

# Radiographic Hip Screening in Cerebral Palsy: Developing POSNA-Wide Consensus

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## Introduction

Cerebral palsy is the most common cause of physical disability affecting children in developed countries.<sup>1</sup> The natural history of hip disease places children with cerebral palsy at risk for progressive lateral hip displacement.<sup>2-4</sup> Soo et al.<sup>2</sup> demonstrated a linear relationship between the rate of hip displacement and a child's Gross Motor Functional Classification System Level (GMFCS). In their population-based study, GMFCS V children demonstrated an incidence of hip displacement of 90% while there were no cases of hip displacement in 114 children with cerebral palsy who were GMFCS level I. Hagglund<sup>5</sup> came to very similar conclusions with respect to a population-based study of children with CP in Sweden. Much can be learned from these population-based studies; knowledge and identification of groups of children with "hips at risk" for displacement are critical for planning surveillance programs and initiating early intervention.<sup>6,7</sup>

Based on the growing evidence supporting hip surveillance for children with cerebral palsy, many developed countries have adopted national/state hip surveillance programs.<sup>5,7-11</sup> Hip surveillance is defined as an active program of serial radiographic hip monitoring to identify patients at risk of hip displacement.<sup>12</sup> Hip surveillance has been proven to be an effective means of identifying hip displacement and, in combination with timely orthopaedic management, has been shown to decrease or prevent the incidence of hip dislocations in children with

CP.<sup>5,13,14</sup> Currently, in the United States, there is no established national/state hip surveillance program for children with cerebral palsy; as a result, significant practice variation exists regarding the timing of obtaining radiographs, which radiographs to take, and which children require imaging. This practice variation exists at a national, state, and hospital level resulting in increased healthcare expenditures, decreased patient safety, and ultimately lower value for our children with cerebral palsy. Based on the growing body of international evidence supporting hip surveillance for children with cerebral palsy, a recent survey was performed across North America to gauge the interest of orthopaedic surgeons in participating in hip surveillance for children with cerebral palsy.<sup>15</sup> This survey found that in North America, less than 20% of respondents were actively following a regular cerebral palsy hip surveillance radiographic screening schedule, while over 90% of respondents indicated willingness to follow a national screening/surveillance program if one existed.

The goal of the Pediatric Orthopaedic Society of North America (POSNA) Quality, Safety and Value initiative (QSVI) is to provide a unified program at the organizational level to coordinate and share the best ideas and practices for improving quality of care, increasing patient safety, and delivering value. To address this gap in standardized care, a clinical trials grant was funded by POSNA (2018) to achieve consensus and develop a society-wide radiographic hip screening protocol for chil-

dren with cerebral palsy. The development of a POSNA-wide hip screening pathway could decrease practice variation across POSNA while facilitating early identification of hip displacement for children with cerebral palsy. We hypothesize that by standardizing the practice of cerebral palsy hip screening across POSNA, a decrease in practice variation would occur, resulting in a decrease in the cost of care delivery, ultimately improving the value of care provided to children with cerebral palsy. Therefore, the purpose of this quality initiative project was to use Modified Delphi methodology to achieve consensus in creating a hip radiographic screening schedule for children with cerebral palsy to meet the diverse needs of our POSNA members.

## Methods

### *Consensus Process*

This QSVI project was determined to be exempt by the local Institutional Review Board at the first author's institution. This project utilized Modified Delphi methodology which is a method for eliciting and refining group judgment. The principles of Modified Delphi consensus are that more minds are better than a single mind and that structured group efforts lead to more accurate results than unstructured efforts.<sup>16</sup> The Modified Delphi technique is a widely used and accepted method for gathering data from respondents within their domain of expertise. The technique is designed as a group communication process, which aims to achieve a convergence of opinion on a specific real-world issue through group consensus. The Modified Delphi technique is well suited as a method for consensus building by using a series of questionnaires delivered using multiple iterations to collect data from a panel of selected subjects.<sup>17</sup>

The primary authors (BS and MWS) created an electronic survey exploring various items related to hip screening in children with cerebral palsy. These questions were developed from reviewing existing hip surveillance programs and clinical pathways developed for hip surveillance.<sup>11,18,19</sup> Panelists were asked to strongly

agree, agree, disagree, or strongly disagree among various statements regarding the implementation of a radiographic hip screening schedule for patients with cerebral palsy. Respondents were able to change their responses to consensus recommendations based on the discussions after each round of questions and/or after rewording of the recommendations.

