MEGA JOURNAL OF CASE REPORTS

OPEN ACCESS

Research Article

Compiled Date: April 05, 2025

Minimally Invasive Pelvic Periacetabular Osteotomy in Ambulatory Children with Cerebral Palsy: A Long Tern Retrospective Study

F. Pelillo[1*], V. Montemaggiori[2], E. Jannelli[3], GL Pasta[4], G. Beltrame[5], NMA Portinaro[6] and M. Mosconi[7]

[1]Department of Orthopaedic, Policlinico San Matteo, Italy

[2]Department of Orthoaedic, Arcispedale Santa Maria Nuova, Italy

[3]Department of Orthopaedic, Policlinico San Matteo, Italy

[4]Department of Orthopaedic, Policlinico San Matteo, Italy

[5]Residency Program in Orthopaedic and Traumatology, University of Milan, Italy

[6]Department of Paediatric Surgery, Fondazione IRCCS Ca' Granda Ospedale Maggiore Policlinico, Italy

[7]Department of Orthopaedic, Policlinico San Matteo, 27100 Pavia, Italy

[*]**Corresponding author**: Francesco Pelillo, Department of Orthopaedic, Policlinico San Matteo, 27100 Pavia, Italy, Tel: 393207655387

Abstract

Hip displacement is a common and debilitating complication in children with cerebral palsy (CP), particularly those classified as GMFCS levels II and III. Traditional reconstructive surgeries, while effective, are associated with higher morbidity. Minimally invasive surgical (MIS) techniques offer a promising alternative for managing hip subluxation and dislocation in this population. Methods: This retrospective study evaluated 20 children (mean age: 9.4 years) with CP (GMFCS levels II and III) who underwent minimally invasive pelvic and femoral osteotomies between 2010 and 2020. Radiographic parameters, including migration percentage (MP), acetabular index (AI), and neck-shaft angle (NSA), were assessed preoperatively and postoperatively. Functional outcomes were measured using the CPCHILD questionnaire. The mean follow-up duration was 6.5 years. Results: Surgical intervention significantly improved radiographic outcomes: mean MP decreased from 59% to 14%, AI from 38.5° to 19°, and NSA from 153° to 128% (all $p < 0.001$). All

patients retained preoperative ambulatory status and reported significant improvements in CPCHILD scores ($p < 0.001$). Complications were minimal, with no infections or non-unions. Only one patient required reoperation due to a postoperative fracture. Conclusions: Minimally invasive pelvic and femoral osteotomies effectively restore hip stability, improve quality of life, and minimize surgical morbidity in ambulatory children with CP. This approach offers a viable alternative to traditional methods, with favorable clinical and radiographic outcomes.

Keywords: Cerebral palsy; Hip dislocation; Minimally invasive surgery

Introduction

Cerebral Palsy (CP) is the most common cause of physical disability in children, with hip displacement representing a significant complication that affects mobility and quality of life. The likelihood of hip displacement is strongly correlated with Gross Motor Function Classification System (GMFCS) levels **[1].** While non-ambulatory children (GMFCS IV and V) face the higher risk, ambulatory children classified as GMFCS II and III are also significantly affected, with rates of hip displacement reaching 50% **[2].** Hip displacement begins insidiously and progresses over time; the imbalance between spastic hip adductors and flexors and weaker hip abductors and extensors contributes to the migration of the femoral head out of the acetabulum, leading to abnormal acetabular loading and acetabular dysplasia **[3].** The uncovered femoral head is subjected to abnormal forces that alter its shape and damage cartilage, while pain and osteoarthritis start developing over time. For ambulatory patients, untreated hip subluxation or dislocation can jeopardize walking ability and quality of life **[4].** Current treatment strategies are influenced by the hip condition and patient's age, while no universal consensus exists **[5].** Soft tissue surgery can be effective in early stages to correct muscle imbalance and slow progression, but definitive surgical interventions, such as pelvic and femoral osteotomies, are often required once dislocation occurs **[6].** Traditional approaches, especially in cases requiring bilateral reconstruction, are generally safe and effective, with favorable outcomes for achieving hip stability despite being associated with relatively higher complication rates, such as extended operative times and increased blood loss **[7].** Advancements in minimally invasive techniques offer promising alternatives, with the potential to reduce complications and improve recovery **[8].** This retrospective study evaluates the long-term effectiveness of this approach in children with CP classified as GMFCS II – III. The primary goals are to maintain hip symmetry, minimize surgical morbidity and operative time.

