28. Excellent results were obtained in the radiological parameters, HSA (Head shaft angle) improved after surgery ( $163^{\circ} \pm 6^{\circ}$  before versus  $150^{\circ} \pm 9^{\circ}$  after, mean difference  $13^{\circ}$  [95% CI 11 to 15]); HEA (Hilgenreiner's epiphyseal angle) also improved ( $10^{\circ} \pm 4^{\circ}$  before versus  $25^{\circ} \pm 9^{\circ}$  after, mean difference  $15^{\circ}$  [95% CI 13 to 18];  $p < 0.001$ ); AI (Acetabular index) and MP (Migration percentage) between the preoperative period and the last visits, with an average difference of  $3^{\circ}$  (95% CI 2 to 4;  $p < 0.001$ ) in AI and 10.1% (95% CI 7 to 13;  $p < 0.001$ ) in MP. As for complications and approaches, in 13 patients, the proximal femoral physis grew out of the transfixure screw, a situation that occurred in 50% of the hips treated with a fully threaded screw and in 39% of those treated with a partially threaded screw. The average length of time the screw was away from the physis did not differ greatly between the fully threaded screw group and the partially threaded screw group (27 months versus 29 months). In the end, 08 patients underwent a replacement with a longer screw, of these, 05 underwent subsequent reconstructive surgery,

including proximal femoral varus rotation osteotomy, with or without pelvic osteotomy, at the expense of progressive hip dislocation after guided growth surgery.

Hsu et al<sup>10</sup> presented a retrospective study of 32 patients which analyzed the influence of the position of the screw on the guided growth of the proximal femur. Patients were divided into two different groups according to the position of the screw, if it was along the medial quarter of the physis, group 1 was designated and the medial quarter of the physis was designated as group 2. There were no significant differences between the groups in terms of preoperative demographic and radiological data. Regarding the Gross Motor Function Classification System (GMFCS), 04 patients had level I, 06 level II, 10 level III, 09 level IV and 03 level V. As for surgery, all patients underwent adductor tenotomy, with fully threaded screws being used in 34 hips and partially threaded screws in 27. Group 1, with 37 hips, was analyzed. At two years, HSA decreased from  $163.6^{\circ}$  (95% CI 161.4 to 165.8) to  $149.7^{\circ}$  (95% CI 147.4 to 152.1) ( $p < 0.001$ , paired t-test); MP was reduced from 28.7% (95% CI 25.6 to 31.7) to 23.8% (95% CI 20.6 to 27.0) ( $p < 0.001$ , paired t-test); AI decreased from  $21.0^{\circ}$  (95% CI 19.2 to 22.8) to  $19.4^{\circ}$  (95% CI 17.6 to 21.2) ( $p = 0.001$ , paired t-test) and FAVA (Femoral anteversion angle) decreased from  $32.0^{\circ}$  (95% CI 28.6 to 35.5) to  $24.3^{\circ}$  (95% CI 21.4 to 27.3) ( $p < 0.001$ , Wilcoxon test). During the first two years, growth of the physis out of the screw occurred in 16 hips, with a median age of seven years (IQR 5.2 to 7.0), while the median age of those who did not show growth of the physis was nine years (IQR 5.2 to 7.0), it can be seen that the children who showed this growth were significantly younger. No premature partial closure of the physis was observed in this series.

In the study by Portinaro et al<sup>1</sup>, 31 patients underwent bilateral hemiepiphyodesis of the proximal femur; however, 03 patients were lost to follow-up, leaving 28 patients. As for the Gross Motor Function Classification System (GMFCS), 07 were level III, 09 level IV and 12 level V. With regard to surgery, partially threaded screws were used in all patients, and in 4 patients a temporary epiphyodesis of the anterior distal femur was performed concomitantly to treat knee flexion deformities; in 22 patients bilateral stretching of the medial distal hamstrings was performed simultaneously and in 3 patients botulinum toxin was injected into the

medial hamstrings and adductors bilaterally. Active and passive mobilization, foot position and gait were started early after surgery, according to the child's pain level, as assessed by the Wong-Baker FACES Pain Assessment Scale, none of which exceeded a score of three. A significant decrease was observed throughout the follow-up period, especially for HSA, with an average decrease of  $8 \pm 7$  degrees (95% CI, 7-11 degrees;  $P < 0.001$ ) at 1 year; AI  $4 \pm 4$  degrees (95% CI, 3-5 degrees;  $P < 0.001$ ) at 1 year; significant improvements for MP between the preoperative values and at 1 year ( $6.52\% \pm 8.41\%$ ; 95%  $P < 0.001$ ). In this study, there was growth of the proximal femoral physis out of the screw at 24 months in 06 patients, of which 01 had the screws replaced but the screw head broke at the end of the replacement, so to avoid this complication, they started placing a second screw parallel to the first in the other 02 patients, while the other 03 patients had a new hip dislocation at 36 months, and a shortening femoral osteotomy with Pemberton pelvic osteotomy was performed after the screws were removed. There was no avascular necrosis, wound infection, chondrolysis, femoral neck fracture or other complications until the last follow-up.