### *Consensus Participants*

Twenty-four pediatric orthopaedic surgeons experienced in the care and management of children with cerebral palsy from various children's hospitals across North America were asked to participate in this project. Surgeons were selected because of clinical experience, a track record of relevant research, and experience in positions of leadership in various academic pediatric orthopaedic and neuromuscular organizations across North America.

### *Initial Survey of Current Practices*

In the first round, the Modified Delphi process began with an open-ended questionnaire on the attitudes of the panel members towards hip surveillance and regular radiographic hip screening as a follow-up to the previously published POSNA-wide survey.<sup>15</sup> This first questionnaire was completed in person with face-to-face discussion during the 2016 POSNA Annual Meeting in Indianapolis, IN. The answers from the open-ended questionnaire were discussed in real time at the meeting and served as the cornerstone of soliciting specific information for a future consensus statement within the Modified Delphi methods. During this process, panelists began to rank order items to establish preliminary priorities among them and identify barriers to a national hip screening program in North America (Table 1).

Results of this first survey were presented in person at the POSNA 2018 Annual Meeting in Austin, TX. Because almost 2 years had passed, this meeting was spent reviewing responses with further discussion toward consensus. After each statement, participants were asked to share their perspectives on hip screening and

**Table 1. Delphi Questions Round 1 for Cerebral Palsy Hip Screening Schedule**

1. Children at GMFCS level I & II with a diagnosis of CP should have a first screening x-ray:
2. Children at GMFCS level I & II with a diagnosis of CP with initial MP <30% at 2 years of age – When should the next radiograph be?
3. Children at GMFCS level III to V with a diagnosis of CP should have a first screening x-ray:
4. Please identify which radiographs make up your CP hip surveillance profile.
5. What migration percentage value constitutes a hip at risk in terms of CP hip surveillance?
6. Which of the following criteria guide your CP hip surveillance?
7. What is the **most important** factor that helps guide your frequency of follow-up?
8. What is the **second most important** factor that helps guide your frequency of follow-up?
9. Do children with CP of all motor types require similar hip surveillance?
10. In hip surveillance, measuring only the Migration Percentage is necessary.
11. Children at GMFCS I & II are at low risk of hip subluxation.
12. Hemiplegic children who are Winters & Gage Type IV require continued hip surveillance after 5 years of age.
13. Children at GMFCS III, IV, and V require more frequent hip surveillance than GMFCS I and II.
14. Children at GMFCS III require regular hip surveillance radiographs yearly after age 2.
15. Children at GMFCS IV/V patients require regular hip surveillance radiographs every 6 months of age from 2 to 6 years of age.
16. A 7-year-old GMFCS III male has a stable MP (<40%) over the last 3 years from yearly radiographs. Is there a role to decrease frequency of follow-up to every 2 years?
17. After surgical intervention (soft tissue release) does your schedule for hip surveillance change?
18. After surgical intervention (bony surgery ± soft tissue release) does your schedule for hip surveillance change?
19. When should hip surveillance stop for children at GMFCS I & II?
20. When should hip surveillance stop for children at GMFCS III, IV, V?
21. When should children be referred to orthopaedics (select all that apply)?

surveillance and which areas of practice variation were most important to clarify. Results from this meeting formed the basis for a second round of consensus statements (Table 2). The discussion from this round formed the basis for the meeting in October 2018, as part of the Clinical Trials Award.

In October 2018, a face-to-face meeting occurred in Chicago, IL, with all 24 participants. Over 2 days, using the Poll Everywhere software (San Francisco, CA), we were able to run multiple iterations of consensus testing in real time. We were able to complete two additional full rounds of consensus cycles with intervening discussion.

Prior to the October meeting, participants were presented with results from the previous survey. Consensus was defined at 80% agreement. Recommendations near consensus (70-79% agreement or disagreement) and those considered indeterminate (<70% agreement or disagreement) were discussed, and modifications to change wording were solicited to improve consensus if possible. Follow-up at the POSNA 2019 Annual Meeting in Charlotte, NC, finalized our consensus statements and provided participants an opportunity to revise their judgments if necessary. The wording of the final product of the process was then reviewed, revised, and accepted via email. The final product was then drafted with the help of a medical graphic designer.