Materials and Methods

This retrospective study included 20 children suffering from CP, classified as GMFCS levels II or III. Children at GMFCS level II can walk in most settings but may require support for long distances or challenging terrains, while those at GMFCS level III typically use assistive devices such as crutches or walkers for mobility and may require a wheelchair for longer distances. These patients underwent surgical treatment for hip subluxation or dislocation between 2010 and 2020. A total of 22 pelvic osteotomies (18 unilateral and 2 bilateral) and 40 proximal femoral osteotomies were performed by the same team of highly specialized surgeons at the same hospital. Soft tissue release procedures, including adductor lengthening were performed concurrently in

16 cases. Among the 20 patients, six had previously undergone a soft tissue procedure, and one had a history of proximal femoral osteotomy. The mean age at the time of surgery was 9.4 years (range, 6–13 years). The mean follow-up duration was 6.5 years (range, 3.5–13 years), and the mean age at the final follow-up was 15.5 years (range, 9–20 years). Preoperatively, only one patient reported hip pain, while the diagnosis of hip subluxation or dislocation in all cases was made based on radiographic findings obtained through the regular hip surveillance program. As part of our standard of care, standard Anteroposterior (AP) pelvic radiographs are acquired in the supine position for all patients with CP every 12 months for hip surveillance.

Radiographic measurements include:

- Reimer's Migration Percentage (MP) defined as the percentage of the femoral head located outside the acetabular bony margin. It is calculated as the ratio between the lateral uncovered portion of the femoral head and the total width of the femoral head.
- Hilgenreiner's Acetabular Index (AI) measured as the angle formed by Hilgenreiner's line—a horizontal line passing through the triradiate cartilage—and the roof of the acetabulum. An increasing AI value indicates worsening dysplasia.
- Neck-shaft angle (NSA) to evaluate coxa vara/valga, measured as the angle formed between the axis of the femoral neck and the axis of the femoral shaft.
- Pelvic obliquity is not standardly measured.

The surgical indications for pelvic and femoral osteotomies in this cohort were a MP > 45%, an AI > 30°, and an NSA > 145°, as measured on standard AP X-rays. Contraindications were radiographic evidence of advanced hip joint degeneration **(Figure 1)**.