## DISCUSSION

The systematic review and meta-analysis on the use of hemiepiphyodesis of the proximal portion of the femur (TMH-PF) for the management of hip dysplasia in children with cerebral palsy (CP) showed good results, reinforcing its role as a minimally invasive alternative to conventional osteotomies. The main findings show a significant improvement in radiographic measurements, including a reduction in the femoral head-neck angle (HSA), acetabular index (AI) and migration percentage (MP), indicating effective bone remodeling over time. <sup>11</sup>

, <sup>12</sup>

The femoral head-neck angle (HSA) is an essential measurement in the assessment of coxa valga and is often increased in children with CP due to abnormal growth of the proximal femur. Studies indicate that high HSA values are directly associated with a higher percentage of migration and risk of hip subluxation, making this measurement one of the main targets of

TMH-PF<sup>13, 14</sup>

Another factor in assessing hip instability in children with CP is the Gross Motor Function Classification System (GMFCS), which classifies patients according to their level of mobility. Children at GMFCS levels IV and V have a significantly higher risk of hip dislocation, with an incidence of up to 90% in the most severe cases<sup>12, 13</sup>. The relationship between GMFCS and the progression of hip dysplasia highlights the importance of early radiographic surveillance and timely interventions to minimize complications<sup>13</sup>.

Despite the improvements observed, the heterogeneity of the studies and the limited methodological quality pose challenges in interpreting the results. Although the technique is generally effective, migration of the physis away from the screw was a common complication, occurring in up to 43% of cases, which raises questions about the need for subsequent surgical revisions and the durability of the effects of HFM-PF<sup>11, 12</sup>. In addition, factors such as age, GMFCS level and screw position were identified as determining the success of the technique, suggesting that careful patient selection is essential<sup>11</sup>.

The study by Hsu et al.<sup>10</sup> made important contributions by evaluating the influence of screw position on the effectiveness of femoral valgus correction. The authors compared different screw locations in the proximal medial physis and showed that the eccentric position of the screw is associated with greater correction of HSA, but also with an increased risk of the physis growing out of the screw. In younger children, who have greater growth potential, the authors recommend a more centralized screw position to reduce the need for early surgical revisions<sup>10</sup>.

The comparison with traditional treatments reinforces the potential benefit of TMH-PF in reducing the need for more invasive osteotomies. Unlike femoral and pelvic osteotomies, which often require prolonged hospital stays and have significant morbidity, TMH-PF can be performed as an outpatient procedure, favoring faster recovery and minimizing associated complications, such as infections and avascular necrosis<sup>9, 11</sup>. However, there is evidence that the effectiveness of the method is reduced in more advanced cases of hip subluxation,



especially when the percentage of migration is greater than 50%, which may indicate the need for earlier surgical interventions to maximize the benefits of guided growth<sup>9, 11, 15</sup>.

Another important aspect to consider is the influence of the technique on acetabular development. The study by Hsieh et al. (2019)<sup>9</sup> showed that TMH-PF not only improved the correction of coxa valga, but also promoted a significant reduction in the percentage of hip migration and the acetabular index. These findings suggest that the technique may provide a protective effect against the progression of hip dysplasia and the need for additional reconstructive surgery.<sup>9, 12, 13</sup>

Given these findings, it is essential that future studies focus on standardizing the technique, defining the ideal criteria for selecting patients and assessing long-term functional outcomes. Prospective clinical trials and studies with longer follow-up times will be essential in order to validate the efficacy and safety of HFM-PF and determine whether its application can significantly reduce the need for reconstructive surgery in children with CP<sup>10, 11, 12</sup>.

## CONCLUSION

Hemiepiphysiodesis of the proximal portion of the femur has emerged as an effective and minimally invasive alternative for the management of hip dysplasia in children with cerebral palsy. The findings show that the technique can contribute to improving hip stability, especially when applied early in selected patients. However, there are still challenges to overcome, such as standardizing the procedure, understanding prognostic factors and the need for long-term studies to assess its functional effects and the durability of the results.