### **Table 2. Consensus Statement (Round 2) Radiographic Hip Screening for Children with Cerebral Palsy**

1. An appropriately positioned supine AP pelvis is the only radiograph required for hip screening in children with CP.
2. In regard to interpreting the AP pelvis radiograph, the migration percentage is the most important value to be recorded.
3. Children with CP should have a screening AP pelvis radiograph before the age of 2 for hip screening.
4. Clinical examination of the range of motion of the hips is an important component of hip screening.
5. An active hip screening program can be performed by orthopaedic surgeons, physical/occupational therapists, physiatrists, neurologists, advanced practice providers, and pediatricians.
6. For the purpose of hip screening in children with CP, treatment intervention needs to be considered when an MP is greater than 40% for any GMFCS level.
7. According to hip screening, a child's GMFCS level is the most important factor which dictates frequency of follow-up.
8. For the purpose of hip screening for CP, children who are GMFCS level IV and V should follow the same screening schedule.
9. For the purposes of hip screening for CP, children can be classified as ambulatory (GMFCS I-III) versus non ambulatory (GMFCS IV/V).
10. For the purposes of hip screening for CP, GMFCS II and III level children should have a similar frequency for follow-up.
11. In the setting of hip screening for CP, an AP pelvis with a MP greater than 50% should prompt the caregiver to discuss surgical intervention and referral to a pediatric orthopaedic surgeon.
12. In the setting of hip screening for CP, a Winters and Gage Type IV hemiplegic child should always be screened according to a GMFCS level II frequency of screening.
13. In the setting of hip screening for CP, a Winters and Gage Type IV hemiplegic child should always be screened according to a GMFCS level II/III frequency of screening.
14. In the setting of hip screening for CP, ambulant children (GMFCS II/III) with a MP less than 30% should have an AP radiograph every 24 months.
15. In the setting of hip screening for CP, ambulant children (GMFCS II/III) with a MP less than 30% should have an AP radiograph every 24 months.
16. In the setting of hip screening for CP, ambulant children (GMFCS II/III) with a MP greater than 40% should have an AP radiograph every 6 months.
17. In the setting of hip screening for CP, ambulant children (GMFCS II/III) with a stable MP less than 30% (no change over last 2 radiographs) and age > 10 one can discontinue hip screening radiographs.
18. In the setting of hip screening for CP, ambulant children (GMFCS I-III), one should stop hip screening at skeletal maturity (closure of triradiate cartilage), regardless of MP.
19. In the setting of hip screening for CP, ambulant children (GMFCS I-III), one should stop hip screening at skeletal maturity (closure of triradiate cartilage), when MP <30%.
20. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V) with a MP under 40% should have regular clinical examination and AP radiograph every 12 months.
21. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V) with a MP greater than 40% should have regular clinical examination and AP radiograph every 6 months.
22. In the setting of hip screening for CP in non-ambulant children (GMFCS IV/V), decision to discontinue surveillance should consider triradiate cartilage status, patient's MP, presence of scoliosis, and pelvic obliquity.
23. In the setting of hip screening for CP in non-ambulant children (GMFCS IV/V), decision to discontinue surveillance should consider triradiate cartilage status and patient's MP.
24. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V), hip screening does not stop at skeletal maturity and should continue with yearly radiographs until care is discontinued.
25. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V), can stop participating in hip screening once their triradiate cartilage is closed—regardless of their MP.
26. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V), can stop participating in hip screening once their triradiate cartilage is closed and MP remains under <30%.
27. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V) with a stable MP less than 40% (no change over last 2 radiographs) and a closed triradiate cartilage can discontinue regular hip screening radiographs.
28. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V) with a stable MP greater than 40% (no change over last two radiographs) and a closed triradiate cartilage can discontinue regular hip screening radiographs.

**Table 3. Consensus Statements Achieved After Round 2  
for Hip Radiographic Screening for Children with Cerebral Palsy**

1. An appropriate positioned supine AP pelvis is the only radiograph required for hip screening in children with cerebral palsy.
2. In regard to Interpreting the AP pelvis radiograph, the migration percentage is the most important value to be recorded.
3. For the purpose of hip screening in children with cerebral palsy, treatment intervention needs to be considered when the migration percentage is greater than 40% for any GMFCS level.
4. According to hip screening, a child's GMFCS level is the most important factor which dictates frequency of follow- up.
5. For the purpose of hip screening in cerebral palsy, children who are GMFCS IV and V should follow the same radiographic screening schedule.
6. In the setting of hip screening for cerebral palsy, an AP pelvis with a MP greater than 50% should prompt the caregiver to discuss surgical intervention and referral to a pediatric orthopaedic surgeon
7. In the setting of hip screening for cerebral palsy, ambulant children (GMFCS I-III), one should stop hip screening at skeletal maturity (closure of triradiate cartilage) when MP <30%.
8. In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V) with an MP greater than 40% should have regular clinical examination and AP radiograph every 6 months.
9. In the setting of hip screening for cerebral palsy in non-ambulant children (GMFCS IV/V), decision to discontinue surveillance should consider triradiate cartilage status, patient's MP, presence of scoliosis, and pelvic obliquity.