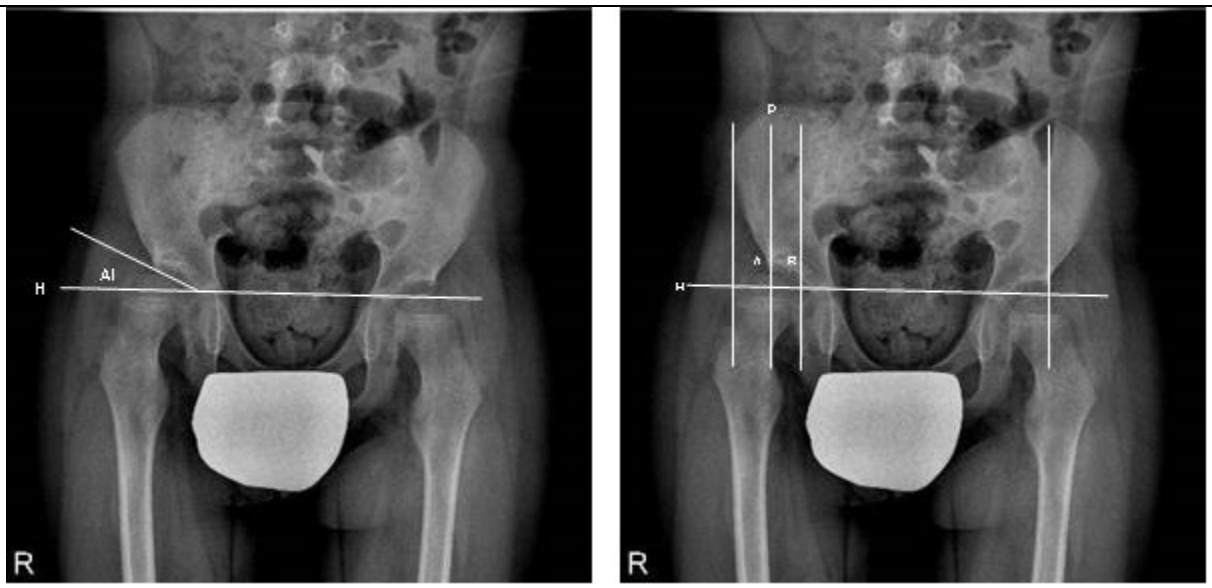

Figure 1: (Left) Measurement of the Acetabular Index (AI), defined as the angle between Hilgenreiner's line (H) and the line extending from the most lateral portion of the acetabulum to Hilgenreiner's line. (Right) Measurement of Reimer's index (or migration percentage), calculated as the ratio of the uncovered portion of the femoral head (A) to the total width of the femoral head (A + B), multiplied by 100. Pre operative AP view of a 9 year-old male, GMFCS level III.

Surgical procedure

Patients were positioned supine on a radiolucent surgical table, and a mobile image intensifier was used intraoperatively. Draping allowed access for bilateral procedures without re-prepping or re-draping. Percutaneous adductor lengthening was performed using an 18G needle. The second operative step involved the pelvic procedure, performed through a 4 cm skin incision (range: 3.5–5 cm) along the external edge of the anterior iliac crest, following part of the classical bikini incision technique **(Figure 2)**. Subperiosteal dissection was used to expose the outer iliac table while preserving theiliac apophysis and avoiding exposure of the inner iliac table. The gluteal muscles were carefully retracted to expose the hip capsule inferiorly and the large ischial notch posteriorly. Before the pelvic osteotomy, the femoral osteotomy was completed through a lateral femoral approach. Wedge bone cuts were made in the intertrochanteric area using an oscillating saw. Fixation was achieved with a 90° cannulated pediatric osteotomy system blade plate, ensuring an anteversion angle of approximately 15° to 20°, based on the patient's age. The periacetabular osteotomy was then performed under image intensifier guidance, following the original Pemberton or Dega technique, as determined by the coverage required. The procedure utilized the bone graft obtained from the femoral osteotomy without the need for additional fixation. This approach allowed controlled reorientation of the acetabulum to improve femoral head coverage. For patients with unilateral pelvic osteotomies, contralateral femoral osteotomies were performed to optimize symmetry in varus-valgus alignment and femoral neck anteversion. Limb length discrepancies exceeding 1

cm were corrected during the procedure. Residual discrepancies of up to 1 cm, favoring the more affected side, were left uncorrected. In all cases, the operative sequence began with adductor release, then pelvic approach and preparation, followed by the femoral osteotomy on the ipsilateral side. Pelvic osteotomy was then performed with the femoral resection being used as autograft. In case of unilateral pelvic osteotomy, the contralateral femoral osteotomy was performed last **(Figure 3).** After surgery, a knee splint brace was applied in the OR for 4 weeks to help control pain and avoid unfavorable postures. Physical therapy protocol included immediate mobilization, immediate stretching, immediate seated positioning, and the use of knee braces for a maximum of 3–4 weeks. Weight bearing is permitted at 6 weeks post-surgery.

