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Unilateral versus bilateral reconstructive hip surgery in children with cerebral palsy: A survey of pediatric orthopedic surgery practice and decision-making

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Abstract

Purpose: This study explored whether surgeons favor unilateral or bilateral reconstructive hip surgery in children with cerebral palsy who have unilateral hip displacement.

Methods: An invitation to participate in an anonymous, online survey was sent to 44 pediatric orthopedic surgeons. The case of an 8 year old at Gross Motor Function Classification System level IV with migration percentages of 76% and 22% was described. Surgeons selected their surgical treatment of choice and provided their rationale. Respondents were also asked to list and rank radiographic parameters used for decision-making and multidisciplinary team members involved in decision-making.

Results: Twenty-eight orthopedic surgeons from nine countries with a mean 21.3 years (range, 5–40 years) of experience completed the survey. A "bilateral VDROs with a right pelvic osteotomy (PO) was selected by 68% (19/28) of respondents; risk of contralateral subluxation (9/19; 47%) and maintaining symmetry (7/19; 37%) were the most common rationales for bilateral surgery. The remaining 32% (9/28) chose a 'right VDRO with a right PO'" with most of these (8/9; 89%) stating the left hip was sufficiently covered. Of 31 radiographic parameters identified, migration percentage, acetabular angle/index, Shenton line, neck shaft angle, and presence of open/closed triradiate growth plates were the most common. Physical therapists (68%) and physiatrists (43%) were most likely to be involved in pre-operative surgical consultation.

Conclusion: There is a lack of agreement on management of the contralateral hip in children with unilateral hip displacement. Further studies comparing patient important outcomes following unilateral and bilateral surgery are required.

Level of Evidence: V

Keywords: Cerebral palsy, displacement, hip, surgery, decision-making

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Figure 1. Anteroposterior radiograph of the pelvis with both hips in the case of an 8-year-old boy with cerebral palsy at GMFCS level IV.

Introduction

Hip displacement is a common musculoskeletal complication affecting one in three children with cerebral palsy (CP).[1–3] Risk of hip displacement is related to a child's functional mobility, with risk greater for children classified at higher levels of the Gross Motor Function Classification System (GMFCS).[1–3] When the Reimer's migration percentage (MP),[4] the measurement of the amount of the femoral head sitting lateral to the acetabulum, exceeds 30% a hip is at risk of progressive displacement.[2,3] When greater than 60%, the hip is considered at risk of dislocation.[3,5]

Reconstructive hip surgery is the primary treatment for management of progressive hip displacement and typically includes soft tissue releases and a varus derotation osteotomy (VDRO) of the proximal femur with or without a pelvic osteotomy (PO).[6,7] While reconstructive surgery is the current standard of care, the optimal surgical procedure(s) or timing of interventions is unclear. Outcomes may be influenced by age at surgery, pre-operative MP, GMFCS level, and surgeon experience.[8–10] In addition, when hip displacement is present in only one hip, treatment of the contralateral, stable hip is controversial. Surgeons may choose to perform a surgical procedure on only the most affected hip (unilateral) or on both hips (bilateral).

The current literature is inconclusive on the fate of the unaffected hip when performing unilateral reconstructive hip surgery in a child with CP. Studies have conflicting results with some reporting relatively low risk for progressive displacement[11–13] and others citing high rates[14,15] at follow-up. The reported range of subluxation or dislocation of the contralateral hip after unilateral hip surgery varies between 4.2% and 74%.[12,14] These rates may be influenced by factors such as the population studied (ambulatory vs non-ambulatory), age at surgery, accompanying soft-tissue procedures, and length of follow-up.

Proponents of unilateral surgery do not feel there is sufficient risk of progressive displacement to warrant the risks associated with bilateral surgery when the contralateral hip is undisplaced.[12,16] Those who support bilateral reconstruction argue there is an advantage to preventing potential future displacement with a single surgery, particularly in non-ambulatory children.[14,15,17] A decision analysis by Park et al.[18] concluded that concurrent prophylactic VDRO on the contralateral stable hip was better than close observation in terms of pain utility measure scores. After review of the current literature, there remains uncertainty over the comparative effectiveness of a prophylactic operation versus a second reconstructive surgery.[19]

With no current consensus, the objective of this study was to investigate the current trend among orthopedic surgeons in the ongoing debate between unilateral versus bilateral reconstruction for unilateral hip displacement. The reasons behind differences in surgical decision-making and care team members involved in decision-making were also explored.