## Results

The participation rate in the survey throughout the five rounds of consensus building was 100%, with all 24 pediatric orthopaedic surgeons completing each consensus round. Overall, the respondents were primarily involved in academic practice (23/24, 96%) associated with a university hospital, and the majority of participants cared mostly for children (>75% of practice being in pediatrics) (23/24, 96%). All of the participants had significant experience in managing children with cerebral palsy, with the majority of respondents indicating that 50-74% of their practice was made of up children with cerebral palsy (54%, 13/24), 25% of the group indicated that >75% of their practice was cerebral palsy, and 21% indicated that cerebral palsy was between 25-49% of their practice.

After the first round of questions, consensus was achieved on several topics related to radiographic hip screening in children with cerebral palsy. Specifically, consensus was achieved on the type of necessary imaging for hip screening with 24/24 (100%) indicating only an Anteroposterior Pelvis x-ray. The majority of

participants felt that a hip “at risk for subluxation” had a migration percentage of 30-39% (20/24, 83%). Finally, there was 100% agreement that GMFCS I and II children were at low risk for hip subluxation while GMFCS III-V required frequent hip screening to identify subluxation.

### *Modified Delphi Method*

After the first round of survey responses and review of the results with an in-person meeting in the spring of 2018, the second consensus round produced nine consensus statements shown in Table 3.

There were six statements that were close to consensus (70-79%): Clinical examination of the range of motion of the hips is an important **component** of hip screening (19/24, 79%); An active hip screening program can be performed by orthopaedic surgeons, physical/occupational therapists, physiatrists, neurologists, advanced practice providers, and pediatricians (17/24, 71%); In the setting of hip screening for cerebral palsy, a Winters and Gage Type IV hemiplegic child should always

**Table 4. Items from Round 2 with Limited to No Consensus**

1. Children with cerebral palsy should have a screening AP pelvis radiograph before the age of 2 for hip screening.
2. For the purposes of hip screening for cerebral palsy, GMFCS II and III level children should have a similar frequency for follow-up
3. In the setting of hip screening for cerebral palsy, ambulant children (GMFCS II/III) with a migration percentage less than 30% should have an AP radiograph every 24 months.
4. In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V) with a stable migration percentage less than 40% (no change over last two radiographs) and a closed triradiate cartilage can discontinue regular hip screening radiographs.
5. For the purposes of hip screening for cerebral palsy, children can be classified as ambulatory (GMFCS I-III) versus non ambulatory (GMFCS IV/V).
6. In the setting of hip screening for cerebral palsy, a Winters and Gage Type IV hemiplegic child should always be screened according to a GMFCS level II frequency of screening.
7. In the setting of hip screening for cerebral palsy, ambulant children (GMFCS II/III) with a stable migration percentage less than 30% (no change over last two radiographs) and age >10 one can discontinue hip screening radiographs.
8. In the setting of hip screening for cerebral palsy, ambulant children (GMFCS I-III), one should stop hip screening at skeletal maturity (closure of triradiate cartilage), regardless of migration percentage.
9. In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V), hip screening does not stop at skeletal maturity and should continue with yearly radiographs until care is discontinued.
10. In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V) can stop participating in hip screening once their triradiate cartilage is closed—regardless of their MP.
11. In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V) with a stable MP greater than 40% (no change over last two radiographs) and a closed triradiate cartilage can discontinue regular hip screening radiographs.

be screened according to a GMFCS II/III frequency of screening (17/24, 71%); In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V) with a MP under 40% should have regular clinical examination with AP radiograph every 12 months (18/24, 75%); In the setting for hip screening for cerebral palsy in non-ambulant children (GMFCS IV/V), the decision to discontinue hip screening should consider the triradiate cartilage status and patient's MP (17/24, 71%); In the setting of hip screening for cerebral palsy, non-ambulant children (GMFCS IV/V), can stop participating in hip screening once their triradiate cartilage is closed and MP remains <30% (17/24, 71%). Another 11 statements were far from consensus and required significant revision and rewording over the following two iterations of discussions (Table 4).

After further discussion, statements not initially reaching consensus were broadened and revised as necessary, and two further rounds of consensus led to agreement of 27 statements which formed the foundation of our hip screening guidelines for children with cerebral palsy (Table 5).

It is important to note that we were unable to achieve consensus on three items which all related to measuring the lateral portion of migration percentage and related to the concept of the gothic arch (Table 6).