Our standard follow-up protocol includes an initial clinical visit with a hip X-ray at 6 weeks post-surgery. If no complications are observed, a second X-ray is performed at 3 months, followed by additional X-rays at 6 months and 12 months. In this cohort of patients, radiological measurements of AI, RI, and NSA were obtained preoperatively, postoperatively, and at 3, 6, and 12 months after surgery; for each radiographic parameters, the mean pre operative and post operative changes have been recorded. Complications of surgery during the whole follow-up period were recorded. The Caregiver Priorities & Child Health Index of Life with Disabilities (CPCHILD) questionnaire was employed to assess the health-related quality of life and caregiver priorities **[9].** This validated tool is designed to capture the physical, emotional, and social well-being of children with severe disabilities through caregiver-reported outcomes. It comprises six domains: activities of daily living/personal care, positioning, transferring and mobility, comfort and emotions, communication and social interaction, health, and overall quality of life. The questionnaire was administered preoperatively and at follow-up visits, with caregivers providing responses on a Likert scale **[10],** which were subsequently converted into domain-specific and total scores. Higher scores indicate better quality of life. The CPCHILD has been shown to have excellent reliability and sensitivity for detecting clinically meaningful changes in this patient population. Data collection and analysis were performed using Excel (v16.82).

Figure 2: Skin incision.

Figure 3: Post operative bilateral femoral osteotomy and left pelvic osteotomy.

Results

Between 2010 and 2020, 20 patients classified as GMFCS II and III, all affected by hip subluxation or dislocation, underwent surgical intervention. This included 22 pelvic osteotomies (two bilateral and 18 unilateral) and 40 proximal femoral osteotomies. Preoperative radiological parameters indicated significant hip dysplasia and subluxation, which were effectively corrected through surgical intervention. The mean preoperative Migration Percentage (MP) was 59% (range, 45%–90%) and improved to a mean of 14% (range, 10%–29%) postoperatively (P = 0.0002). Similarly, the mean preoperative Acetabular Index (AI) of 38.5° (range, 34°–42°) decreased to 19° (range, 15°–28°) after surgery (P = 0.0002). The Neck-Shaft Angle (NSA) also demonstrated marked improvement, with a mean preoperative value of 153° (range, 145°–160°) decreasing to 128° (range, 115°–140°)postoperatively (P = 0.0002). Femoral anteversion, assessed preoperatively using the trochanteric prominence angle, was addressed and corrected during surgery as needed **(Figure 4)**.

Figure 4: (Left) Preoperative imaging showing bilateral femoral subluxation and acetabular dysplasia. (Right) Postoperative imaging demonstrating bilateral Varus Derotational Osteotomy (VDRO) and pelvic osteotomy.

Postoperative management included pain control with an epidural catheter for 48 to 72 hours, supplemented by anti-spastic treatment with Diazepam for 15 to 20 days. Notably, only one patient reported pain during the pre-operative assessment, and all patients remained pain-free throughout the follow-up period. One patient, who underwent bilateral pelvic and femoral osteotomies, required a single unit of blood transfusion. Complications were minimal, with no cases of superficial or deep infections, delayed healing, non-union, or skin ulcers reported. One patient sustained a femoral fracture during a postoperative transfer to the Radiology Department, requiring reoperation to replace the blade plate with a 3.5 LCP **(Figure 5)**. All patients retained their preoperative ambulatory status and successfully returned to their baseline functional level (GMFCS), as expected. The Caregiver Priorities & Child Health Index of Life with Disabilities (CPCHILD) outcomes showed a significant improvement in quality of life ($P = 0.0008$). Postoperative assessments revealed enhancements across all domains of the CPCHILD questionnaire, including activities of daily living, personal care, positioning, transferring, mobility, comfort, emotions, communication, social interaction, health, and overall quality of life.

