Surveillance Guidelines for Children with Cerebral Palsy 2021

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Every child should be referred for hip surveillance[1] immediately following a cerebral palsy (CP)[2] diagnosis.

The reported rates of hip displacement[3] and hip dislocation[3] in children with CP[2] vary widely, ranging from 2% to 75% (Bagg et al, 1993). Recent population studies identified the rate of hip displacement[3] to be around 30%. Hip displacement[3] is not related to a movement disorder, but is directly related to gross motor function as determined by the **Gross Motor Function Classification System** (GMFCS)[4] (Soo et al, 2006, Hagglund et al, 2007, Connelly et al, 2009, Kentish et al, 2011).

Here's the good news: Hip dislocation[3] is preventable through early identification and intervention.

Hip surveillance[1] is the process of identifying and monitoring critical early indicators of progressive hip displacement[3]. Early identification is an essential part of the strategy for prevention of hip displacement[3] and its sequelae[3]. These Hip Surveillance[1] Guidelines document the recommended process for screening, monitoring and triaging to orthopaedic services as part of the overall prevention of hip dislocation[3] (Kentish et al, 2011, Terjesen, 2012). 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 functional ability[5]. When to begin hip surveillance[1] depends on the child's age[6] and the frequency of ongoing hip surveillance[1] 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]. How MP[9] changes over time — or remains stable[10] — is more important than any one, single measurement of MP[9] (hence why we recommend repeated measurements at specific intervals).

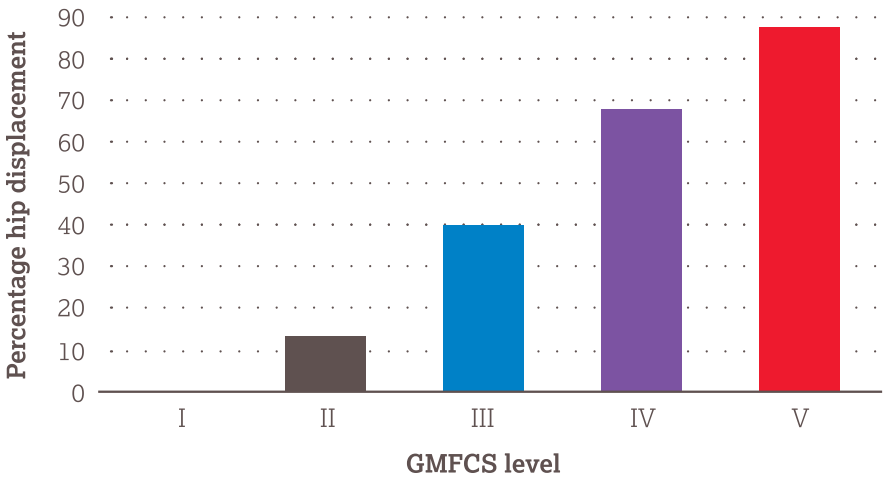


Figure 1: Hip displacement (migration percentage >30%) by GMFCS Level (Soo et al, 2006)

Annotations and References

1. Hip surveillance

Hip surveillance is the process of monitoring and identifying the critical early indicators of progressive hip displacement[3]. These early indicators include GMFCS[4], age[6], gait classification (WGH IV)[12] 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 displacement[3] of the hip while minimizing radiation exposure. Hip surveillance cannot be based on clinical assessment[8] alone.

Hip surveillance will assist identification of 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 until skeletal maturity[17] or discharge[14]. Hip surveillance should recommence: following the postoperative period for any child who has undergone surgery for hip management[32], following neurosurgical interventions[28] such as selective dorsal rhizotomy[28], or intrathecal baclofen[28], 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 and determination of GMFCS[4] are not yet confirmed[13].

A body of evidence supports the implementation of hip surveillance as an effective means towards prevention of hip dislocation[3]. A systematic review of the evidence for children with CP[2] (Gordon and Simkiss, 2006) identified six studies where results showed support for hip surveillance programs. All studies used radiological measures[7] to monitor hip displacement[3], with MP[9] (Reimers, 1980) most frequently used. The monitoring of MP[9] enabled identification of children for surgery at a younger age[6], thus reducing the need for later salvage surgery[32].

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.

In line with the decision made by the Surveillance of Cerebral Palsy in Europe (SCPE, 2000) and methodology adopted in 2003 by The Australian Cerebral Palsy Register Group, (Blair et al, 2007), for the purposes of this document any definition of CP is accepted that includes the following five key elements (Mutch et al, 1992):

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; and
4. This interference/lesion/abnormality is in the developing/immature brain
5. It is permanent but not unchanging

An international review of "The Definition and Classification of Cerebral Palsy" in 2006 defines 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*

This definition was annotated in an attempt to provide better clarification of the classification and description of CP. The definition is now widely accepted internationally.

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]. It is posited that the more clinically similar a child's condition is to CP, the more likely that these guidelines will be effective in identifying hips at risk.

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 or recognisable progressive brain disorders (Badawi et al, 1998), or from brain injury acquired in childhood within the first two to three years of life.

In the absence of natural history data for children with acquired brain injury, early and frequent surveillance[1] is recommended, as clinical experience indicates a high prevalence of hip displacement[3] in this group.

Motor disorders of spinal, peripheral nerve, muscular or mechanical origin are not considered like conditions.

Disorders of impaired cognition with no gross motor impairment are not considered like conditions.

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[9] is between 10% and 99%.

Hip dislocation

Is defined when the femoral head is completely displaced laterally out of the acetabulum (MP[9] = 100%).

The sequelae of progressive hip displacement

Are variable (Cornell, 1995). 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[25]. Problems with limited range of movement[21] and pain[25] can interfere with function[5], ability to be positioned, hygiene and personal care. In a large subset of children the progressive displacement can develop into 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[5] of children with CP[2]. 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.