Materials and methods

Following institutional Research Ethics Board approval, an invitation to participate in an anonymous online survey was sent to 44 pediatric orthopedic surgeons with expertise in the treatment of children with CP. This included surgeons contributing to an existing prospective, multi-center database studying hip outcomes in patients with CP (CP Hip Outcomes Project, https://clinicaltrials.gov/ct2/show/NCT01987882) and surgeons known to the study authors. Data collected in the survey were captured and stored using the online Research Electronic Data Capture (REDCap) platform.[20] One reminder to complete the survey was sent 4 weeks after the initial request. Respondents were first asked questions related to their practice settings, medical system, facility type, and whether standardized hip surveillance guidelines were followed in their institution.

The case of an 8-year-old boy at GMFCS level IV was then presented. An anteroposterior (AP) pelvis radiograph showing pre-operative MPs of 76% and 22% on the right and left, respectively, was included (Figure 1). Based on the given information, surgeons were asked to select which bony procedure they would perform from the following options: "right VDRO," "right VDRO with a right PO," "bilateral VDROs," "bilateral VDROs with a right PO," or "bilateral VDROs with bilateral POs." Respondents were asked to provide the reasoning for their decision-making in an open-text box. For those selecting a unilateral procedure, surgeons were also asked to identify in what circumstances they would perform a bilateral procedure and, for those reporting they would complete a bilateral surgery, when a unilateral procedure would be performed. Relevant literature related to unilateral and bilateral surgery was not provided to participants prior to the survey.

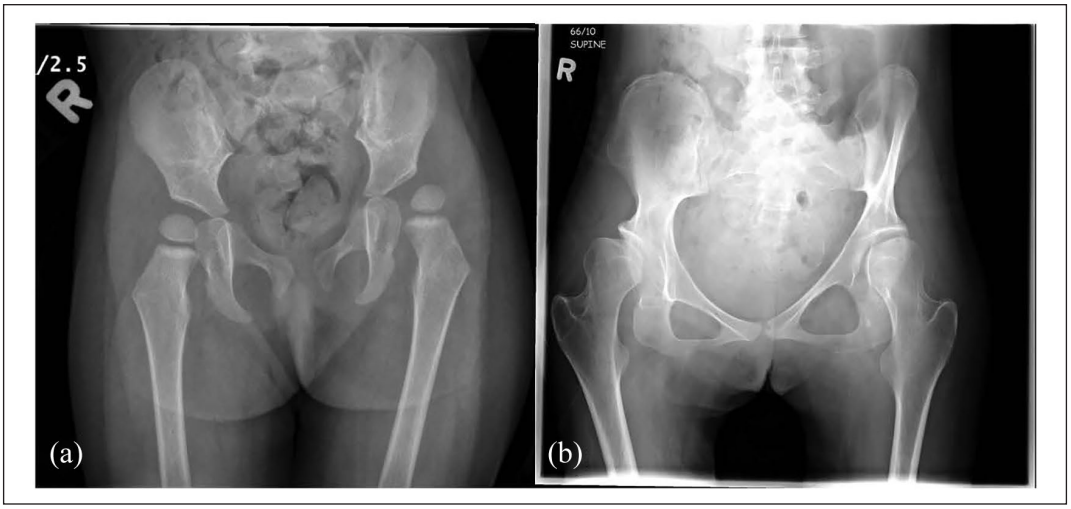

Figure 2. Radiographs used to list and rank radiographic parameters (qualitative or quantitative) for documentation, management, or treatment decision-making in (a) skeletally immature and (b) skeletally mature child.

To understand the radiological variables involved in surgical decision-making, respondents were asked to list and rank, in order of importance, radiographic parameters that they would consider for documentation, management, or treatment decision-making based on AP pelvis radiographs of a younger child (Figure 2(a)) and an adolescent (Figure 2(b)). Finally, healthcare professionals involved in the decision-making process and pre-operative preparation were identified from a provided list.

De-identified survey records were exported from REDCap for analysis. Descriptive statistics were used. Categorical variables were described with frequencies and percentages. Continuous variables were described with means, where appropriate. Open-text comments were analyzed and like responses counted.

Results

Twenty-eight orthopedic surgeons from nine countries, over five continents, with a mean 21.3 years (range, 5–40 years) of experience, completed the survey (Table 1). Surgeons reported to work in medical systems described as publicly funded (50%), mixed public/private (43%), and private (7%).

When asked to identify what model of care best described their practice, 68% (19/28) reported an interdisciplinary model in which professionals work together closely on a common goal, 21% (6/28) reported a transdisciplinary practice, where professionals share competencies, and 11% (3/28) reported a multidisciplinary model, where professionals work on their own goals in an autonomous way. Table 2 shows the most common healthcare providers reported to be involved in pre-operative consultation and surgical decision. Only one surgeon reported no other team members were involved in surgical decision-making.