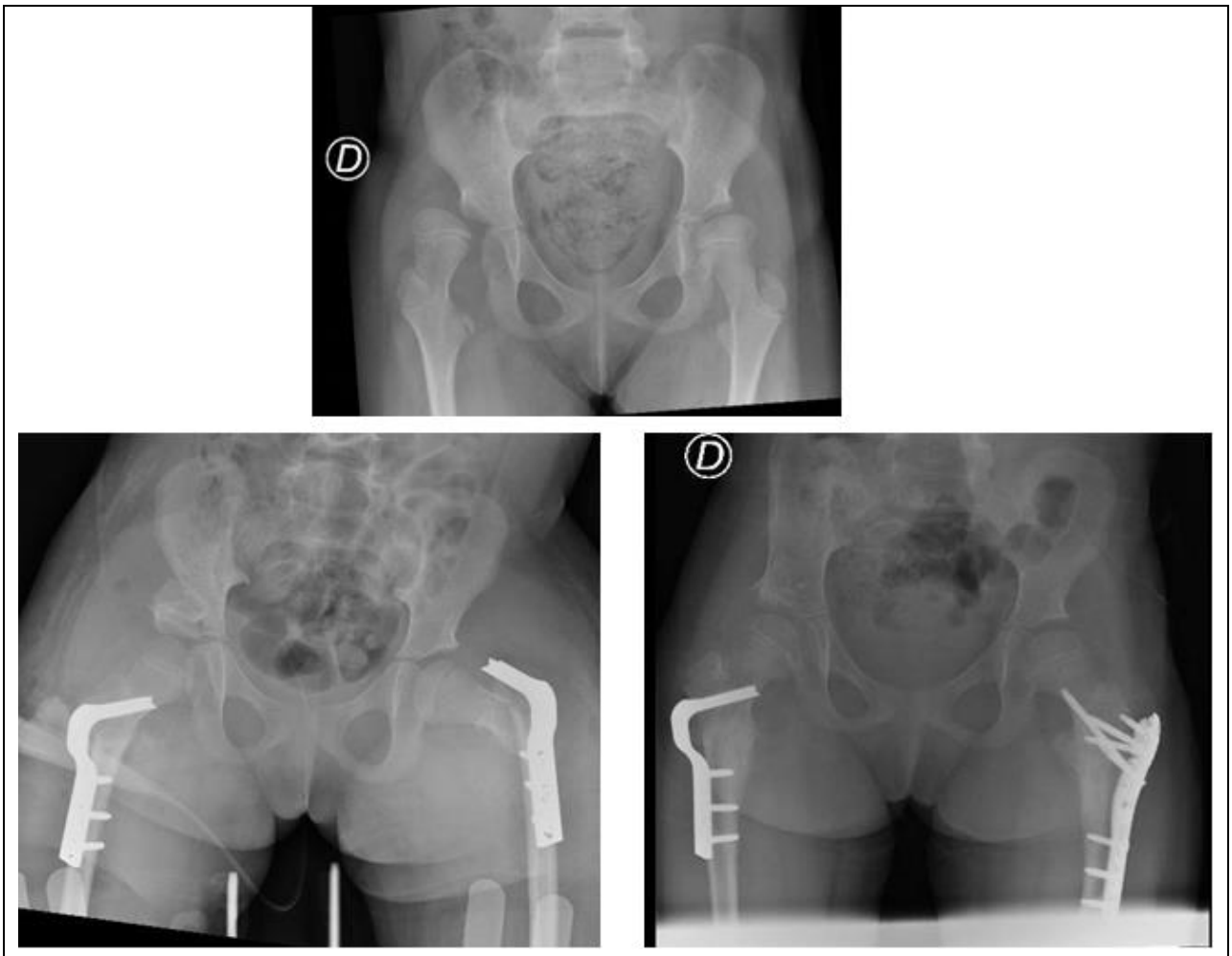

Figure 5: (Top) Preoperative AP X-ray of the pelvis showing right hip dislocation and left hip subluxation. (Top left) Imaging of a left femoral fracture. (Top right) Postoperative imaging of the left femoral fracture after reduction and synthesis.