The GMFCS classifies the gross motor function[5] of children and youth with CP[2] on the basis of their self-initiated movement with particular emphasis on sitting, walking, and wheeled mobility (Palisano et al, 1997, Palisano et al, 2007, Palisano et al, 2008).

The GMFCS has five levels for describing differences in severity of motor abilities[5]. 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[5] is dependent on age[6], separate descriptions are provided for several age[6] bands within each level. The age[6] ranges described are as follows: 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 children classified prior to six years of age[6] to be reclassified after six years of age[6] (Palisano et al, 2006) hence the need to confirm GMFCS level at each occasion of clinical presentation.

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 what the child can do (usual performance in home, school, and community settings), rather than what the child may be able to achieve at their best (capability). It is therefore important to classify current performance in gross motor function[5] 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.

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. Preterm or premature is defined as a gestational age less than 36 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[11]. For hip surveillance[1] the standard radiograph[11] required is an antero-posterior (AP) radiograph[11] of the pelvis (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].

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[1], clinical assessment should include both subjective and objective aspects of assessment to identify and document concerns, care and comfort, pain[25], any change in gross motor function[5] including gait[20] and assessment of the child's spine[18], pelvis[19] and lower limb musculoskeletal system[21]. The assessor should be able to classify the child's GMFCS[4] level and gait pattern if WGH IV[12].

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 2**).

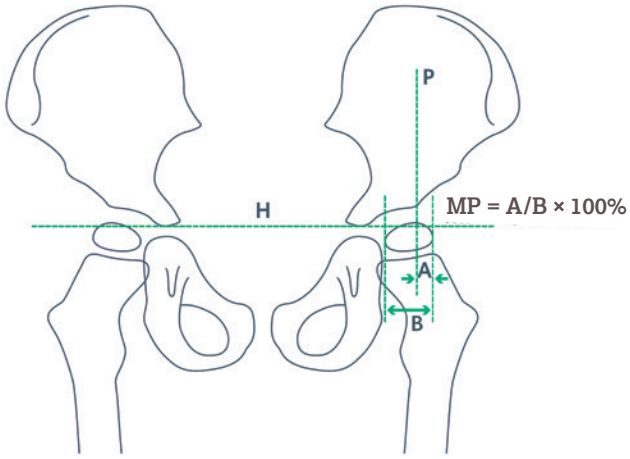


Figure 2 Migration Percentage (Reimers, 1980)

Migration percentage (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 2**).

MP = A/B X 100%

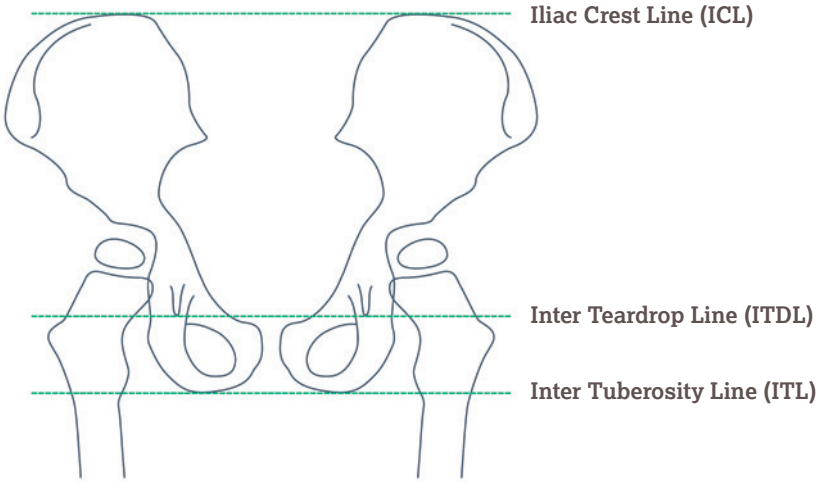


Figure 3 shows alternative placement options for H-line which can be used when the triradiate cartilage has closed.

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[6] at an average rate of about 5.5% per year. A change greater than 8% in repeated measurement by one experienced measurer is required to be 95% confident of true change (Parrott et al, 2002, Faraj et al, 2004). For the purpose of this document, stability of MP[9] is progression of not more than 10% in a twelve month period (Gordon and Simkiss 2006) over a period of two to three years.

An unstable MP[9] is when the progression is greater than or equal to 10% over a twelve month period.

11. Antero-posterior (AP) pelvic radiograph

An antero-posterior (AP) pelvic radiograph within certain positioning limits is required to enable MP[9] to be accurately measured. The MP[9], is to a large extent, dependent on the abduction or adduction of the leg, so the leg should be in neutral abduction/adduction (**Figure 4A**). Acceptable range of adduction/abduction is +/- 6°. The effect of rotation of the leg is small (when in the range of acceptable abduction/adduction). The MP[9] can be measured only if the Hilgenriener's line can be plotted accurately: i.e. the triradiate cartilages need to be clearly visible and the pelvis not in forward or backward pelvic tilt. This tilt needs to be corrected in children who have a fixed flexion deformity of the hip(s)[21] or a significant lumbar lordosis (Scrutton and Baird, 1997) (**Figure 4B**).