After review of the final hip screening guidelines, 100% of study participants agreed with and supported the publication and agreed to implement the screening protocol at their institution (Appendix, page 12).

**Table 5. Final Consensus Statements for a National Radiographic Hip Screening Protocol for Children with Cerebral Palsy**

Consensus Statements	Consensus		
	Total	Strongly Agree	Agree
1. For the purpose of radiographic hip screening in children with CP, a screening AP pelvis should be taken at age 2 or first presentation after 2.	96%	61%	35%
2. For the purposes of radiographic hip screening in children with CP, ambulant children without assistive devices (GMFCS I and II) should have similar frequency of radiographic follow-up	92%	42%	50%
3. For the purposes of radiographic hip screening in children with CP, minimally to non-ambulant children (GMFCS IV and V) should have a similar frequency of follow-up.	96%	46%	50%
4. For the purposes of radiographic hip screening in children with CP, a migration percentage greater than 30% should prompt referral to a pediatric orthopaedic surgeon.	99%	67%	33%
5. In the setting of hip screening for CP, an AP pelvis with a MP greater than 40% should prompt the treating orthopaedic surgeon to discuss surgical intervention.	100%	58%	42%
6. Active participants of a radiographic hip screening program can include orthopaedic surgeons, physical/occupational therapists, physiatrists, neurologists, advanced practice provider, pediatricians, and radiologists.	100%	42%	58%
7. Clinical examination of hip range of motion is an important component that may increase the frequency of radiographic hip screening in children with CP.	100%	46%	54%
8. Hip range of motion alone does not replace the need for a regular radiographic hip screening plan.	100%	92%	8%
9. In the setting of radiographic hip screening for CP, ambulant children (GMFCS I-II) with a MP less than 30%, after the age of 2 or initial screening radiograph should have another AP radiograph at 6 and 10 years of age.	96%	38%	58%
10. In the setting of radiographic hip screening for CP, ambulant children (GMFCS I-II), should stop hip screening at skeletal maturity (closure of triradiate cartilage), when MP <30% provided that there has been no radiographic change of the past two screening radiographs.	100%	33%	67%
11. In the setting of radiographic hip screening for CP, ambulant children (GMFCS I/II) with a stable MP less than 30% (no change over last two radiographs) and skeletal maturity with closed triradiate cartilage can stop radiographic screening.	100%	42%	58%
12. In the setting of radiographic hip screening for CP, a Winters and Gage Type IV hemiplegic (child with asymmetric internal hip rotation, hip flexion and adduction on the affected side) should be screened with greater frequency than other hemiplegic children.	100%	50%	50%

