Australian Hip Surveillance Guidelines for Children with Cerebral Palsy 2020

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Australian National Hip Surveillance Working Group 2019–20

These guidelines were updated by the National Hip Surveillance Working Group during 2019–2020. They are due for review by December 2025.

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This document is endorsed by:

AusACPDM
Australasian Academy of Cerebral Palsy and Developmental Medicine

This document can be downloaded from:
www.ausacpdm.org.au/professionals/hip-surveillance

Preface

Background and development of national hip surveillance guidelines in Australia

The overarching objective of the *Australian Hip Surveillance Guidelines for Children with Cerebral Palsy* is to provide evidence based recommendations for the routine surveillance of hip displacement for all children with cerebral palsy (CP).

Hip displacement has been shown to have a negative association with quality of life (Jung et al., 2014; Ramstad et al., 2017). Limited hip surveillance and access to appropriate surgical intervention is associated with poorer hip morphology and subsequently higher levels of pain (Wawrzuta et al., 2016), making early identification and referral to orthopaedic assessment through hip surveillance essential to maintaining good hip health into adulthood.

The guidelines aim to provide evidence-based guidance for clinical decision making related to the commencement, frequency and cessation of hip surveillance, and to guide timely triage and referral for individual orthopaedic assessment and management. They are also a tool for the information and education of all health professionals working with children with CP and their families.

The guidelines are based on the key principles of:

- Early identification of displacement to facilitate early intervention
- Standardisation of monitoring programs
- Balancing risk and benefit: reducing radiation exposure for children in lower risk categories and
- Screening and stratification techniques based on risk factors to facilitate efficiencies of health service use

Monitoring of hip displacement for children with CP has been conducted in some states of Australia from as early as 1997, however criteria related to age of commencement, frequency of review, type of assessment and when to stop monitoring varied. The identification of a linear relationship between progressive hip displacement and the Gross Motor Function Classification System (GMFCS) has since provided a framework for the development of national hip surveillance guidelines relative to a child's risk of developing hip displacement (Soo et al., 2006).

The *Consensus Statement on Hip Surveillance for Children with Cerebral Palsy: Australian Standards of Care, 2008 (Standards of Care)* (Wynter, et al., 2011) was developed by a working group of five physiotherapists and an orthopaedic surgeon from tertiary facilities across three Australian states. The development was undertaken by literature review and a formal external consensus process. The *Standards of Care* did not seek to be prescriptive with respect to service model or method of delivery of hip surveillance.

At the time of development, it was recognised that ongoing, regular review of the *Standards of Care* should be undertaken to consider the impact of new evidence, and a process of 5 yearly review was established.

In 2013 a National Working Group consisting of physiotherapists and orthopaedic surgeons representing each Australian state undertook a review of the *Standards of Care* to consider the impact of new research evidence and to ensure it was user friendly. This review process comprised a systematic literature review following PRISMA guidelines, a national survey of orthopaedic surgeons working with children with CP, and analysis of data from state-based hip surveillance databases. This review informed the revised and renamed *Australian Hip Surveillance Guidelines for Children with CP: 2014* (Wynter et al., 2015).

Review of the 2014 *Guidelines* commenced in 2019 with an updated systematic review and evaluation of the guidelines using the AGREE II methodological framework for the development of clinical guidelines (AGREE Next Step Consortium, 2017). Consensus was sought from an expanded National Working Group, with the addition of representation from two paediatric rehabilitation physicians.

Recent evidence reporting a variety of barriers that parents and caregivers can experience when engaging with hip surveillance, including challenges associated with having an X-ray (Toovey et al., 2020), was considered when reviewing the frequency of hip surveillance. The Victorian Hip Surveillance Consumer Advisory Committee, comprising parents of young people with CP, was consulted regarding the proposed changes. Committee members provided positive feedback that research reporting challenges that children and parents can encounter when having a radiograph had been considered in the review. They felt it critical that changes to the *Guidelines* were primarily based on evidence related to risk of progressive hip displacement and that a balance in responding to evidence in both areas was reached. No further changes were requested or made following the consultation process.

The results of this comprehensive review process form the basis for the *Australian Hip Surveillance Guidelines for Children with Cerebral Palsy: 2020*.

Independent endorsement was granted by the AusACPDM for a period not exceeding five years.

Every child should be referred for hip surveillance[1] at the time CP[2] is identified

Population studies have identified the prevalence of hip displacement[3] to be around 30%. Hip displacement[3] is not related to the movement disorder but is related directly to gross motor function as determined by the Gross Motor Function Classification System (GMFCS)[4] (Ching and Khoo, 2017; Connelly et al., 2009; Hagglund et al., 2007; Kentish et al., 2011; Soo et al., 2006; Wordie et al., 2020).

Hip dislocation[3] is preventable through early identification and intervention as part of an integrated program for every child with CP[2]. Hip surveillance[1] is the process of identifying and monitoring the early indicators of progressive hip displacement[3] and is a critical part of evidenced-based care (Novak et al., 2020). Early identification is an essential part of the strategy for prevention of hip dislocation and its sequelae[3] which include pain, reduced function and difficulty with caregiving. Several studies have also demonstrated that severity of hip displacement is associated with decreased quality of life, providing further evidence of the benefits of hip surveillance[1] (Jung et al., 2014; Marcström et al., 2019; Ramstad et al., 2017; Ramstad & Terjesen, 2016; Wawrzuta et al., 2016).

These Hip Surveillance Guidelines document the recommended process for screening, monitoring and triage for orthopaedic assessment as part of the overall prevention of hip dislocation[3] (Hägglund et al., 2014; Hägglund et al., 2005; Kentish et al., 2011; Terjesen, 2012; Wordie et al., 2020; Wynter et al., 2015). Surgical recommendations and management guidelines do not form part of this document.

Although the risk of hip displacement[3] is related directly to the GMFCS[4] (**Figure 1**), hip surveillance[1] is required for every child with CP[2] regardless of gross motor function ability[5]. The **commencement** of hip surveillance[1] is dependent on corrected age[6] and the **frequency** of ongoing hip surveillance is determined by GMFCS[4] level, radiological measures[7] and clinical assessment[8].

The prime radiological measure[7] for hip surveillance[1] is migration percentage (MP)[9]. Change or stability[10] of MP[9] over time are more relevant than a single MP measure[9], hence the recommendation for repeated measures at specific intervals.