Table 1. Surgeon demographics, practice data, and health care team members.

	Responses ($n = 28$)
Years in practice	Mean 21.3 years (range, 5–40)
Approximate patient visits per year	Mean 1350 (range, 100–4500)
Approximate percentage of practice devoted to children with cerebral palsy	Mean 58% (range, 20%–100%)
Country	
USA	13 (46%)
Canada	4 (14%)
Sweden	3 (11%)
UK	2 (7%)
Australia	2 (7%)
Denmark	1 (4%)
India	1 (4%)
Israel	1 (4%)
New Zealand	1 (4%)
Hospital setting	
Pediatric specialty hospital	20 (71%)
Tertiary care hospital (adult and pediatric hospital)	7 (25%)
General hospital (adult and pediatric hospital)	1 (4%)
Model of care	
Interdisciplinary	19 (68%)
Transdisciplinary	6 (21%)
Multidisciplinary	3 (11%)

All surgeons reported following standardized hip surveillance guidelines. The Australian Standards of Care (10/28) and American Academy of Cerebral Palsy and Developmental Medicine (AACPDM) Care Pathway (7/28) being the most common. A population-based hip surveillance program was reported by 54% (15/28) of respondents.

Table 2. Healthcare team members involved during pre-operative care.

Healthcare team members	Surgical consultation Pre-operative	Pre-operative preparation
Physical therapist	19 (68%)	18 (64%)
Physiatrist	12 (43%)	8 (29%)
Nurse practitioner	11 (39%)	17 (61%)
Nurse	9 (32%)	12 (43%)
Social worker	9 (32%)	12 (43%)
Neurologist	7 (25%)	6 (21%)
Occupational therapist	5 (18%)	8 (29%)
Pediatrician	5 (18%)	14 (50%)
Orthotist	4 (14%)	5 (18%)
Complex care physician	3 (11%)	8 (29%)
Anesthesiologist	3 (11%)	18 (64%)
Respirologist	3 (11%)	4 (14%)

For the case scenario, 68% (19/28) reported they would perform "bilateral VDROs with a right PO," while 32% (9/28) chose a "right VDRO with a right PO." Reasons for selecting a unilateral or bilateral procedure and scenarios when respondents would choose the alternate procedure are summarized in Table 3. Of the surgeons who selected the bilateral procedure, risk of contralateral subluxation (9/19; 47%) and maintaining symmetry (7/19; 37%) were the most common rationales. Of those who selected the unilateral procedure, most (8/9; 89%) reported they would not do a bilateral VDRO because the left hip was well covered.

In total, 31 unique radiographic parameters were identified by surgeons as being used for documentation, management, or treatment decision-making. Surgeons identified between two and eight parameters. For the radiograph of a younger child (Figure 2(a)), MP was identified by 86% of surgeons as the most important parameter to consider during pre-operative planning and decision-making for surgery, followed by acetabular angle/index, Shenton's line, neck shaft angle, and the presence of open triradiate growth plates/physes. For the radiograph of an older child (Figure 2(b)), MP was again the most often first ranked parameter (79%) followed by acetabular angle/index, neck shaft angle, morphology of the femoral head, and Shenton's line. A list of all radiographic parameters can be found in Supplemental Tables 1 and 2.

Discussion

Our findings confirm there exists a lack of agreement among an international group of pediatric orthopedic surgeons with expertise in the management of children with CP on whether to treat the contralateral, undisplaced hip in a child with CP who has unilateral hip displacement. The percent agreement used to define consensus can vary but 75% is frequently used.[21] While the majority (68%) of respondents opted to treat the undisplaced hip in the case example of an 8-year-old child at GMFCS level IV, almost one third chose not to intervene. This variability highlights the continued need for additional evidence comparing these two treatment approaches.

The most common reason cited by surgeons to perform reconstructive surgery on the undisplaced hip was to prevent contralateral displacement. Children who are non-ambulatory, like in the presented case, are at highest risk for hip displacement and previous findings have demonstrated that the contralateral hip is at greater risk of deterioration in these children.[1–3,14,15,22] Noonan et al.[14] concluded there were limited indications for unilateral hip surgery in severely involved children undergoing initial hip surgery, especially if any acetabular dysplasia is present. Younger age, ranging from 6 to 9 years, has also been identified as a possible risk factor for progressive displacement of the contralateral hip.[14,16,18,22,23] While not identified by surgeons, it is likely these factors influenced decision-making in this survey.