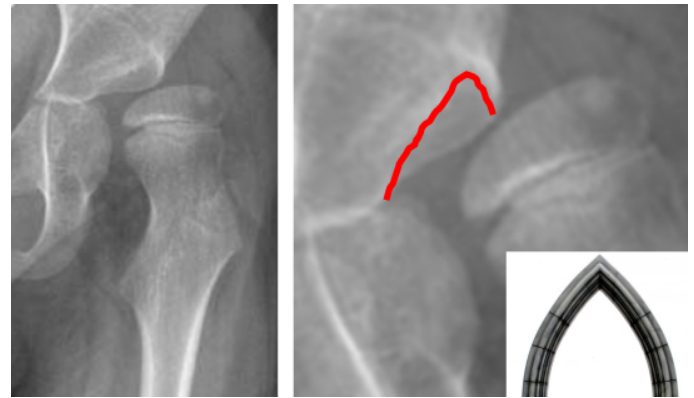
Consensus Statements (cont.)	Consensus		
	Total	Strongly Agree	Agree
13. In the setting of radiographic hip screening for CP, a Winters and Gage Type IV hemiplegic child (asymmetric hip internal rotation, hip flexion, and adduction) should be screened according to the frequency of the functional ambulator with assistive devices (GMFCS III).	94%	26%	70%
14. In the setting of radiographic hip screening for CP, functionally ambulant children with assistive devices (GMFCS III) with a stable MP less than 30% (no change over last two radiographs) and skeletal maturity with closed triradiate cartilage can decrease radiographic frequency of screening.	100%	42%	58%
15. In the setting of radiographic hip screening for CP, non-ambulant children (GMFCS IV/V) should have regular clinical examination and AP radiograph every 6-12 months.	96%	50%	46%
16. In the setting of radiographic hip screening for CP in minimal to non-ambulant children (GMFCS IV/V), decision to decrease frequency of screening should consider triradiate cartilage status, scoliosis, pelvic obliquity, and patient's MP.	100%	42%	58%
17. In the setting of radiographic hip screening for CP, minimal to non-ambulant children (GMFCS IV/V), can decrease radiographic hip screening once their triradiate cartilage is closed and MP remains under <30% for two successive years, in the setting of stable scoliosis or pelvic obliquity.	100%	26%	74%
18. Appropriate position for regular radiograph CP hip screening includes positioning the child with a horizontal pelvis, neutral adduction and abduction and patella facing upwards.	84%	38%	46%
19. In the setting of hip screening for CP in non-ambulant children (GMFCS IV/V), decision to discontinue surveillance should consider triradiate cartilage status, patient's MP, presence of scoliosis, and pelvic obliquity.	100%	42%	58%
20. An appropriately positioned supine AP pelvis is the only radiograph required for hip screening in children with CP.	100%	83%	17%
21. In regard to interpreting the AP pelvis radiograph, the migration percentage is the most important value to be recorded.	100%	96%	4%
22. For the purpose of hip screening in children with CP, treatment intervention needs to be considered when an MP is greater than 40% for any GMFCS level.	100%	42%	58%
23. According to hip screening, a child's GMFCS level is the most important factor which dictates frequency of follow-up.	100%	42%	58%
24. For the purpose of hip screening for CP, children who are GMFCS level IV and V should follow the same screening schedule.	100%	54%	46%
25. In the setting of hip screening for CP, an AP pelvis with a MP greater than 50% should prompt the caregiver to discuss surgical intervention and referral to a pediatric orthopaedic surgeon.	100%	79%	29%
26. In the setting of hip screening for CP, ambulant children (GMFCS I-III), one should stop hip screening at skeletal maturity (closure of triradiate cartilage), when MP <30%.	92%	40%	52%
27. In the setting of hip screening for CP, non-ambulant children (GMFCS IV/V) with a MP greater than 40% should have regular clinical examination and AP radiograph every 6 months.	96%	75%	21%

## Discussion

One in three children with cerebral palsy will suffer from hip displacement and potential dislocation.<sup>2</sup> Left untreated, hip displacement can cause pain and decreased quality of life.<sup>20</sup> Evidence supports the use of systematic hip surveillance to identify children at risk for hip displacement and facilitate timely orthopaedic intervention.<sup>13</sup> Previous work across POSNA has demonstrated that currently, few practice standardized hip screening for children with cerebral palsy, while many would be happy to follow guidelines if they existed at the society or national level.<sup>15</sup> Here, we present a consensus statement for radiographic hip screening for children with cerebral palsy which was achieved through Modified Delphi methodology using the power of 24 experts in the care of children with cerebral palsy.

Hip surveillance is defined as an active program of serial radiographic hip monitoring to identify patients at risk of progressive hip displacement.<sup>7</sup> A major component of hip surveillance is identifying those children who do not regularly present to a physician's office for follow-up. Here we present a schedule for radiographic hip screening and follow-up for children with cerebral palsy in North America. Currently in North America, the majority of hip screening for cerebral palsy occurs at tertiary care referral centers which is in stark contrast to how hip surveillance is implemented in other countries where population-based programs are designed to identify at-risk children who may not be routinely seen by the orthopaedic surgeon. Therefore, at present, true hip surveillance for children with CP, as defined globally, is not possible in most current healthcare systems in the United States.

Examining clinical variation in medical practice is an important step in measuring efficiency and effectiveness of healthcare delivery. Variations in healthcare delivery and utilization can indicate potential opportunities to reduce costs and improve value without compromising patient care.<sup>21</sup> The Modified Delphi process substantially increased consensus during our study.<sup>17</sup> Despite having reached consensus in nine statements after the initial survey; an additional 18 statements reached consensus



**Figure 1.** This radiograph of the hip with subluxation of 50% also demonstrates dysplastic upsloping of the lateral acetabular margin which is reminiscent of a gothic arch.

through the iterative process of discussion, reflection, and reconfiguration. It is not surprising that we were able to achieve early consensus with nine of the initial statements and this reflects the relatively broad scope of literature already available documenting effective hip surveillance programs across the world.<sup>8,9,13,18</sup>

Through nominal group technique, we were able to achieve consensus in what radiographs are necessary to be used (single anteroposterior pelvis radiograph), when screening should start (@ 2 years of age), and how frequent radiographic hip screening should occur for children with cerebral palsy. Furthermore, as a group, we identified that by clustering children according to their GMFCS level (GMFCS I-II and GMFCS IV/V) we would enhance provider comprehension of the hip screening guidelines and hopefully improve widespread adoption and implementation.