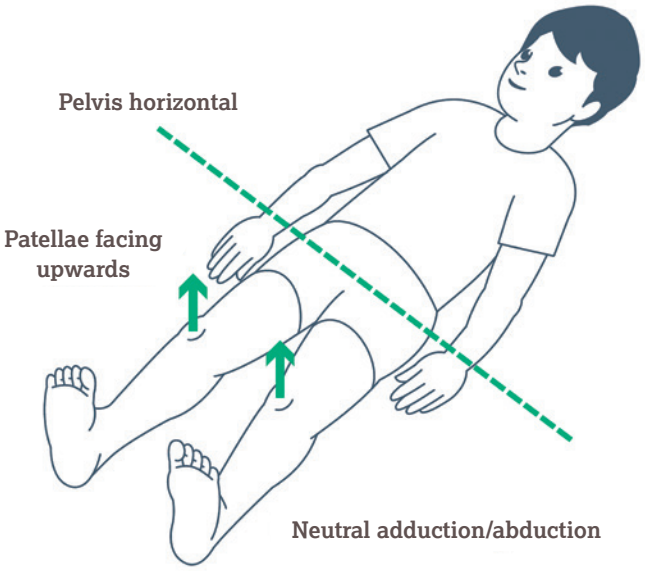


Figure 4A Positioning for AP pelvic radiograph

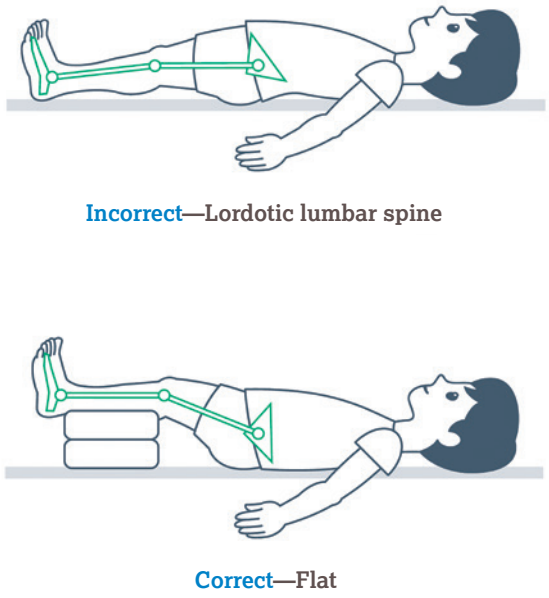


Figure 4B Positioning for AP pelvic radiograph

12. Winters, Gage and Hicks classification

Winters, Gage and Hicks (WGH) classification of hemiplegic gait[20] describes four types of gait[20] 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[20], normal dorsiflexion range in stance phase of gait[20]

Group II excessive plantarflexion of the ankle in both stance and swing phase of gait[20]

Group III Group II deviations as above plus limited flexion/extension range of motion at the knee during stance and swing phases of gait[20]

Group IV Group III deviations as above plus limited flexion/extension range of motion at the hip during stance and swing phases of gait[20]

This is represented diagrammatically in **Figure 8**.

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[20] deviations 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 at the hip level should also be considered in this group for the purposes of hip surveillance[1]. While this classification is based on three dimensional gait analysis kinematic data, visual observation of gait[20] and musculoskeletal measures[21] relating to the hip are sufficient for classification of WGH IV for the purpose of hip surveillance[1]. Children classified as WGH IV are those at risk of progressive hip displacement[3]. Children with WGH IV develop displacement[3] later than children with bilateral CP[2] and the hip MP[9] progresses slowly until puberty[16]. Presentation at puberty[16] may be characterised by pain[25], rapid increasing leg length discrepancy[19], apparent leg length discrepancy[19] and/or pelvic obliquity[19].

13. Confirmed GMFCS

For the purpose of this document, **confirmed is defined as the GMFCS[4]** level which best fits today's assessment. GMFCS[4] levels may not always be distinct or easily apparent, particularly for the younger child and between the higher levels (Palisano et al, 1997, Gorter et al, 2009). It is important to reassess for the correct GMFCS[4] level on each occasion of hip surveillance[1].

14. Discharge

Discharge is the cessation or release from continuing surveillance[1]. Children will most often be involved with other management programs including spasticity[23] management or orthopaedic gait[20], corrective surgery according to best practise and evidence based medicine. Gait[20] corrective surgery may simultaneously address displacement[3] of the femoral head whilst correcting other bony alignment.

15. Normal/abnormal migration percentage

A normal migration percentage (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[6] was 10%. For the purpose of these guidelines, normal MP[9] is less than 10% after the corrected age[6] of four years. A MP[9] above 30% is high and should be considered at risk/abnormal.

16. Puberty

Puberty can be recognised by a combination of growth acceleration, development of secondary sexual characteristics, chronological age[6] 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 13 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[6] and in CP[2] the percentage is even higher (Dimeglio, 2006). Delayed bone age is particularly common in severe CP[2] (GMFCS[4] IV and V) and it is probable that the pattern of skeletal maturation varies by GMFCS[4] level. Although hip displacement[3] may occur in children with CP[2] from early childhood, the pubertal growth spurt is a period of particular risk for both progression of existing hip displacement[3], the development of hip displacement[3] in previously stable[10] hips, as well as the development of pelvic obliquity[19] and scoliosis[18].

17. Skeletal maturity

There are a number of operational definitions of **skeletal maturity** from radiographic parameters which may be selected according to the patient population. One of the earliest is closure of the triradiate cartilage (Dimeglio, 2006) 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 5**).

The closure of the triradiate cartilage (Acheson, 1957) can be a useful marker if the radiograph[11] does not include the iliac crests. For adolescents who are GMFCS[4] I–III this may suffice. However, for adolescents at GMFCS[4] IV and V, the prevalence of scoliosis[18] and pelvic obliquity[19] is high and 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.