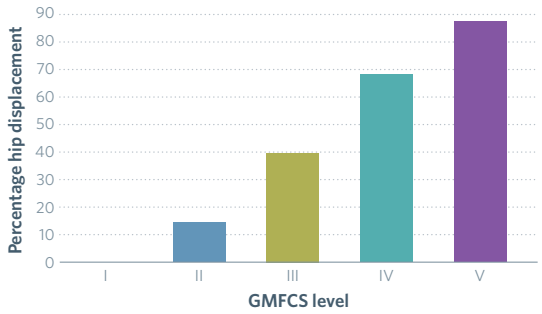


Figure 1. Hip displacement (migration percentage greater than 30%) by GMFCS Level (Soo et al., 2006)

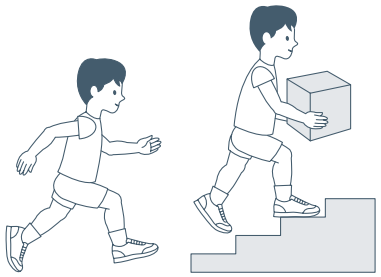
Recommended frequency of hip surveillance

GMFCS I

- Initial clinical assessment[8] at twenty-four months of age[6] (or at identification if older than twenty-four months). **No** routine AP pelvic radiograph[11] required
- Review at three years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS I is confirmed[12], repeat clinical assessment[8]. AP pelvic radiograph[11] is **NOT** required
    - ~ If GMFCS level has changed, continue surveillance according to confirmed classification[12]
  - If identified as Winters, Gage and Hicks (WGH) group IV hemiplegia[13] (Winters et al., 1987) (**Figure 2**), continue surveillance according to WGH group IV classification
- Review at five years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS I is confirmed[12], repeat clinical assessment[8]. AP pelvic radiograph[11] is **NOT** required and if no other significant signs, discharge[14] from surveillance
    - ~ If GMFCS level has changed, or if identified as WGH group IV hemiplegia[13] (**Figure 2**), continue surveillance according to confirmed classification[12]

Referral for orthopaedic assessment should occur when:

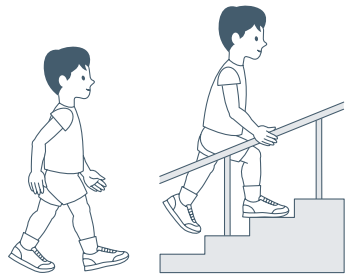
- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified



GMFCS I

GMFCS II

- Initial clinical assessment[8] and AP pelvic radiograph[11] at twenty-four months of age[6] (or at identification if older than twenty-four months)
- Review at three years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS II confirmed[12], repeat clinical assessment[8]. AP pelvic radiograph[11] is **NOT** required
    - ~ If GMFCS level has changed, continue surveillance according to confirmed classification[12]
- Review at five years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS level II confirmed[12], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If GMFCS level has changed, or if identified as WGH group IV hemiplegia[13] (**Figure 2**), continue surveillance according to confirmed classification[12]
  - If MP[9] is abnormal[17] continue twelve monthly surveillance until stability[10] is established
- Review at eight to ten years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS II confirmed[12], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If GMFCS level has changed, or if identified as WGH group IV hemiplegia[13] (**Figure 2**), continue surveillance according to confirmed classification[12]
  - If MP[9] is stable[10] discharge[14] from surveillance
  - If MP[9] is abnormal[17] continue twelve monthly surveillance, including AP pelvic radiograph[11], until stability[10] is established or skeletal maturity[18]
- In the presence of pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20], continue twelve monthly surveillance



GMFCS II

Referral for orthopaedic assessment should occur when:

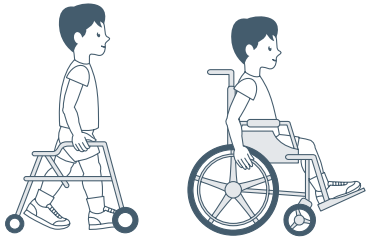
- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified

GMFCS III

- Initial clinical assessment[8] and AP pelvic radiograph[11] at twenty-four months of age[6]
- Review at three years of age
  - Verify GMFCS[4] level
    - ~ If GMFCS III confirmed[12], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If GMFCS level has changed, continue surveillance according to confirmed classification[12]
- Continue twelve monthly surveillance with clinical assessment[8] and AP pelvic radiograph[11] until skeletal maturity[18]
- At skeletal maturity[18], in the presence of pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20], continue twelve monthly surveillance

Referral for orthopaedic assessment should occur when:

- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified



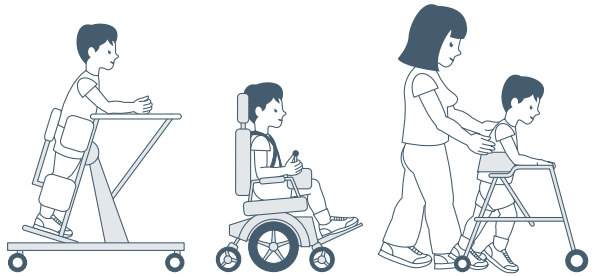
GMFCS III

GMFCS IV

- Initial clinical assessment[8] and AP pelvic radiograph[11] at twelve to twenty-four months of age[6]
- Review six months later
  - Verify GMFCS[4] level
    - ~ If GMFCS IV confirmed[12], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If GMFCS level has changed, continue surveillance according to confirmed classification[12]
- Continue 6 monthly surveillance until MP[9] stability[10] is established
- If MP[9] is abnormal[17] continue six monthly surveillance until MP[9] stability[10] is established
- When MP[9] is stable[10] reduce frequency of surveillance to twelve monthly until skeletal maturity[18]
- Independent of MP[9], when clinical[8] and/or radiographic evidence of scoliosis[21] or pelvic obliquity[19] is present six monthly surveillance is required until skeletal maturity[18]
- At skeletal maturity[18], if MP[9] is abnormal[17] and progressive scoliosis[21] or significant pelvic obliquity[19] is present continue twelve monthly surveillance

Referral for orthopaedic assessment should occur when:

- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified



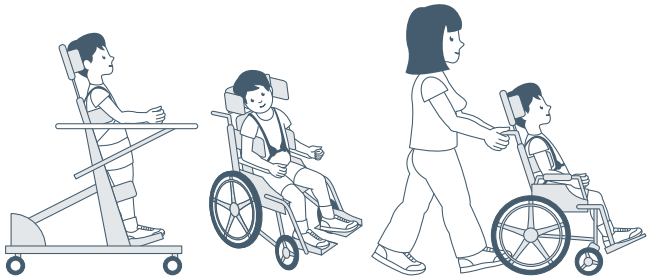
GMFCS IV

GMFCS V

- Initial clinical assessment[8] and AP pelvic radiograph[11] at twelve to twenty-four months of age[6]
- Review six months later
  - Verify GMFCS[4] level
    - ~ If GMFCS IV confirmed[12], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If GMFCS level has changed, continue surveillance according to confirmed classification[12]
- Continue 6 monthly surveillance until MP[9] stability[10] is established
- If MP[9] is abnormal[17] continue six monthly surveillance until MP[9] stability[10] is established
- When MP[9] is stable[10] reduce frequency of surveillance to twelve monthly until skeletal maturity[18]
- Independent of MP[9], when clinical[8] and/or radiographic evidence of scoliosis[21] or pelvic obliquity[19] is present, six monthly surveillance is required until skeletal maturity[18]
- At skeletal maturity[18], if MP[9] is abnormal[17] and progressive scoliosis[21] or significant pelvic obliquity[19] is present, continue twelve monthly surveillance

Referral for orthopaedic assessment should occur when:

- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified



GMFCS V

Hemiplegia: Winters, Gage and Hicks IV (WGH IV[13])

WGH group IV[13] gait pattern (Winters et al., 1987) usually declares itself by four to five years of age.

The child with a classification of WGH group IV[13] has the potential for late onset progressive hip displacement[3] regardless of GMFCS[4] level.