Respondents also commonly noted that bilateral surgery was chosen to maintain symmetry. Similar rationales included balancing the pelvis, maintaining sitting balance, and prevention of pelvic obliquity or a wind-blown deformity. It has been suggested that the balance of the forces controlling the pelvis are altered with unilateral hip reconstruction such that the opposite side of the pelvis becomes elevated putting the contralateral hip at risk for progressive displacement.[15,23] Heidt et al.[24] found when pelvic obliquity was present, the hip on the high side was at increased risk of dislocating. However, evidence for whether unilateral reconstruction contributes to pelvic obliquity is lacking. Avoiding a leg length discrepancy was also cited as a reason for bilateral surgery. Larsson et al.[11] suggested the magnitude of a leg length discrepancy should not impair sitting ability; there is no literature on the impact function. While reconstructive hip surgery has been shown to improve quality of life in the Caregiver Priorities & Child Health Index of Life with Disabilities (CPCHILD) domains of positioning and transferring/mobility,[25,26] we are unaware of any literature comparing the impact of unilateral and bilateral surgery on post-operative mobility such as sitting balance, participation in transfers, standing tolerance, or walker use. Loss of function in these daily activities may be meaningful for children and families and should be considered in children classified as non-ambulatory.

Most surgeons who selected a unilateral procedure did so as they felt the hip was sufficiently covered with a MP measuring below 30%. Some also noted that the acetabulum was well developed. When MP is less than 25% or 30% with an acetabular index of less than 25 degrees, risk has been reported as low and no surgical intervention warranted.[16,23] One surgeon, in open-text comments, noted that they did "not feel comfortable operating on a femur

Table 3. Reasons provided by surgeons in open-text for performing a unilateral or bilateral VDRO and indications for the opposite procedures.

Unilateral preferred	Number of surgeons ($n=9$)	Bilateral preferred	Number of surgeons ($n=9$)
Reasons for unilateral		Reasons for bilateral	
Left hip sufficiently covered/low MP	8 (89%)	Left hip at risk of subluxation	9 (47%)
Acetabulum well developed	3 (33%)	Symmetry	7 (37%)
Older child	2 (22%)	Avoid leg length difference	5 (26%)
Pelvic obliquity limited	1 (11%)	Manage/decrease pelvic obliquity	3 (16%)
"Coxa valga" relatively low for non-ambulatory CP	1 (11%)	Balance pelvis	3 (16%)
		Seating balance	2 (11%)
		Avoid wind-blown deformity	2 (11%)
		Valgus	2 (11%)
		Malrotation	1 (5%)
		Majority of unilateral surgeries fail	1 (5%)
		Majority of hips have similar FNA/NSA	1 (5%)
		Improved long-term outcome	1 (5%)
		Ease of single surgical event	1 (5%)
		Don't believe in unilateral surgery	1 (5%)
Indications for bilateral surgery		Indications for unilateral surgery	
High MP/displacement of both hips	6 (67%)	Hemiplegia	7 (37%)
Coxa valga	3 (33%)	None	4 (21%)
Young age	2 (22%)	Too medically fragile	2 (11%)
Marked femoral torsional deformity	2 (22%)	Revision surgery	2 (11%)
If repeat osteotomy on original side	1 (11%)	Older age/skeletally mature	2 (11%)
Increasing lateral to medial epiphyseal height discrepancy	1 (11%)	Difficult open reduction (plan for other side in 6 weeks)	1 (5%)
No significant acetabular deficiency (AI $<$ 25 degrees)	1 (11%)	Intraoperative anesthetic complications that required abandoning surgery	1 (5%)
Instability on arthrogram (medial pooling dye) that is improved in frog abduction	1 (11%)	Ambulatory	1 (5%)
		Entirely normal hip	1 (5%)
		Other side already done	1 (5%)
		Really young child	1 (5%)
		Family preference	1 (5%)

VDRO: varus derotation osteotomy; MP: migration percentage; CP: cerebral palsy; FNA: femoral neck anteversion; NSA: neck-shaft angle; AI: acetabular index.

when Reimer's [MP] is only 22% due to increase in perioperative morbidity." The benefits of preventing possible future surgery must be balanced against the risks of perioperative morbidity associated with additional procedures and greater operating time including, but not limited to, blood loss, risk of transfusion, infection, injury to nearby structures, pressure sores, and cardiovascular and respiratory complications.[18] Post-operative complications include non-union, inaccurate correction, avascular necrosis, fracture below the plate, and hematoma.[18]