Interestingly, there was only one area where consensus was not reached. There was uniform consensus that the migration percentage is the most important radiographic value to be measured for hip surveillance in children with cerebral palsy. Identification of the lateral margin of the acetabular rim was not as uniform in definition. The lateral margin of the acetabular rim is critical for the placement of Perkin's line and the calculation of the migration percentage;<sup>22</sup> however, we could not reach consensus on where the appropriate landmark exists for Perkin's line. Specifically, we were divided as to where this

**Table 6. Statements for Which Consensus Could Not Be Achieved for Radiographic Hip Screening for Children with Cerebral Palsy**

	Consensus				
	Totals	Strongly Agree	Agree	Disagree	Strongly Disagree
1. In measuring the MP, the appropriate landmark for the lateral edge of the acetabulum is the most lateral edge of the bony acetabulum.	75% agreement	8%	67%	25%	0%
2. In measuring the MP, the appropriate landmark for the lateral edge of the acetabulum is the most lateral aspect of the sourcil.	62% agreement	17%	46%	38%	0%
3. In measuring the MP, if a gothic arch is present, the appropriate landmark for the lateral edge of the acetabulum is the midpoint of the apex of the arch.	75% agreement	8%	67%	21%	4%

lateral line lies at the lateral most part of the acetabulum, the most lateral aspect of the sourcil, or the midpoint of the gothic arch. For all three of these scenarios, we were close to achieving consensus but failed. These results support the recent findings of Miller et al.,<sup>22</sup> who reported that there was poor inter and moderate intra-rater reliability in identifying a gothic arch on an AP pelvis radiograph. This lack of agreement here may make the identification of a gothic arch, or more importantly, identification of a hip that is at risk delayed and could negatively impact the time to referral to a pediatric orthopaedic surgeon.

In conclusion, we present a radiograph hip screening schedule that can be applied for children with cerebral palsy. This schedule is unique in that it was developed through a Delphi methodology, using nominal group technique to try and identify statements and practice which is most familiar to pediatric orthopaedic surgeons with POSNA and across North America. With this new surveillance guideline, we hope we can eliminate unnecessary radiographs and standardize our surveillance pathways for the more at-risk and vulnerable children with cerebral palsy within our society.

### Acknowledgements

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# CP Hip Radiographic Screening Guideline

## Assumptions and Definitions

**Hip surveillance** is defined as the active monitoring process which identifies early indicators for hip displacement in children with cerebral palsy (CP). Hip surveillance assumes that all eligible children within a population participate.

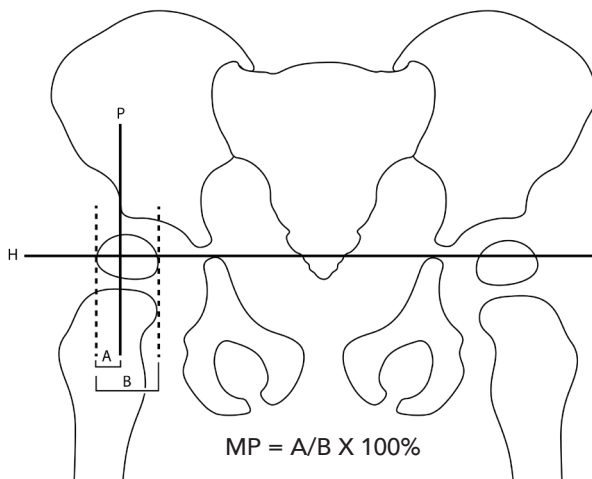
**Hip Screening** is a suggested radiographic schedule to be used by any CP health care provider (Orthopedist, Neurologist, Physiatrist, Pediatrician, and Advanced Practice Provider). Hip screening identifies when radiographs should be taken for those patients who present for care, while surveillance describes processes designed to identify patients not regularly seen by health care providers and define roles of various stakeholders in the surveillance process.

For the purpose of this consensus statement, **hip displacement** refers to the percent of the femoral head which has migrated out of the acetabulum and is measured by calculating the **migration percentage (MP)**.