- Review at five years of age
  - Verify WGH gait classification[13] and GMFCS[4] level
    - ~ If WGH group IV[13] confirmed, repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If not WGH group IV[13] continue according to GMFCS classification[13]
  - If MP[9] is stable[10], review at ten years of age
  - If MP[9] is abnormal[17], continue twelve monthly surveillance including AP pelvic radiograph[11], until MP[9] stability[10] is established
- Review at ten years of age
  - Verify WGH classification[13]
    - ~ If WGH group IV[13] confirmed, repeat clinical assessment[8] and AP pelvic radiograph[11]
    - ~ If not WGH group IV[13] continue according to GMFCS classification[12]
  - Continue twelve monthly surveillance until skeletal maturity[18]
- At skeletal maturity[18] if significant scoliosis[21], pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20] are present, continue twelve monthly surveillance

Referral for orthopaedic assessment should occur when:

- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified

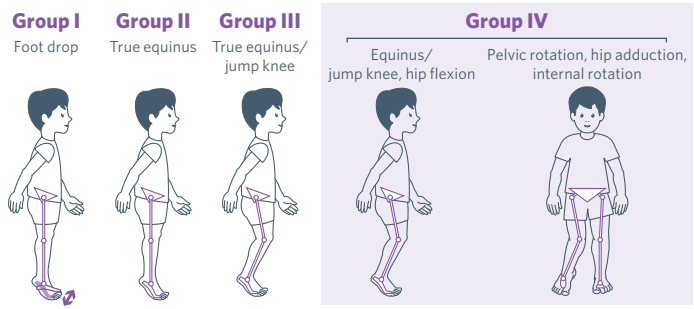


Figure 2. Gait patterns in hemiplegia (Winters, Gage and Hicks, 1987)

Key considerations for hip surveillance

Increased frequency of hip surveillance may be indicated in the presence of:

- Deterioration in function[5] including altered gait[20], decreased ability or tolerance of sitting or standing
- Scoliosis[21], pelvic obliquity[19], or significant leg length discrepancy[19]
- Deterioration in musculoskeletal measures[22] relating to the hip
  - reduced range of movement, reduced muscle length, development of, or increased asymmetry[23] of range of movement
- Onset or increase in pain[15] related to the hip

Referral for orthopaedic assessment should occur when:

- MP[9] progresses to greater than 30%
- There is pain[15] related to the hip
- Other musculoskeletal conditions[16] or concerns are identified

These risk factors are not necessarily an indication for surgery. The intention of hip surveillance[1] is that orthopaedic assessment occurs early and at the appropriate time. Every child referred to orthopaedic assessment should be managed with an individual treatment plan[24] which may include ongoing hip surveillance[1].

Hip surveillance should resume following:

- The postoperative period for any child who has undergone surgery for hip displacement[1] or scoliosis[21]
- Neurosurgical interventions[25] such as selective dorsal rhizotomy (SDR)[25] or intrathecal baclofen (ITB)[25]
- An unplanned break in surveillance for any other reason

Hip Surveillance after skeletal maturity[18] and transition[26] into adulthood

- As part of transition[26] the hip should be classified according to the Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS)[27] (Robin et al., 2009) (**Figure 8**)
  - If MCPHCS grade IV or V, refer for ongoing orthopaedic assessment
  - If MCPHCS grade II or III, provide advice regarding future hip health[28]
- Referral for ongoing orthopaedic assessment should occur in the presence of pain[15], progressive scoliosis[21], significant pelvic obliquity[19] and/or deteriorating function[5] (Heidt et al., 2015; Jung et al., 2014; Oda et al., 2017; Rodby-Bousquet et al., 2013; Wawrzuta et al., 2016)

Annotations

1. Hip surveillance

Hip surveillance is the process of monitoring and identifying the critical early indicators of hip displacement[3]. These early indicators include GMFCS[4] level, age[6], gait classification (WGH group IV[13]) and MP[9]. The information gathered from the clinical assessment[8] and radiological review[11] are vital components of hip surveillance and are required to capture often silent hip displacement[3] while minimising radiation exposure. Hip surveillance cannot be based on clinical assessment[8] alone.

Hip surveillance can assist identifying prognosis for the hip, inform planning for ongoing hip management, support education and assist clear communication. Surgical recommendations and management guidelines are beyond the scope of this document.

Hip surveillance is an ongoing process that continues for every child at least until skeletal maturity[18] or discharge[14]. Hip surveillance should recommence following the post-operative period for any child who has undergone surgery for hip displacement or scoliosis[21], following neurosurgical interventions[25] such as SDR or ITB, or following an unplanned break in surveillance for any other medical reason.

All children with CP[2] or 'like' conditions should be referred for hip surveillance even if classification of GMFCS[4] is not yet confirmed[12].

The initial *Consensus Statement (2008)* (Wynter et al., 2011) and the *Australian Hip Surveillance Guidelines for Children with Cerebral Palsy: 2014* (Wynter et al., 2015) documented commencement and frequency of hip surveillance, where surveillance is based on risk relative to GMFCS[4] level. Since the development and implementation of these guidelines in 2008, a number of population-based studies have demonstrated the effectiveness of hip surveillance programs at identifying progressive hip displacement in children with CP[2] (Hägglund et al., 2014; Hägglund et al., 2005; Kentish et al., 2011; Terjesen, 2012; Wordie et al., 2020). All studies have used radiological measures[7] to monitor hip displacement[3], with MP[9] (Reimers, 1980) the most frequently used. The monitoring of MP[9] enabled identification of children for surgery at a younger age, thus reducing the need for later salvage surgery[30] (Gordon and Simkiss, 2006; Hägglund et al., 2014; Wordie et al., 2020).

The Australian Hip Surveillance Guidelines for Children with Cerebral palsy: 2020 incorporate new evidence in this area.

2. Cerebral palsy

The term cerebral palsy (CP) refers to *cerebral palsy and like conditions*, where clinical signs or descriptions are most relevant, not aetiology (Blair and Cans, 2018). An international review of "The Definition and Classification of Cerebral Palsy" in 2006 defined CP as:

> *"A group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain. The motor disorders of cerebral palsy are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems."* (Rosenbaum et al., 2007)

For the purposes of this document the definition of CP includes the following five key elements (Bax et al., 2005):

1. CP is a group of disorders, i.e. it is an umbrella term
2. It involves a disorder of movement and/or posture and of motor function
3. It is due to a non-progressive interference/lesion/abnormality
4. This interference/lesion/abnormality is in the developing/immature brain, and
5. The interference/lesion/abnormality in the developing/immature brain is permanent but the functional limitations may progress and/or change

For the purposes of these guidelines, *'like'* conditions refers to those conditions where motor dysfunction results from genetic and metabolic aetiologies, including clearly recognised syndromes, recognisable progressive brain disorders, or from brain injury acquired in childhood within the first two years of life (Blair and Cans, 2018; Smithers-Sheedy et al., 2014). In the absence of natural history data for children with post neonatally acquired brain injury, early and frequent surveillance is recommended, as clinical experience indicates a high prevalence of hip displacement in this group.