One must also consider that there may not be one correct answer to this question.[16,19] Reconstructive hip surgery is a major surgical procedure that is associated with risks and may not be appropriate as a prophylactic procedure for all children and families. Respondents who selected a bilateral procedure noted that a unilateral procedure may be performed in this situation if the child was too medically fragile for bilateral surgery or if the family preferred a unilateral procedure (Table 3). As an example, parents may express concern about an intervention on their child's undisplaced hip if that side has greater strength and is relied upon for mobility. Alternatively, a leg length discrepancy that requires adaptations of the child's standing frame or wheelchair may influence parents' decision for a bilateral procedure. There are no parent-reported outcomes related to this topic in the literature. The experience of families undergoing unilateral and bilateral procedures may add important insight.

In the presented case scenario, there was clear consensus on the treatment of the right hip with a VDRO and a PO with all respondents (100%) selecting this treatment. This is not surprising given the case example featured an almost dislocated right hip with acetabular dysplasia. When MP is high, a PO is recommended (70%–80%).[10,27] Better clinical results have been reported in children at higher GMFCS levels when deformities in both the pelvis and the proximal femur are addressed.[28] In a recent prospective review, Terjesen[29] reported better primary correction with combined pelvic and proximal femoral osteotomies in severely displaced hips.

MP was the leading radiological parameter used for both the skeletally immature and mature pelvis. MP is accepted as the most reliable and accurate measure of hip displacement with excellent intra and interobserver reliability.[30,31] MP is a linear measure of subluxation that can be applied over a large age range, is not very sensitive to patient positioning, and is easy to measure.[4,5] Acetabular index was the next most commonly reported parameter used by respondents. Hip displacement is common without acetabular dysplasia and MP usually increases prior to acetabular index.[32] Despite this, three surgeons ranked acetabular index higher than MP. Its value is a factor when considering a PO.[8] Respondents commonly reported Shenton's line was a radiographic parameter of interest. Shenton's line is expected to be intact in a normal hip, but the likelihood of a break in this line increases with progressive displacement.[33] Neck-shaft angle, the presence of an open or closed triradiate cartilage, and, in the skeletally mature hip, the shape of the femoral head were the final parameters most commonly identified; their use is likely related to surgical planning.

All respondents reported following hip surveillance guidelines. Hip surveillance guidelines have been developed for the early identification of hip displacement in order to allow for earlier treatment, reduce the need for salvage hip surgeries, and avoid future impairment, including pain.[34–36] Current hip surveillance guidelines stop short of recommending what treatment should be offered. Regardless of the surgeon's decision to complete a unilateral or bilateral procedure, children undergoing hip surgery should return to hip surveillance following recovery. The risk for progressive displacement remains and follow-up to skeletal maturity is recommended.[34,35] Surveillance programs that follow children until skeletal maturity and record surgical outcomes have the opportunity to provide long-term outcome data on children undergoing hip reconstruction and the ongoing debate on unilateral versus bilateral reconstructive surgery.

Most surgeons (96%) consulted a multidisciplinary team while formulating a surgical plan. Respondents reported most commonly involving a physiotherapist, physiatrist, and nurse practitioner in surgical decision-making. This highlights the complexity in surgical planning required for these patients. Involving the multidisciplinary team likely offers greater opportunity to understand the needs and goals of the child and family. Further exploration of how each of these team members was involved and contributed to surgical decision-making is required.

This study had limitations. Surgeons were asked to make surgical decisions based on a single radiograph. Respondents noted the importance of different radiographs, including frog lateral, abduction internal rotation, and scoliosis views. In addition, previous imaging was not provided. Sequential radiographs may have altered decision-making by providing greater insight into the stability of the hip over time. Intraoperative arthrograms may also influence decision-making on whether to consider an open reduction or PO, but these procedures were not the focus of this study question. Presumably, factors related to the child and family would also be considered as part of surgical decision-making but only age and GMFCS level were provided. While this survey was completed by an international group of surgeons, the number of participants was relatively small and surgeons in low-resource, developing countries were not well represented.

In conclusion, there is variation in practice when treating unilateral hip displacement in CP. Current evidence supports continuing hip surveillance until skeletal maturity following both unilateral and bilateral surgical intervention. Prospective long-term functional, radiological, and patient-specific outcome studies of children with CP following unilateral and bilateral reconstructive surgery are required.

Author contributions

Stacey D Miller: Study design, survey development, data analysis, manuscript preparation.
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Kishore Mulpuri: Study design, survey development, data analysis, manuscript preparation.

Compliance with ethical standards

This study received ethics approval from the applicable Research Ethics Board.

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Supplemental material

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