Discussion

Hip displacement is a significant health concern in children with CP due to its high prevalence and its potential to severely impact patient comfort, care, mobility, and health-related quality of life if left untreated. The primary objective of managing hip displacement in children with CP is to preserve flexible, well-located, and pain-free hips with a symmetrical range of motion **[11].** When the migration percentage exceeds 50% and hip subluxation or dislocation occurs without femoral head degeneration, reconstructive hip surgery, including femoral and/or acetabular osteotomy, is recommended to restore normal hip anatomy and biomechanics in ambulatory patients with CP **[3].** The necessity of bilateral corrective surgical osteotomy remains a topic of debate, but it is generally accepted in practice **[12].** The results of this study further support the efficacy of reconstructive surgery in addressing hip displacement in ambulatory CP patients. Combined minimally invasive pelvic and femoral osteotomies not only achieve significant

improvements in key radiographic parameters, such as Migration Percentage (MP) and Acetabular Index (AI), but also maintain preoperative GMFCS levels while delivering favorable clinical outcomes, including a low complication rate and improved quality of life. These results align with the primary goals of hip reconstruction: restoring anatomical alignment and preserving functional mobility. Moreover, the findings are consistent with existing literature, which demonstrates the long-term stability and effectiveness of combined pelvic and femoral reconstructions, regardless of ambulatory status **[11,13].** The minimally invasive surgical technique described in this study offers several distinct advantages, further supporting its adoption in the management of hip displacement in CP patients. By utilizing a streamlined operative approach, including a 4 cm incision along the anterior iliac crest, careful subperiosteal dissection to preserve the iliac apophysis, and controlled reorientation of the acetabulum, this method minimizes surgical trauma. The use of percutaneous adductor lengthening with an 18G needle and local adrenaline injection further reduces soft tissue damage and minimizes the risk of hematoma and swelling. This meticulous technique ensures effective correction while limiting exposure and preserving surrounding structures. The benefits are evident in the significant reduction of surgical time, which lowers the risk of postoperative infections **[14].** Importantly, no infections were recorded during the follow-up period, a notable achievement given that infections following pelvic osteotomy have been reported in up to 18.75% of cases in prior studies **[15].** Additionally, the technique results in low blood loss, with a transfusion rate of only 10%, which is markedly lower than rates previously reported in the literature **[16,17].** The optimized surgical sequence—beginning with adductor release, followed by pelvic preparation, femoral osteotomy, and autograft utilization—further streamlines the procedure and enhances its safety and efficiency. These findings, along with the reduced risks associated with the minimally invasive technique, establish it as a viable alternative for performing periacetabular osteotomies in CP patients, as also discussed by Canavese **[8].** Statistical analysis of this study revealed a significant improvement in overall quality of life, as measured by the CPCHILD Index ($P = 0.0008$). This result highlights the broader impact of the minimally invasive technique, extending beyond radiographic and surgical outcomes to include meaningful enhancements in daily living, comfort, mobility, and emotional well-being. These improvements underscore the technique's role in addressing not only the physical but also the psychosocial aspects of care for CP patients.

While the findings of this study are encouraging, several limitations should be acknowledged. The retrospective design inherently imposes certain constraints on the analysis. Furthermore, the relatively small sample size may limit the generalizability of the results, as it may not fully represent the broader variability in outcomes that could be observed in a larger or more diverse patient population. However, the uniformity in patient characteristics, such as age and functional levels, combined with the use of a standardized surgical technique performed by a single experienced surgeon, helps to mitigate these concerns. Although the absence of a control group prevents direct comparisons with traditional methods, the positive outcomes reported are consistent with existing literature. This consistency supports the conclusion

that the minimally invasive approach is a viable and effective option for managing hip dysplasia in ambulatory CP patients.