In conditions other than CP, where there is no evidence for the natural history of hip displacement[3], the risk seems likely to also relate to functional ability[5] (Kentish et al., 2011). However, generalised hypotonia and/or developmental delay without a diagnosis of CP or another recognised genetic or metabolic aetiology is **not** considered a 'like' condition. While it is recognised that there may be an increased risk for hip displacement in some individuals with these conditions, this group is clinically heterogeneous and the natural history of hip displacement[3] is not well documented in the literature, therefore difficult to characterise. Children with generalised hypotonia and/or developmental delay should be assessed on an individual basis and referred for orthopaedic assessment if needed.

3. Progressive hip displacement, dislocation and sequelae

Progressive hip displacement refers to the gradual displacement of the femoral head laterally out of the acetabulum. This displacement is expressed as a migration percentage (MP)[9].

Hip Subluxation defines the state of the hip joint and can be used interchangeably with hip displacement where MP is between 10% and 99%.

Hip Dislocation is defined when the femoral head is completely displaced laterally out of the acetabulum (MP = 100%).

The *sequelae* of progressive hip displacement are variable. Progressive displacement can result in asymmetric pressure that may deform the femoral head and/or acetabulum (also termed acetabular dysplasia). Hip dysplasia may lead to degeneration of articular cartilage and pain[15] (Marcström et al., 2019; Ramstad et al., 2017; Ramstad and Terjesen, 2016; Wawrzuta et al., 2016). Problems with limited range of movement[22] and pain[15] can interfere with function[5], ability to be positioned, hygiene and personal care, and may result in reduced health related quality of life (Jung et al., 2014; Ramstad et al., 2017). Progressive displacement has been shown to be a risk factor for development of dislocation of one or both hips (Cooke et al., 1989).

4. The Gross Motor Function Classification System (GMFCS)

The Gross Motor Function Classification System (GMFCS) is used to describe the gross motor function of children with CP[2] (Palisano et al., 1997). The GMFCS was published in 1997 and expanded and revised in 2007. When referring to GMFCS in these guidelines the authors are referring to the expanded and revised version of the GMFCS (Palisano et al., 2008).

The GMFCS classifies the gross motor function of children and youth with CP on the basis of their self-initiated movement, with particular emphasis on sitting, walking, and wheeled mobility (Palisano et al., 1997; Palisano et al., 2006; Palisano et al., 2008).

The GMFCS has five levels for describing differences in children's motor abilities. Distinctions between levels are based on functional limitations, the need for hand-held mobility devices or wheeled mobility and, to a much lesser extent, quality of movement. Since classification of motor function is dependent on age, separate descriptions are provided for several age bands within each level: before 2nd birthday, from 2nd to 4th birthday, from 4th to 6th birthday, from 6th to 12th birthday, and from 12th to 18th birthday. There is a tendency for the gross motor function of children classified prior to six years of age to be reclassified after six years of age (Palisano et al., 2006) hence the need to confirm GMFCS level at each occasion of hip surveillance[1].

The distinctions between levels I and II are not as pronounced as the distinctions between the other levels, particularly for infants less than two years of age[6].

Emphasis is on the child's **usual** performance in home, school, and community settings, rather than what the child may be able to achieve at their best. It is therefore important to classify current performance in gross motor function and not to include judgments about the quality of movement or prognosis for improvement. Generally it takes only a few minutes to assign a GMFCS classification.

The GMFCS: Expanded and Revised (Palisano et al., 2008) and supporting resources can be downloaded free of charge from the website: https://canchild.ca/en/resources/42-gross-motor-function-classification-system-expanded-revised-gmfcs-e-r

5. Gross motor functional ability

Gross motor functional ability refers to the gross motor activities that the child is able to accomplish in his/her own environment (performance) rather than what he/she may be able to achieve in a testing situation (capability). Gross motor functional ability includes the achievement of developmental milestones.

6. Corrected age

Assessment for hip surveillance[1] takes into consideration corrected age for prematurity up to two years of age. Pre-term or premature is defined as a gestational age less than thirty six weeks. To calculate corrected age subtract the expected date of birth (i.e. not actual date of birth) from the date of evaluation.

7. Radiological measures

These are reproducible measures taken manually or electronically from a standard radiograph. For hip surveillance[1] the standard radiograph required is an antero-posterior (AP) radiograph of the pelvis[11] (Reimers, 1980; Scrutton et al., 2001). Radiological measures may be less accurate in the very young and will not be accurate below twelve months of age[6].

Whilst MP[9] is the most widely used radiological index for hip surveillance, multiple radiological criteria have been described for the assessment of the hip in children with CP[2]. For the proximal femur, these include, but are not limited to, neck shaft angle, head shaft angle and epiphyseal tilt (Finlayson et al., 2018). On the acetabular side, the acetabular index and Sharp's acetabular angle are useful measures of acetabular dysplasia. None of these measures are independent — they are interrelated to each other and to GMFCS[4] (Robin et al., 2008). In general, they are more useful in planning intervention and outcome studies than for hip surveillance[1].

Two tools which have been suggested to have an impact on hip surveillance are the Pelvic Adjusted Migration Percentage (PAMP) (Hägglund et al., 2018) and the CPUP risk score (Hermanson et al., 2015). The effect of pelvic obliquity[19] (PO) on routine hip surveillance is minimal because the majority of younger children with CP have a level pelvis or PO less than five degrees (Hägglund et al., 2018; Heidt et al., 2015). Once PO reaches greater than ten degrees the effect on measurement of MP is more apparent (Hägglund et al., 2018; Heidt et al., 2015). There is emerging evidence that PAMP may be a better measure than traditional MP if PO is greater than ten degrees. Once PAMP has been used it should continue to be used consistently for that child. The CPUP risk score is a calculation of risk of progressive displacement for an individual child at GMFCS III-V based on age, GMFCS level, head shaft angle and MP and is a predictive clinical tool that maybe used for this group of children (Hermanson et al., 2015).

8. Clinical assessment

The essential elements of clinical assessment undertaken for hip surveillance[1] are only a part of the overall assessment required by a child with CP[2]. For the purpose of hip surveillance, clinical assessment should include both subjective and objective aspects of assessment to identify and document concerns related to care and comfort, pain[15], any change in gross motor function[5] including deteriorating gait[20], and assessment of the child's spine[21], pelvis[19] and lower limb musculoskeletal system[22]. The assessor should be able to classify the child's gross motor function by the GMFCS[4] and identify WGH group IV[13] gait pattern (Winters et al., 1987).

9. Migration percentage (MP)

This is a radiographic measure[7] of the amount of ossified femoral head that is not covered by the ossified acetabular roof (Reimers, 1980). It is the percentage of the femoral head which is lateral to the acetabular margin on an AP pelvic radiograph[11] (**Figure 3**).

MP is measured by drawing a horizontal line (Hilgenreiner's or H-line) through the most superior medial point of each triradiate cartilage and a vertical line (Perkin's or P-line) drawn perpendicular to it at the lateral margin of the acetabulum. The amount of the femoral head which is lateral to Perkin's line (A) is expressed as a percentage of the ossified femoral head (B) (**Figure 3**).

MP = A/B × 100%

Figure 4 shows alternative placement options for H-line which can be used when the triradiate cartilage has closed or is obscured.