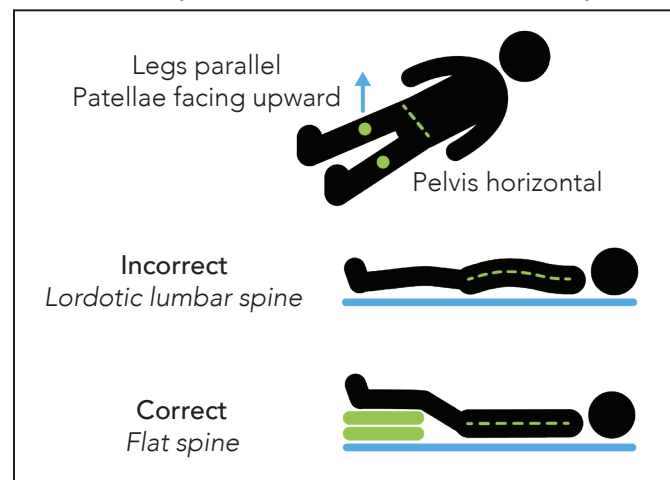
## General Principles

1. In children with spastic CP, hip displacement and dislocation are often painful and should be avoided
2. For the purposes of screening children with CP, hip screening should begin at age 2 or first presentation thereafter
3. The initial screening radiograph should be an AP pelvis (frog lateral not needed)
4. Hip range of motion examination **does not** replace the need for regular screening radiographs but is an important adjunct. Clinical examination should be performed yearly on all children with CP
5. Screening guidelines **only** apply if the MP is stable and <30%. Worsening MP coverage (>5% change) will result in consideration of intervention, and necessitates increased vigilance of the child's hips, rather than continuing on this screening schedule
6. Children with hemiplegia, Winters and Gage Type IV (those with asymmetric hip IR, flexion, and adduction) should follow the GMFCS I/II frequency until age 10 and then follow the GMFCS III frequency
7. **Factors to consider when decreasing the screening schedule should include:** skeletal maturity (closure of triradiate cartilage), stable radiographs over a 2 year interval, stable pelvic obliquity and scoliosis
8. It is important to maintain regular hip screening after orthopedic, soft tissue, or reconstructive hip surgery

## Migration Percentage



## Standard positioning for AP Pelvic radiographs



## Migration Percentage Guidelines

<30%	Continue regular screening according to GMFCS level
>30%	Hips at risk – refer to pediatric orthopedic surgeon for consideration of surgical treatment

# Hip Screening Guidelines

## Ambulatory without Handheld Mobility Aid

GMFCS Level I & II

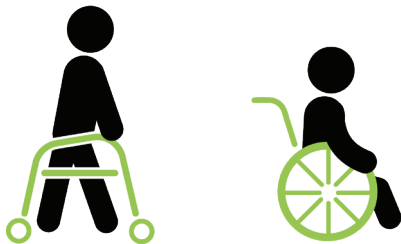


Winters and Gage Type IV  
Hip flexion, adduction,  
and internal rotation

<b>Age 2</b>	Clinical Exam and AP Pelvis
<b>Age 6</b>	Clinical Exam and AP Pelvis
<b>Age 10</b>	Clinical Exam and AP Pelvis. If Winter and Gage Type IV Hemiplegia, clinical exam and AP Pelvis <b>every 2 years</b> until skeletal maturity (closed triradiate cartilage)
<b>Skeletal Maturity</b>	Clinical Exam and AP Pelvis. Screening can stop at skeletal maturity (triradiate closure) if MP <30%

## Ambulatory with Handheld Mobility Aid

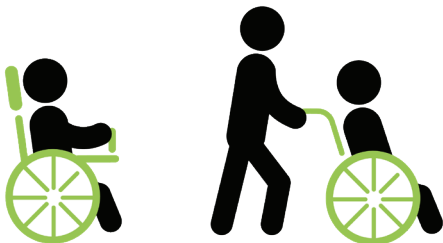
GMFCS Level III



<b>Age 2 - 10</b>	Clinical Exam and AP Pelvis <b>every 12 months</b> after 2 years of age
<b>Age 10 - Skeletal Maturity</b>	Clinical Exam and AP pelvis <b>every 2 years</b> provided MP was stable over previous 2 years
<b>Skeletal Maturity</b>	Clinical Exam and AP Pelvis. Frequency of screening can decrease if MP <30% and there is no change over 2 years after skeletal maturity (closed triradiate cartilage)

## Marginal Ambulatory and Non-Ambulatory

GMFCS Level IV & V



<b>Age 2 - Skeletal Maturity</b>	Clinical exam and AP Pelvis <b>every 6-12 months</b> until age 10 and then may decrease to yearly visits provided that the MP is stable and under 30%
<b>After Skeletal Maturity</b>	Clinical Exam and AP Pelvis. Frequency of screening can decrease if MP <30% and there is no change over 2 years after skeletal maturity (closed triradiate cartilage)