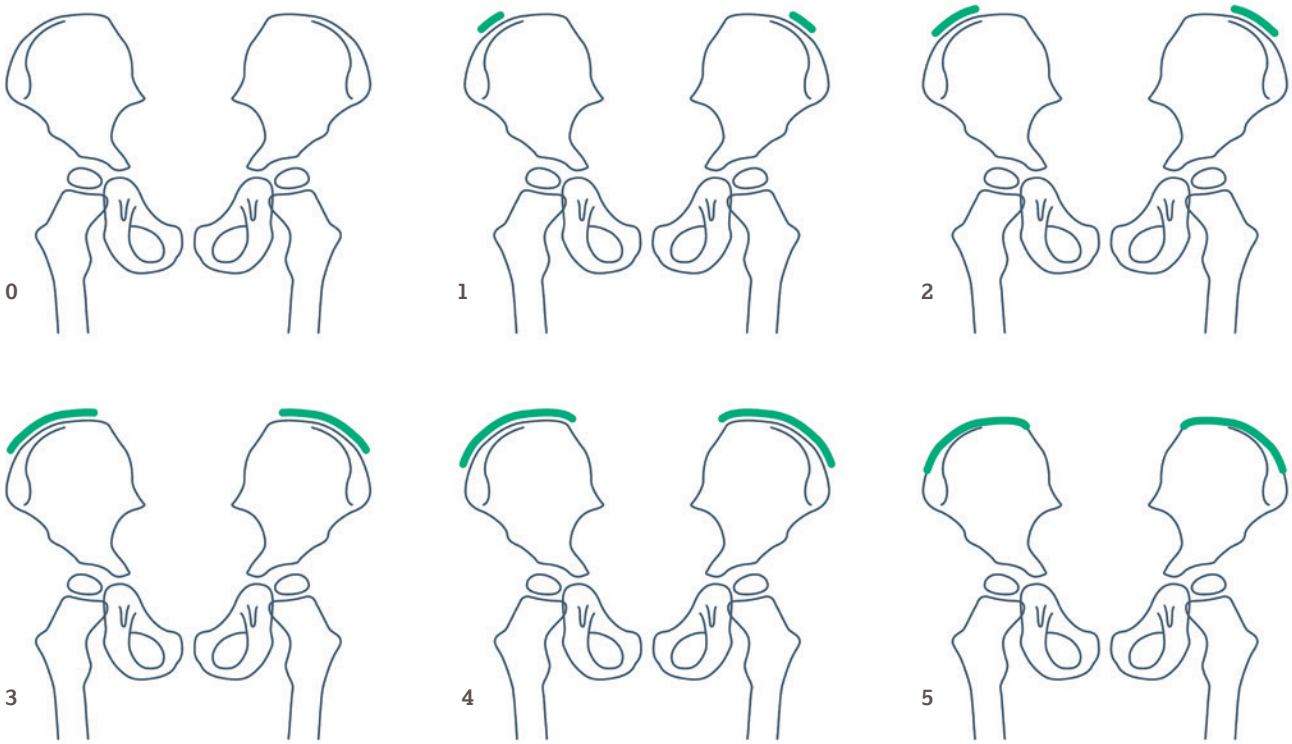


Figure 5 Risser's sign

18. 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[2] are related to the severity of involvement and are most common in GMFCS[4] IV and V (Miller, 2005). Initially the problems are postural but tend to progress rapidly and become fixed[24] during puberty[16].

Radiographic surveillance for spinal deformity should include antero-posterior[11] and lateral radiographs of the whole spine including the pelvis. These radiographs should be taken with the least amount of support required (i.e. standing independently for children and adolescents at GMFCS[4] I and II, standing with the usual support for children and adolescents who function[5] at GMFCS[4] III and sitting with support for children and adolescents who function[5] at GMFCS[4] IV and V). For some children and adolescents with severe fixed deformities, supine radiographs are sometimes the only feasible technique.

19. Pelvic obliquity, real and apparent leg length discrepancy

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[18]) or below the pelvis (leg length inequality, hip displacement/dislocation[3] or asymmetric contractures of the hip adductors or hip flexors[21]), or from a combination of suprapelvic and infrapelvic influences. The hip on the "high side" is uncovered (increased MP[9]) and the hip on the "low side" has more cover (decreased MP[9]). Obliquity may be the result of the child wiggling and not being able to lie still. Clinically important obliquity shows up on serial AP pelvic radiographs[11] with a consistent pattern — that is, 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. In skeletally mature children there are three other options, the inter-teardrop line (ITDl), the iliac crest line (ICL) or the inter-tuberosity line (ITL) (**Figure 6**).

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[21] of real and apparent leg length with interpretation of this information with radiographs of the pelvis and/or spine. Although unilateral hip subluxation[3] and dislocation[3] may result in a real leg length discrepancy, there is frequently a combination of real and apparent discrepancy.

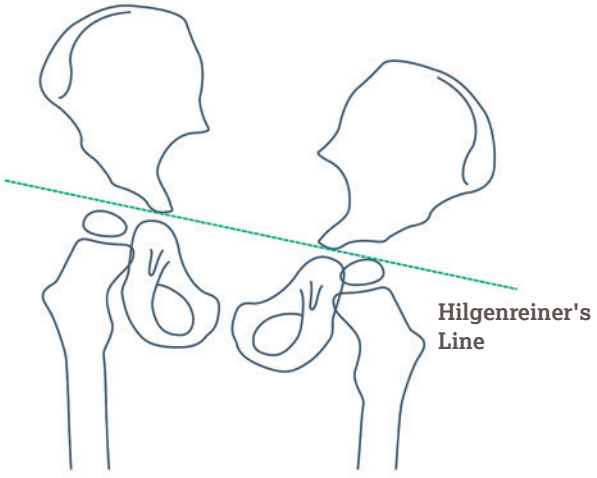


Figure 6A Prepuberty

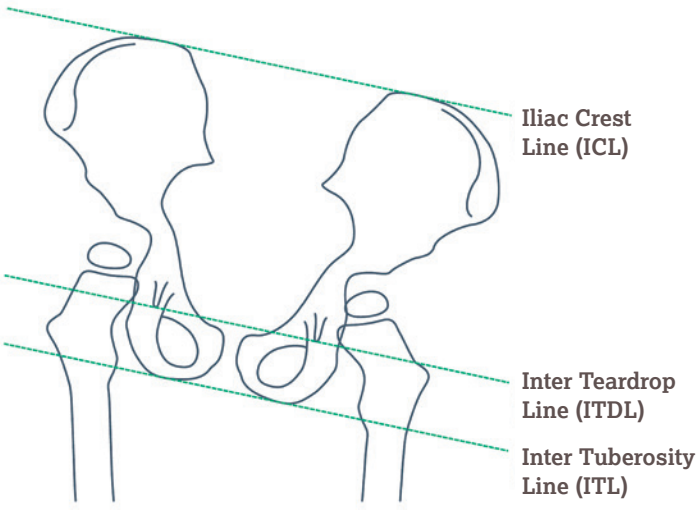


Figure 6A Pelvic obliquity

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[24] of the pelvis with retraction or pelvic obliquity[19], increased hip adduction[21] or internal rotation[21], changes or increased asymmetry[24] of step length. This is by no means inclusive of all possible gait deviations.