When a gothic arch is present, the lateral margin of the acetabulum can be difficult to define (Miller et al., 2020). This can affect the accuracy of the standard MP measure by up to a 9% underestimation (Wek et al., 2020) and this should be considered when referring on for orthopaedic assessment. Modified MP measurement protocols have been reported when a gothic arch is present (Wek et al., 2020).

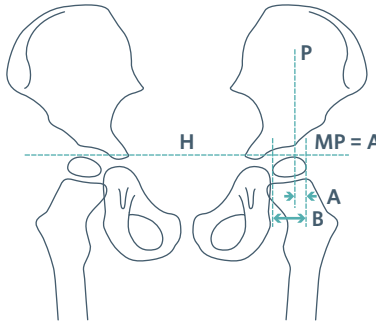


Figure 3. Migration percentage (MP) (Reimers, 1980)

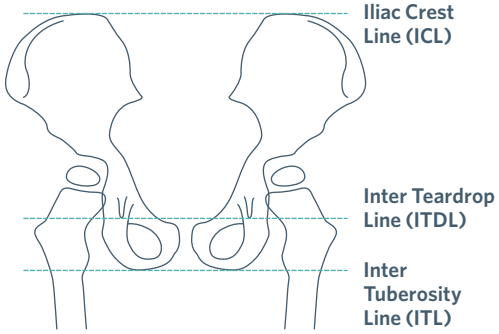


Figure 4. Alternative position for H-line once triradiate cartilage has closed

10. Stability of migration percentage

In children with CP[2] the majority of hips are normal at birth (Bleck, 1987; Laplaza et al., 1993; Vidal et al., 1985). In the absence of treatment, the MP[9] increases progressively from an early age at an average rate of about 5.5% per year. A change of greater than 8% in repeated measurement by one experienced measurer is required to be 95% confident of true change (Kinch et al., 2015; Parrott et al., 2002; Shore et al., 2019). For the purpose of this document, **stable MP** is progression of not more than 10% in a twelve month period over a period of two to three years (Gordon and Simkiss, 2006).

An **unstable MP** is when the progression is greater than or equal to 10% over a twelve month period.

11. Antero-posterior (AP) pelvic radiograph

A supine AP pelvic radiograph within certain positioning limits is required to enable MP[9] to be accurately measured. The MP is, to a large extent, dependent on the abduction or adduction of the leg, so the leg should be positioned in neutral abduction/adduction (**Figure 5A**). When an AP pelvic radiograph does not show neutral femur positioning it is not always necessary to repeat the imaging as surveillance is based on a series of radiographs over time. Unnecessary repetition adds to cumulative radiographic exposure for the child. There is limited evidence on an acceptable range of adduction/abduction. An adducted femur will increase the MP and abducted femur will decrease the MP from the true value. Consensus expert opinion in Australia accepts +/- ten degrees of hip abduction or hip adduction. The effect of rotation of the leg on MP is small.

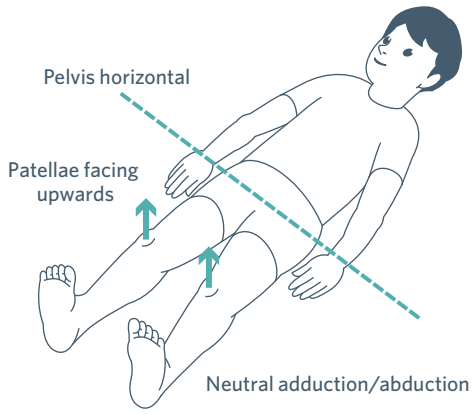
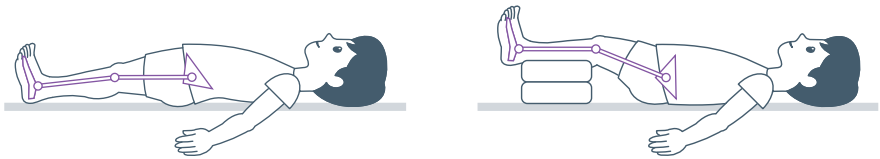


Figure 5A. Positioning for AP pelvic radiograph

The MP[9] can be measured only if the Hilgenriener's line can be plotted accurately, that is, the triradiate cartilages are clearly visible or there is sufficient view for alternative placement options for H-line when the triradiate cartilage has closed (**Figure 4**), and the pelvis is not in forward or backward tilt. Pelvic tilt needs to be corrected in children who have a fixed flexion deformity of the hip(s)[22] or a significant lumbar lordosis (Scrutton and Baird, 1997) (**Figure 5B**).



Incorrect—Lordotic lumbar spine

Correct—Flat

Figure 5B. Positioning for AP pelvic radiograph: pelvic tilt

Gonadal shielding is usually not recommended for paediatric imaging of the pelvic area, either in the primary beam or close to the primary beam (within five cm). The risk and benefit of using gonadal shielding should be considered and use of a shield should be according to local practice guidelines (American Association of Physicists in Medicine, 2019; The British Institute of Radiology, 2020; Fawcett and Barter, 2009; Fawcett et al., 2012; Frantzen et al., 2012; Tsai et al., 2014).

12. Confirmed GMFCS

For the purpose of this document **confirmed** is defined as the GMFCS[4] level which best fits on today's assessment. GMFCS levels may not always be distinct or easily apparent, particularly for the younger child and between the higher functioning levels (Hanna et al., 2009; Palisano et al., 2006). It is important to reassess for the correct GMFCS level on each occasion of hip surveillance[1].

13. Winters, Gage and Hicks classification

Winters, Gage and Hicks (WGH) classification of hemiplegic gait describes four types of gait pattern based on the sagittal plane kinematics of the ankle, knee, hip and pelvis (Winters et al., 1987). The characteristic of each group is as follows:

Group I: Foot drop in the swing phase of gait, normal dorsiflexion range in stance phase of gait

Group II: Excessive plantarflexion of the ankle in both stance and swing phase of gait

Group III: Group II deviations plus limited flexion/extension range of motion at the knee during stance and swing phases of gait

Group IV: Group III deviations plus limited flexion/extension range of motion at the hip during stance and swing phases of gait

This is represented in **Figure 2**.

There are limitations in using this classification as it is based only on sagittal plane kinematics (Dobson et al., 2006). Many children with hemiplegia will present with coronal and transverse plane gait deviations, such as pelvic obliquity[19] and pelvic retraction that may predispose them to a higher risk of hip displacement[3] than those with only sagittal plane deviations. Hence children with coronal or transverse plane abnormalities, particularly pelvic obliquity[19] and/or retraction and hip internal rotation, should also be considered in group IV for the purposes of hip surveillance[1]. While this classification is based on three-dimensional gait analysis kinematic data, visual observation of gait and musculoskeletal measures[22] relating to the hip are sufficient for classification of WGH group IV for the purpose of hip surveillance[1]. Children classified with WGH group IV gait are those at risk of progressive hip displacement[3]. Children with WGH group IV gait may develop displacement later than children with bilateral CP[2] and the hip MP[9] can progress slowly until puberty[29]. Children with significant asymmetrical diplegia may also follow this pattern of progression of hip displacement and clinicians should be alert to monitoring the more involved side. Children functioning at GMFCS II and presenting with very asymmetric diplegia may be considered under this classification for hip surveillance. Presentation at puberty[29] may be characterised by pain[15], rapid increasing leg length discrepancy[19], apparent leg length discrepancy[19] and/or pelvic obliquity[19].