References

1. Palisano Robert J, Peter Rosenbaum, Doreen Bartlett, Michael H. Livingston. "Content Validity of the Expanded and Revised Gross Motor Function Classification System." Dev Med Child Neurol. 2008;50(10):744-50.
2. B. Soo et al. "Hip displacement in cerebral palsy," J Bone Joint Surg Am. 2006;88(1):121-9.
3. J. J. Howard et al. "Hip displacement in children with cerebral palsy: surveillance to surgery - a current concepts review," SICOT J. 2024:10:30.
4. Badina Alina, Xavier du Cluzel de Remaurin, Nejib Khouri. "Long-Term Outcomes of Hip Reconstruction Surgery in Children with GMFCS III Diplegic Cerebral Palsy." Orthop Traumatol Surg Res. 2023;109(3):103344.
5. Battisti Nicoletta, Massimo Cozzaglio, Silvia Faccioli, Silvia Perazza, Annalisa Groppi, Lorena Menta, et al. "Prevention of Hip Dislocation in Severe Cerebral Palsy (GMFCS III-IV-V): An Interdisciplinary and Multi-Professional Care Pathway for Clinical Best Practice Implementation." Eur J Phys Rehabil Med. 2023;59(6):714-723.
6. B. J. Shore, X. Yu, S. Desai, P. Selber, R. Wolfe, H. K. Graham, "Adductor surgery to prevent hip displacement in children with cerebral palsy: the predictive role of the Gross Motor Function Classification System," J Bone Joint Surg Am. 2012;94(4):326-34.
7. D. E. Westberry, L. Carson, E. R. Shull, L. C. Hyer, "Hip reconstruction in children with cerebral palsy: does magnitude of surgery influence complications and outcomes?," J Pediatr Orthop B. 2023;32(5):461-469.
8. Canavese F, G. De Coulon. "Percutaneous Pelvic Osteotomy in Non-Ambulatory Cerebral Palsy Patients." Orthop Traumatol Surg Res. 2014;100(3):329-32.
9. Narayanan Unni G, Darcy Fehlings, Shannon Weir, Shannon Knights, Sonia Kiran, Kent Campbell. "Initial Development and Validation of the Caregiver Priorities and Child Health Index of Life with Disabilities (CPCHILD)." Dev Med Child Neurol. 2006;48(10):804-12.
10. R. Likert, "A technique for the measurement of attitudes," Arch Psychol. 1932;22(140);55–55.
11. G. Beltrame, A. Panou, A. Peccati, H. Tsibidakis, F. Pelillo, N. M. Portinaro, "Radiographic and Clinical Results of Combined Bone and Soft-Tissue Tailored Surgeries for Hip Dislocation and Subluxation in Cerebral Palsy," Children (Basel). 2025;12(1):91.
12. Verasak Thamkunanon. "Bilateral Hip Reconstruction Improve Hip Stability, Pelvic Balance and Mobility Function in Children with Cerebral Palsy." Pediatr Dimensions. 2017;2(2).
13. Alassaf Nabil, Neil Saran, Theirry Benaroch, Reggie Cherine Hamdy. "Combined Pelvic and Femoral

Reconstruction in Children with Cerebral Palsy." J Int Med Res. 2018;46(1):475-484.

14. H. Cheng et al., "Prolonged operative duration is associated with complications: a systematic review and meta-analysis," J Surg Res. 2018:229:134-144.
15. Faust Millis, Sachin Allahabadi, Ishaan Swarup. "Rates of Readmission and Reoperation Following Pelvic Osteotomy in Adolescent Patients: A Database Study Evaluating the Pediatric Health Information System." J Hip Preserv Surg. 2022;9(1):51-58.
16. J. J. Min et al., "Blood Loss and Related Laboratory Changes after Single-Event Multilevel Surgery and Hip Reconstructive Surgery in Patients with Cerebral Palsy," Clin Orthop Surg. 2021;13(3):406-414.
17. Pulido Luis F, George C. Babis, Robert T. Trousdale. "Rate and Risk Factors for Blood Transfusion in Patients Undergoing Periacetabular Osteotomy." J Surg Orthop Adv. 2008;17(3):185-7.

Citation of this Article

Pelillo F, Montemaggiori V, Jannelli E, Pasta GL, Beltrame G, Portinaro NMA and Mosconi M. Minimally Invasive Pelvic Periacetabular Osteotomy in Ambulatory Children with Cerebral Palsy: A Long Tern Retrospective Study. Mega J Case Rep. 2025;8(4):2001-2011.

Copyright