21. Musculoskeletal measures relating to the hip

Musculoskeletal measures relating to the hip should include assessment of the spine[18], pelvis[19], leg length discrepancy[19] and physical examination of the lower limbs including passive and dynamic range of movement (Boyd and Graham, 1999), muscle strength and measures of spasticity[23].

Assessment of musculoskeletal measures around the hip should 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
- Dynamic contracture as measured by Modified Tardieu Scale[23] (Boyd and Graham, 1999)
  - » Hip adductors
  - » Hamstrings
- Modified Ashworth Scale[23] (Bohannon and Smith, 1987)
  - » Hip adductors
  - » Hamstrings
  - » Hip flexors
- Functional mobility
  - » Functional Mobility Scale (FMS) (Graham et al, 2004)
- Assessment of pain[25] about the hip

22. Muscle tone

Muscle tone refers to the normal resting tension or the change in the resistance of the muscle to passive movement or muscle lengthening. It excludes resistance as a result of joint, ligament or skeletal properties such as those that may occur with fixed deformities, including contracture (Sanger et al, 2003). An abnormal increase in resistance to passive movement is termed hypertonia. Hypertonia may be the result of a number of factors, one of which is spasticity[23].

23. Spasticity

Spasticity is a disorder of the motor system characterised by a velocity dependent increase in muscle tone[22] with exaggerated tendon jerks, resulting from hyperexcitability of the stretch reflex. It is one component of the upper motor neuron syndrome, along with released flexor reflexes, weakness and loss of dexterity (Mayer, 2002). When spasticity is present, the resistance to externally imposed movement rises rapidly above a threshold speed or joint angle (Delgado and Albright 2003, Sanger et al, 2003). Spasticity does not worsen with age but its manifestation of movement such as the paucity of variety of movement, may result in worsening of secondary effects of spasticity e.g. contractures (Delgado and Albright, 2003).

The Modified Tardieu Scale (MTS) is a rating of spasticity that measures the intensity of muscle reaction at maximal velocity movement through range (Boyd and Graham, 1999). The quality of the muscle response is noted if there is a "catch" in motion and the angle at which the "catch" occurs is measured. The "catch" is sometimes referred to as R1, the first resistance to rapid passive movement. It is described as the clinical estimate of the threshold angle of spasticity (Boyd and Graham, 1999). A lowering of the "threshold" for R1 (i.e. an earlier "catch"), may be an indication that there is increasing spasticity. Spasticity can be graded using the Modified Ashworth Scale (MAS) (Bohannon and Smith, 1987).

24. 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[8] and/or radiologically[11] 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[18], pelvis[19] and/or limbs characterised by the lack or absence of symmetry which cannot be voluntarily or passively corrected. This can be assessed clinically and/or radiologically[11] 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 assessment[8], or is subjectively described by the patient/caregiver as having recently appeared.

25. 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[3] or dislocation[3]. In some cases pain may be clinically expressed in the knee or leg but be referred from the hip. The relationship between hip pain and displacement[3] or dislocation[3] remains elusive in children and adults. Chronic musculoskeletal pain is a complaint in up to 73% of children (Parkinson et al, 2010) and up to 67% of adults with CP[2] (Engel et al, 2003), most commonly in the low back, hip (Engel et al, 2003, Jahnsen et al, 2004, Opheim et al, 2009) and leg (Engel et al, 2003, Parkinson et al, 2013).

In non-ambulatory adolescents with CP[2] pain has been reported at rest, with certain positions, or with such movements as passive abduction[21] (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[8] for hip surveillance[1].

26. Other orthopaedic conditions

Other orthopaedic 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 or toxic synovitis, 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 tumors.

27. Individualised management plan

Individualised management plan is the adaptation of a standard management plan in response to individual clinical presentation and need. This management plan may include ongoing hip surveillance[1], altered frequency of surveillance[1] and/or intervention including surgical intervention[32].

28. Neurosurgical interventions

Neurosurgical interventions include those directed at the central nervous system to modulate spasticity[23] and movement disorders. Selective dorsal rhizotomy (SDR) is a neurosurgical procedure used in children with CP[2] to reduce spasticity[23] 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 only a portion of these are transected, leaving the others intact, thereby preserving sensory function and minimizing sphincter dysfunction (Grunt et al, 2013).

Continuous intrathecal Baclofen transfusion (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 spasticity[23] and abnormal posturing.

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

29. 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 et al, 1993).

Transition from hip surveillance[1] will occur at the point of discharge[14] from surveillance[1] or at the conclusion of paediatric services. Young people with CP[2] with a risk related to future pain[25] or progressive hip displacement[3] require advice, information and at times referral to adult services to ensure optimal hip health[31] in the future.

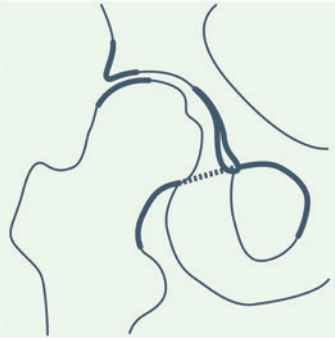
Classification of The Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS)[30] at skeletal maturity[17] is required to identify hips at risk of future progressive displacement[3], pain[25] associated with arthritic changes or dislocation[3]. The presentation of MCPHCS[30] III or IV in young people GMFCS[4] II or III and/or WGH IV[12], may benefit from counselling on the possibility of future interventions for optimizing hip health[31]. The presentation of MCPHCS[30] IV or V in young people with progressive scoliosis[18] and/or pelvic obliquity[19] requires ongoing hip surveillance[1] as hip dislocation[3] in this population remains an ongoing risk.