14. Discharge

Discharge is the cessation of continuing hip surveillance[1]. Children will most often continue to be involved with other management programs including tone management or orthopaedic gait corrective surgery[30] according to best practice and evidence based medicine. Gait corrective surgery[30] may simultaneously address displacement[3] of the femoral head whilst correcting other bony alignment.

15. Pain

Pain in the hip region for children with CP[2] is variably reported in the literature and may or may not be associated with hip displacement or dislocation[3]. In some cases pain may be clinically expressed in the knee or other part of the leg but be referred from the hip. Chronic musculoskeletal pain is a complaint for up to 73% of children (Mckinnon et al., 2019; Parkinson et al., 2013; Ramstad and Terjesen, 2016; Wawrzuta et al., 2016) and up to 67% of adults with CP[2] (Engel et al., 2003), occurring most commonly in the low back (Penner et al., 2013), hip and leg (Engel et al., 2003; Mckinnon et al., 2019; Parkinson et al., 2013).

In adolescents with CP[2] who do not ambulate, pain has been reported at rest, with certain positions, or with such movements as passive abduction (Hodgkinson et al., 2001). Identifying the source of pain in the region of the hip is a challenge. In children with limited communication, the clinician must rely on the perception of the parents or caregivers to help identify the source. Pain may originate in the skin or subcutaneous tissues, the musculature surrounding the hip, the osteoarticular structures, or may be referred from another location (Spiegel and Flynn, 2006).

Pain should be measured and recorded as part of the clinical assessment[22] for hip surveillance[1].

16. Other musculoskeletal conditions

Other musculoskeletal conditions include, but are not limited to, developmental dysplasia of the hip, muscle contracture that is not able to be managed conservatively, an inflammatory reaction, such as transient synovitis or sepsis, a slipped capital epiphyses, perthes disease, excessive femoral anteversion, juvenile idiopathic arthritis, septic arthritis or bursitis, osteomyelitis, other unusual bone or joint anomalies and in rare cases, bone tumours.

17. Normal/abnormal migration percentage

A normal MP[9] is considered to be zero or even negative as displacement[3] should not occur in a normal hip (Perkins, 1928). Reimers (1980) found that among children with normal motor development, the 90th centile for hip migration at four years of age was 10%. For the purpose of these guidelines, normal MP is less than 10% after the corrected age[6] of four years (Reimers, 1980), a near normal MP is between 10–15%, and an MP of greater than 15% is considered abnormal. MP equal or greater than 30% is considered at risk (Cooperman et al., 1987; Dobson et al., 2002).

18. Skeletal maturity

There are a number of definitions of skeletal maturity utilising radiographic parameters which may be selected according to the patient population. One of the earliest is closure of the triradiate cartilage (Dimeglio, 2001) which is followed by closure of the growth plate of the olecranon apophysis at the elbow, followed by progressive capping and closure of the iliac apophysis, also known as the Risser sign (Risser, 1958) (**Figure 6**).

The closure of the triradiate cartilage (Dimeglio, 2001) can be a useful marker if the radiograph[11] does not include the iliac crests, and this may suffice for adolescents functioning at GMFCS I–III. However, for adolescents functioning at GMFCS IV and V the prevalence of scoliosis[21] and pelvic obliquity[19] is high and these postural variations may impede visualisation of the triradiate cartilage. It is suggested that skeletal maturity should be judged using the Risser sign which requires an AP radiograph[11] of the pelvis including the iliac crests.

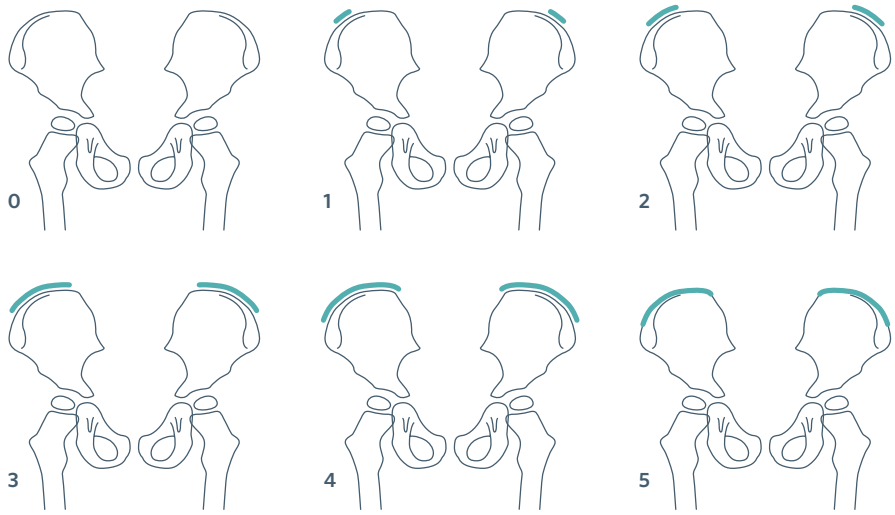


Figure 6. The Risser sign

19. Pelvic obliquity, real and apparent leg length discrepancy

Pelvic obliquity (PO) strongly correlates with hip morphology (Heidt et al., 2015). Pelvic obliquity may occur in younger children with CP[2] as the result of muscle imbalances around the trunk, pelvis and hips. Pelvic obliquity may be secondary to influences above the pelvis (scoliosis[21]) or below the pelvis (leg length inequality, hip displacement/dislocation[3] or asymmetric contractures of the hip adductors or hip flexors[22]), or from a combination of suprapelvic and infrapelvic influences. Obliquity observed on a radiograph may be the result of challenges associated with positioning the child or them not being able to lie still. Clinically important obliquity shows up on serial AP pelvic radiographs[11] with a consistent pattern — the same side is always up and the opposite side is always down. Pelvic obliquity can be measured from the angle of Hilgenreiner's line to the horizontal in growing children (**Figure 7A**). In skeletally mature children there are three alternatives to Hilgenreiner's line — the inter-teardrop line, the iliac crest line or the inter-tuberosity line (**Figure 7B**). A study by Heidt et al. (2015) found the inter-teardrop line to be the most reliable.

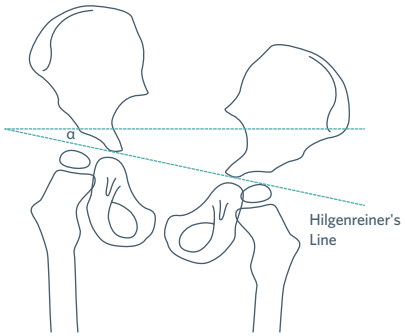


Figure 7A. Pelvic Obliquity, pre puberty
α = degree of pelvic obliquity

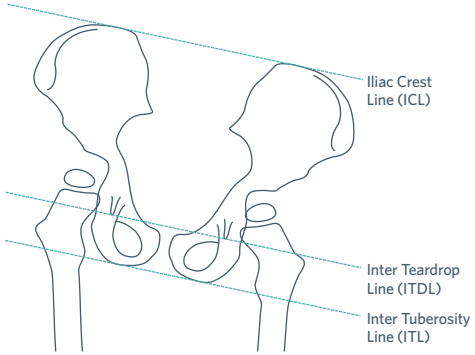


Figure 7B. Pelvic obliquity, post puberty

There is good evidence that PO increases hip instability on the high side of the pelvis and simultaneously increases hip stability on the low side of the pelvis (Crawford et al., 2017; Heidt et al., 2015). Once PO reaches greater than ten degrees the effect of the obliquity on hip stability, measurement of MP[9] and long-term outcomes of hip morphology are more apparent (Hägglund et al., 2018). Consistent PO of greater than ten degrees should be considered as a trigger for referral for orthopaedic assessment of the cause of the PO.