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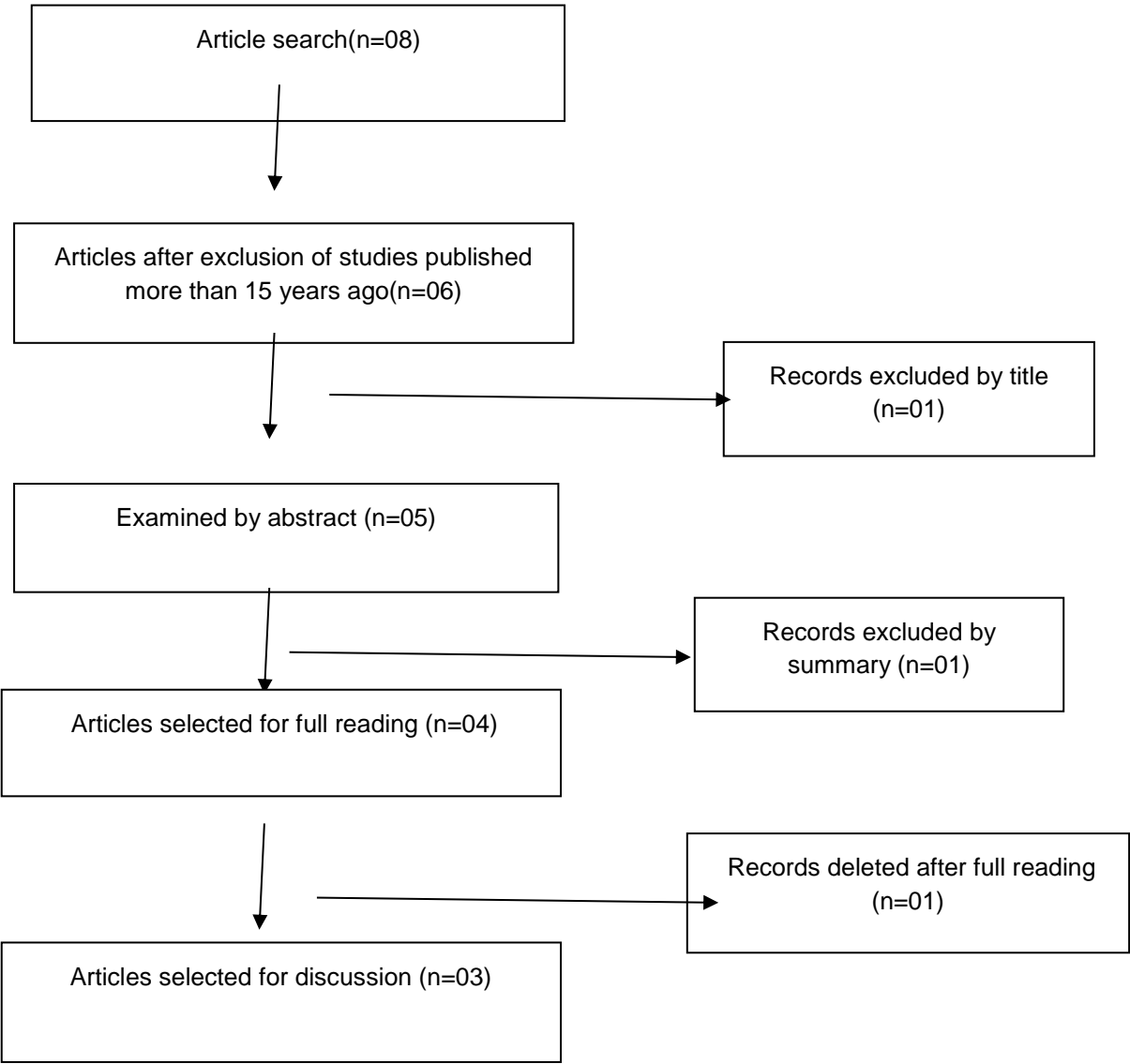
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Figure 1 - Studies selected according to PRISMA methodology



Source: Own authorship (2025).

Table 1. Results obtained by the selected studies.

Study	Approach	M/F patients	Results
Hsieh et al	Hemi epifisiodesse femoral proximal	17/7	Head shaft angle (HAS), Hilgenreiner's epiphyseal angle (HEA), Migration percentage (MP), Acetabular index (IA) , GMFCS nível
Hsu et al	Hemi epifisiodesse femoral proximal	9/28	Head shaft angle (HAS), Migration percentage (MP), Acetabular index (IA), Femoral anteversion angle (FAVA), GMFCS level
Portinaro et al	Hemi epifisiodesse femoral proximal	11/17	Neck shaft angle (NSA), Acetabular indicators (IA), Migration percentage (MP), GMFCS level

**Table 2- Pre- and post-operative scores for migration percentage (MP) after proximal femoral hemi-epiphysiodesis**

Study	Sample	Middle Ages	Preoperative MP	Post-operative MP
Hsieh et al	24 patients	8 (5 a 12)	39 ± 10	29 ± 17
Hsu et al	37 patients	7 (6.5 a 9.0)	28.7 (25.6 a 31.7)	4.9 (3.3 a 6.4)
Portinaro et al	28 patients	7.5 ± 1.3 (4 a 11)	33.5 ± 11.29	25.96 ± 10.29

**Figure 2 - Florest graph of the analysis of the radiological parameter MP in patients undergoing proximal femoral hemi-epiphysis.**