Summary documentation at transition, must include details of orthopaedic interventions[32] for the hip.

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

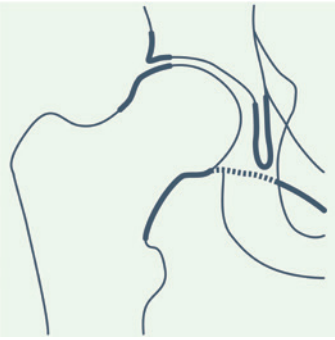
The Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS) (Robin et al, 2009) is a five level ordinal grading system, which was designed to describe hip morphology at skeletal maturity[17] for young people with CP[2] across all GMFCS[4] levels. The classification covers a wide range of radiographic features, from a Grade I (normal[15] hip), through to a Grade V (dislocated hip[3]). The classification includes sub-classifications for femoral head deformity, acetabular deformity and pelvic obliquity[19]. For detail of the sub-classifications refer to the published paper (Robin et al, 2009). A Grade VI was added to denote that the hip joint has been lost to some form of salvage surgery[32]. The utilization 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[2] at skeletal maturity[17]. The MCPHCS is valid, (based on the MP[9]) and has been shown to be reliable (Murnaghan et al, 2010).

Figure 7 Melbourne Cerebral Palsy Hip Classification Scale (Robin et al, 2009)



Grade I: 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 inverted lateral margin and normal teardrop development
4. Pelvic obliquity less than 10 degrees

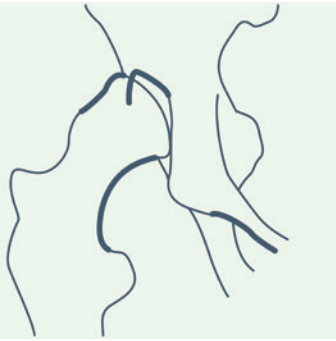


Grade II: Near Normal Hip – Migration Percentage –>10% –<15%

1. Shenton's arch intact
2. Femoral head round or almost round
3. Acetabulum: Normal or near normal development
4. Pelvic obliquity less than 10 degrees

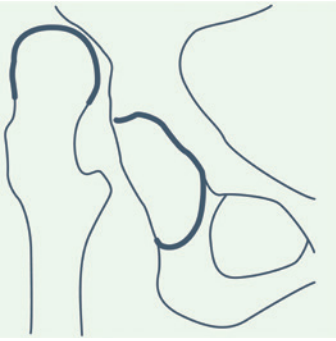
Grade III: Dysplastic Hip – Migration Percentage >15% –<30%

1. Shenton's arch intact or broken by less than or equal to 5mm
2. Femoral head round or mildly flattened
3. Acetabulum normal or mildly dysplastic including blunting of the acetabular margin and a widened teardrop
4. Pelvic obliquity less than 10 degrees



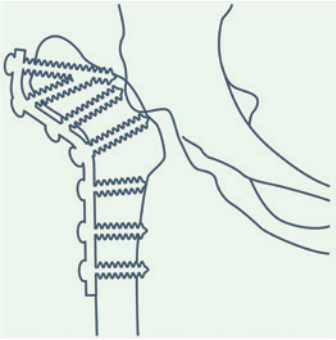
Grade IV: Subluxated Hip – Migration Percentage >30% <100%

1. Shenton's arch broken by more than 5mm
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable



Grade V: Dislocated Hip – Migration Percentage –>100%

1. Shenton's arch completely disrupted
2. Femoral head variable deformity
3. Acetabulum variable deformity
4. Pelvic obliquity variable



Grade VI: Salvage Surgery

1. Valgus osteotomy
2. Arthrodesis
3. Excision arthroplasty (Castle) ± valgus osteotomy (McHale)
4. Replacement arthroplasty

31. Hip health

A healthy hip should be a flexible, pain[25] free joint that does not limit function[5]. The femoral head should be well covered by the acetabulum.

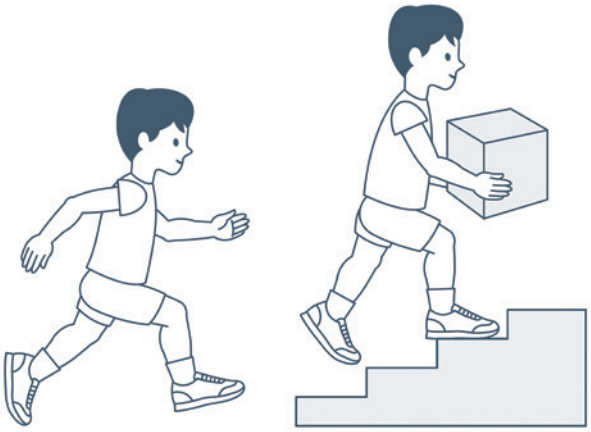
32. Orthopaedic interventions

Management options for the hip include both nonoperative and operative measures. Nonoperative interventions include postural systems, seating and standing systems and bracing. Orthopaedic surgical interventions include preventive, reconstructive and salvage surgery. These include both soft tissue and bony procedures. Discussion of surgical recommendations and management guidelines are beyond the scope of this document.