It is important to determine the contributions of both real and apparent shortening in the evaluation of leg length discrepancy as well as the contribution of suprapelvic and infrapelvic factors. This is done by careful clinical examination[22] of real and apparent leg length with interpretation of this information with radiographs of the pelvis and/or spine. Although unilateral hip displacement[3] and dislocation[3] may result in a real leg length discrepancy, there is frequently a combination of real and apparent discrepancy.

20. Gait

Gait describes the particular manner or way of moving on foot. It is the description of locomotion style. Alterations in gait that may necessitate increased frequency of hip surveillance[1] may include increasing asymmetry[23] of the pelvis with retraction or pelvic obliquity[19], increased hip adduction[22] or internal rotation[22], changes or increased asymmetry[23] of step length. This is by no means inclusive of all possible gait deviations.

21. Scoliosis

In CP[2] most spinal deformities involve neuromuscular scoliosis, although sagittal plane deformities such as kyphosis (thoracic spine) and lordosis (lumbar spine) are also common. Spinal deformities in children with CP are related to the severity of involvement and are most common at GMFCS[4] IV and V (Miller, 2005; Oda et al., 2017; Persson-Bunke et al., 2012; Rodby-Bousquet et al., 2013). Initially the problems are postural but tend to progress rapidly and become fixed during puberty[29]. Clinical assessment and regular monitoring of the spine should be part of overall musculoskeletal surveillance for children with CP.

Radiographic surveillance for spinal deformity should include antero-posterior and lateral radiographs of the whole spine including the pelvis. The radiograph should be taken with the least amount of support required, i.e. independent standing for children and adolescents at GMFCS I and II, standing with usual support for those who function at GMFCS III, and sitting with support for those who function at GMFCS IV and V. For some children and adolescents functioning with severe fixed deformities, supine radiographs are sometimes the only feasible technique.

Associations between hip displacement[3] and postural asymmetries are reported in cross-sectional studies that highlight the value of hip surveillance[1] programs, however the current evidence is unable to determine causality (Oda et al., 2017; Rodby-Bousquet et al., 2013). Even after surgery for scoliosis, hip surveillance[1] should continue as risk of progressive hip displacement may not be mitigated by correction of scoliosis (Crawford et al., 2017; Oda et al., 2017). Specific recommendations for timing and frequency of spinal surveillance is beyond the scope of this document.

22. Musculoskeletal measures relating to the hip

Musculoskeletal measures relating to the hip should include assessment of the spine[21], pelvis[19], leg length discrepancy[19] and physical examination of the lower limbs including passive and dynamic range of movement muscle strength, and measures of tone/spasticity (Boyd and Graham, 1999). There is no strong evidence for a relationship between these measures and hip MP[9] but we recommend that they are assessed as part of hip surveillance[1] to think about these factors in clinical decision making and until strong evidence emerges that they are not related.

Assessment of musculoskeletal measures around the hip, function and pain[15] may include:

- Passive range of movement
  - Hip abduction with hips at 90 degrees of flexion
  - Hip abduction with hips at 0 degrees of flexion
  - Thomas test
  - Hip flexion
  - Hip extension (Staheli)
  - Hip internal rotation
  - Hip external rotation
  - Femoral neck anteversion (FNA)
  - Popliteal angle
  - Pelvic obliquity[19]
- Real and apparent leg length
- Functional mobility categorised by the Functional Mobility Scale (FMS) (Graham et al., 2004)
- Assessment of pain[15] about the hip
- Assessment of tone, which may include:
  - Dynamic contracture as measured by Modified Tardieu Scale (Boyd and Graham, 1999)
    - Hip adductors
    - Hamstrings
  - Australian Spasticity Assessment Scale (Love et al., 2016)
    - Hip adductors
    - Hamstrings
    - Hip flexors
  - Hypertonia Assessment Tool (Marsico et al., 2017) to identify presence of hypertonia in the lower limbs
- Barry Albright Dystonia Scale (Barry et al., 1999) to quantify dystonia in lower limbs

23. Fixed posture and asymmetry

Fixed posture describes structural changes to the posture/mobility of the trunk and/or limbs that cannot be voluntarily or passively corrected. This can be assessed clinically and radiologically and is differentiated from non-structural postural changes which may be fully corrected.

Asymmetry is dissimilarity in corresponding parts on opposite sides of the body which are normally alike.

Fixed asymmetry describes structural changes to the trunk, pelvis and/or limbs, and is characterised by the lack or absence of symmetry which cannot be voluntarily or passively corrected. This can be assessed clinically and radiologically and is differentiated from non-structural postural changes which may be fully corrected.

Newly developed is a clinical sign or measure of recent onset which was not apparent at the previous clinical assessment or radiograph, or is subjectively described by the patient/caregiver as having recently appeared.

24. Individual treatment plan

An individual treatment plan is the adaptation of a standard management plan in response to individual clinical presentation and need. This management plan may include ongoing surveillance[1], altered frequency of surveillance and/or intervention including surgical intervention[30].

25. Neurosurgical interventions

Neurosurgical interventions include those directed at the central nervous system to modulate movement disorders.

Selective dorsal rhizotomy (SDR) is a neurosurgical procedure used in children with CP[2] to reduce spasticity in the lower limb by surgically interrupting the afferent input of the monosynaptic stretch reflex. The procedure involves dividing the dorsal root into separate rootlets and transecting a portion of these, leaving the others intact, thereby preserving sensory function and minimising sphincter dysfunction (Grunt et al., 2014).

Continuous intrathecal Baclofen infusion (ITB) involves the administration of Baclofen directly to the cerebrospinal fluid, by way of a surgically implanted pump with a catheter directed into the intrathecal space. The continuous administration of Baclofen acts directly at the level of the spinal cord to reduce abnormal posturing.

Referral back to hip surveillance[1] should occur following neurosurgical interventions.

26. Transition

Transition is defined as *"the purposeful planned movement of adolescents and young adults with chronic physical and medical conditions from child-centred to adult-oriented health care systems"* (Blum, 1995).

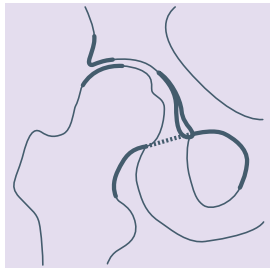
Transition from hip surveillance[1] will occur at the point of discharge[14] from surveillance or at the conclusion of paediatric services. Young people with CP[2] with a risk related to future pain[15] or progressive hip displacement[3] require advice, information, and at times referral to adult services to ensure optimal hip health[28] in the future. Summary documentation provided at transition should include details of orthopaedic interventions[30] that have been undertaken for the hip/s.

Classification of the hips according the Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS)[27] at skeletal maturity[18] is required to identify hips at risk of pain[15] associated with arthritic changes, future progressive displacement or dislocation[3] (Wawrzuta et al., 2016) Young people functioning at GMFCS II or III and/or WGH group IV[13] presenting with MCPHCS grade 3 or 4 hip/s may benefit from counselling on the possibility of future interventions for optimising hip health[28]. A MCPHCS grade 4 or 5 hip/s in young people with progressive scoliosis[21] and/or pelvic obliquity[19] requires continuation of surveillance as hip dislocation[3] remains an ongoing risk in this population (Wawrzuta et al., 2016).

27. The Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS)

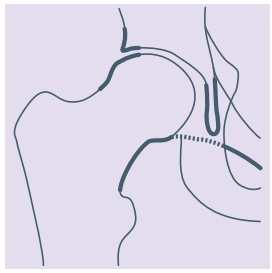
The Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS) (Robin et al., 2009) which has been expanded and revised (Burns et al., 2014) (**Figure 8**) is an ordinal grading system, which was designed to describe hip morphology at skeletal maturity[18] for young people with CP[2] across all GMFCS[4] levels. The classification covers a wide range of radiographic features from grade 1 (normal hip), through to grade 6 (dislocated hip). The MCPHCS includes sub-classifications of femoral head deformity, acetabular deformity and pelvic obliquity[19]. For detail of the sub-classifications refer to the published papers (Robin et al., 2009, Burns et al., 2014). grade 7 denotes that the hip joint has been lost to some form of salvage surgery[30].
The utilisation of MP[9] in the MCPHCS ensures backwards compatibility with data from hip surveillance[1] in childhood. It is recommended as a simple way of classifying the outcomes of hip development, hip surveillance[1] and management in children with CP at skeletal maturity[18] (Wawrzuta et al., 2016). The MCPHCS is valid (based on the MP[9]) and has been shown to be reliable (Murnaghan et al., 2010; Shrader et al., 2017).

Figure 8. Melbourne Cerebral palsy Hip Classification Scale (Expanded and Revised) (Robin et al., 2009; Burns et al., 2014)



Grade 1: Normal hip — migration percentage <10%

1. Shenton's arch intact
2. Femoral head round (within 2mm using Mose circles)
3. Acetabulum — normal acetabular development with a normal horizontal sourcil, an everted lateral margin and normal tear drop development
4. Pelvic obliquity <5˚
5. No degenerative change, no pain

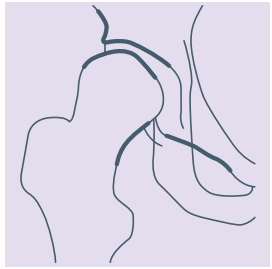


Grade 2: Near normal hip — migration percentage ≥10% ≤15%

1. Shenton's arch intact
2. Femoral head round or almost round
3. Acetabulum — normal or near normal development
4. Pelvic obliquity <5˚
5. Low risk of degenerative change, usually pain free

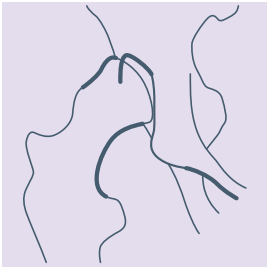
Grade 3: Dysplastic hip — migration percentage >15% ≤30%

1. Shenton's arch intact or broken by ≤5mm
2. Femoral head round or mildly flattened
3. Acetabulum normal or mildly dysplastic including blunting of the acetabular margin and a widened tear drop
4. Pelvic obliquity <10˚
5. Low risk of degenerative change, occasionally mild pain



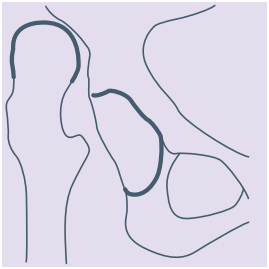
Grade 4: Dysplasia with mild subluxation — migration percentage >30% <60%

1. Shenton's arch broken by >5mm
2. Femoral head some flattening
3. Acetabulum dysplastic
4. Pelvic obliquity variable
5. Risk of degenerative change, pain variable



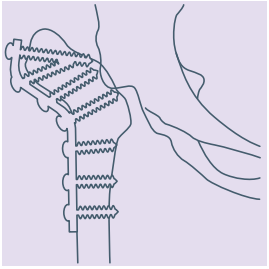
Grade 5: Moderate to severe subluxation — migration percentage ≥60% <100%

1. Shenton's arch broken by >10mm
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable
5. Degenerative change frequent, pain frequent



Grade 6: Dislocated hip — migration percentage ≥100%

1. Shenton's arch completely disrupted
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable
5. Degenerative change frequent, pain frequent



Grade 7: Salvage surgery

1. Valgus osteotomy
2. Arthrodesis
3. Excision arthroplasty (Castle) +/- valgus osteotomy (McHale)
4. Replacement arthroplasty
5. Pain relief following salvage surgery, variable

28. Hip health

The hip should be a flexible, pain-free joint that does not limit function[5]. The femoral head should be well covered by the acetabulum.

29. Puberty

Puberty can be recognised by a combination of growth acceleration, development of secondary sexual characteristics, chronological age and bone age. Bone age can be assessed with a range of radiological investigations of which radiograph of the wrist or elbow are the most widely used. In typically developing children, girls will experience the onset of puberty at eleven years (bone age) and boys at thirteen years (bone age) but there is wide variation in both typically developing children and even more so in children with CP[2]. In typically developing children, about 50% have a bone age that is significantly different from their chronological age and in CP the percentage is even higher (Dimeglio, 2001). Delayed bone age is particularly common in children function at GMFCS[4] IV and V and it is probable that the pattern of skeletal maturation varies by GMFCS level. Although hip displacement[3] may occur in children with CP from early childhood, the pubertal growth spurt is a period of particular risk for both progression of existing hip displacement, the development of hip displacement in previously stable[10] hips, as well as the development of pelvic obliquity[19] and scoliosis[21].

30. Orthopaedic interventions

Orthopaedic surgical interventions can include gait corrective surgery, soft tissue, reconstructive and salvage procedures. Discussion of surgical recommendations and management guidelines are beyond the scope of this document.

Disclaimer

These guidelines are based on review of the current medical literature and current knowledge of the natural history of CP and data from established hip surveillance programs in Australia.

These guidelines are based on careful and considered analysis of expert opinion and the evidence to date. There may well be a range of unknown factors yet to be determined in hip surveillance for children with CP. Clinical judgement can and should override these guidelines when clinical or carer concerns are noted, and appropriate action should be taken.

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Child and Adolescent Health Service

These hip surveillance guidelines for children with cerebral palsy were endorsed by the Australasian Academy of Cerebral Palsy and Developmental Medicine (AusACPDM) in November 2020. Endorsement by AusACPDM is granted for a period not exceeding five years, at which date the approval expires. The AusACPDM expects that these guidelines will be reviewed no less than once every five years.

These Australian Hip Surveillance Guidelines are due for review by December 2025.

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