Guidelines

GMFCS I

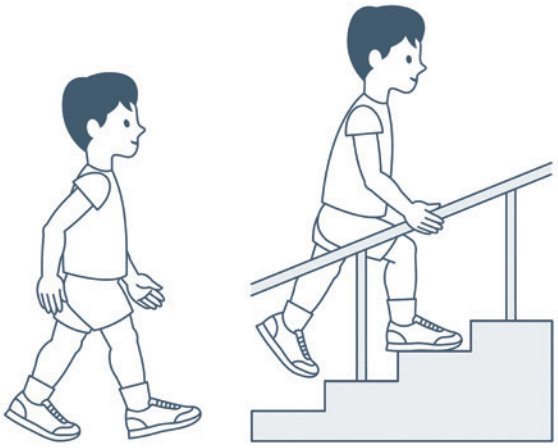
- Initial clinical assessment[8] and antero-posterior (AP) pelvic radiograph[11] at twelve to twenty-four months of age[6] (or at identification if older than twenty-four months)
- Review at three years of age[6]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] I is confirmed[13], repeat clinical assessment[8]. AP pelvic radiograph[11] is **NOT** required
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
  - » If identified as group IV hemiplegia as described by Winters, Gage and Hicks (WGH)[12], 1987 in **Figure 8**, ongoing surveillance[1] according to WGH IV[12] classification
- Review at five years of age[6]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] I is confirmed[13], repeat clinical assessment[8]. AP pelvic radiograph[11] is **NOT** required and if not showing other significant signs, discharge[14] from surveillance[1]
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
    - › If identified as WGH IV[12] hemiplegia (**Figure 8**), ongoing surveillance[1] according to WGH IV[12] classification



GMFCS I

GMFCS II

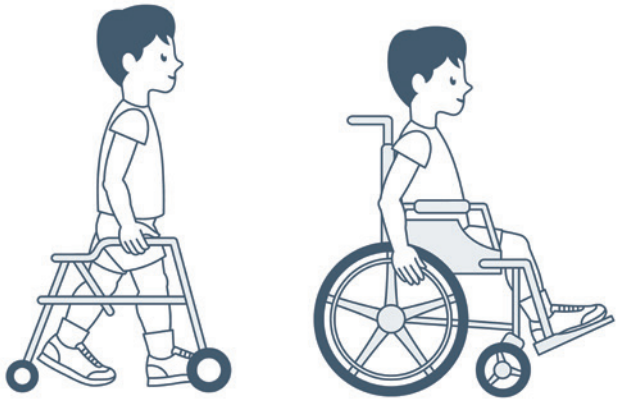
- Initial clinical assessment[8] and AP pelvic radiograph[11] at twelve to twenty-four months of age[6] (or at identification if older than twenty-four months)
- Review twelve months later
  - » Verify GMFCS[4] level
    - › If GMFCS[4] II confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
  - » If MP[9] is abnormal[15] and/or unstable[10], continue twelve monthly surveillance[1] until stability[10] is established
  - » When MP[9] is stable[10], review at four to five years of age[6]



GMFCS II

- Review at four to five years of age[6]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] level II confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS[4] level has changed, or if identified as WGH IV[12] hemiplegia (**Figure 8**), ongoing surveillance[1] according to confirmed[13] classification
  - » If MP[9] is stable[10], review at eight to ten years of age[6]
  - » If MP[9] is abnormal[15] and/or unstable[10], continue twelve monthly surveillance[1] until stability[10] is established
- Review at eight to ten years of age[6], prepuberty[16]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] II confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS[4] level has changed, or if identified as WGH IV[12] hemiplegia (**Figure 8**), ongoing surveillance[1] according to confirmed[13] classification[1]
  - » If MP[9] is stable[10], discharge[14] from surveillance[1]
  - » If MP[9] is abnormal[15] and/or unstable[10], continue twelve monthly surveillance[1] until stability[10] is established or skeletal maturity[17]
- In the presence of pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20], continue twelve monthly surveillance[1]

GMFCS III



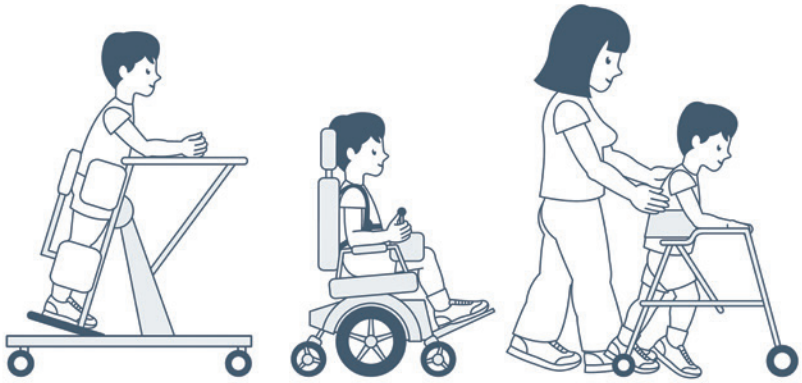
GMFCS III

- 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[4] III confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
  - » If MP[9] is abnormal[15] and/or unstable[10], continue six monthly surveillance[1] until MP[9] stability[10] is established
  - » When MP[9] is stable[10], reduce frequency to twelve monthly surveillance[1]
- Review at seven years of age[6]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] III confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
  - » If MP[9] is abnormal[15] and/or unstable[10], continue six monthly surveillance[1] until MP[9] stability[10] is established
  - » If MP[9] is stable[10], below 30%, and gross motor function[5] is stable, AP pelvic radiographs[11] may be discontinued until prepuberty[16]
  - » Twelve monthly AP pelvic radiographs[11] must resume prepuberty[16] and continue until skeletal maturity[17]
- At skeletal maturity[17], in the presence of pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20], continue twelve monthly surveillance[1]

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[4] IV confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › If GMFCS4 level has changed, ongoing surveillance[1] according to confirmed[13] classification
  - » If MP[9] is abnormal[15] and/or unstable[10], continue six monthly surveillance[1] until MP[9] stability[10] is established
  - » When MP[9] is stable[10], reduce frequency of surveillance[1] to twelve monthly
- Review at seven years of age[6]
  - » If MP[9] is stable[10], below 30% and gross motor function[5] is stable, surveillance[1] may be discontinued until prepuberty[16]
  - » Twelve monthly AP pelvic radiographs[11] must resume prepuberty[16] and continue until skeletal maturity[17]

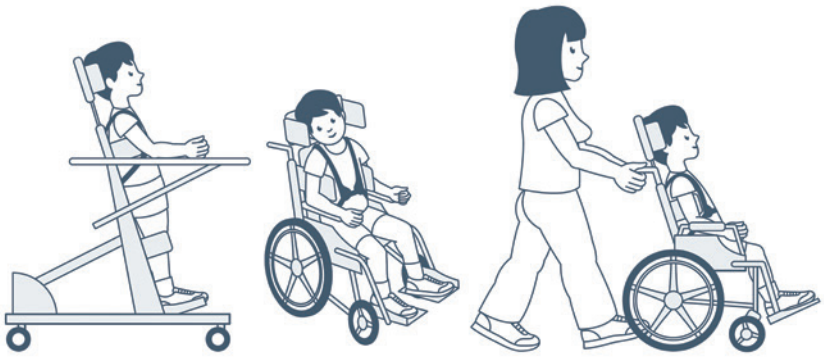
- Independent of MP[9], when clinical[8] and/or radiographic evidence of scoliosis[18] or pelvic obliquity[19] is present, six monthly surveillance[1] is required until skeletal maturity[17]
- At skeletal maturity[17], if MP[9] is abnormal[15] and progressive scoliosis[18] or significant pelvic obliquity[19] is present, continue twelve monthly surveillance[1]



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
- Repeat clinical assessment[8] and AP pelvic radiograph[11]
  - » Verify GMFCS[4] level
    - › If GMFCS[4] V confirmed[13], continue six monthly surveillance[1] until seven years of age[6] or until MP[9] stability[10] is established
    - › If GMFCS[4] level has changed, ongoing surveillance[1] according to confirmed[13] classification
- Review at seven years of age[6]
  - » If MP[9] is stable[10], below 30% and gross motor function[5] is stable, continue twelve monthly surveillance[1] until skeletal maturity[17]
- Independent of MP[9], when clinical[8] and/or radiographic evidence of scoliosis[18] or pelvic obliquity[19] is present, six monthly surveillance[1] is required until skeletal maturity[17]
- At skeletal maturity[17], if MP[9] is abnormal[15] and progressive scoliosis[18] or significant pelvic obliquity[19] is present, continue twelve monthly surveillance[1]



GMFCS V

Winters, Gage and Hicks hemiplegia group IV (WGH IV)[12]

WGH IV[12] gait[20] pattern clearly declares itself by four to five years of age[6].

The child with a classification of WGH IV[12] has the potential for late onset progressive hip displacement[3] regardless of GMFCS[4] level.

- Review at five years of age[6]
  - » Verify WGH[12] and GMFCS[4]
    - › If WGH I–III[12], ongoing hip surveillance[1] according to confirmed[13] GMFCS[4]
    - › If WGH IV[12] and MP[9] stable[10], review ten years of age[6]
  - » If MP[9] is abnormal[15] and/or unstable[10], continue twelve monthly surveillance[1] until MP[9] stability[10] established
- Review at ten years of age[6]
  - » Verify WGH IV[12]
    - › If WGH IV[12] confirmed[13], repeat clinical assessment[8] and AP pelvic radiograph[11]
    - › Continue twelve monthly surveillance[1] until skeletal maturity[17]
- At skeletal maturity[17] if significant scoliosis[18], pelvic obliquity[19], leg length discrepancy[19] or deteriorating gait[20], continue twelve monthly surveillance[1]

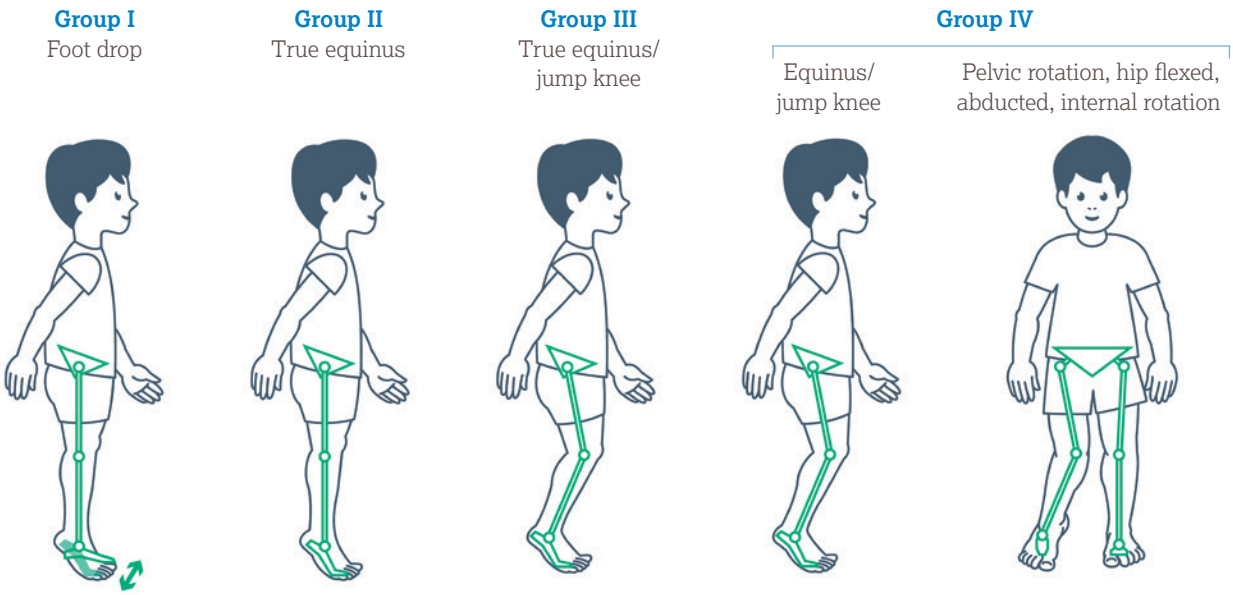


Figure 8 Gait patterns in hemiplegia (Winters, Gage and Hicks, 1987)

Increased frequency of hip surveillance will be required when:

- Deterioration in function[5] including altered gait[20], decreased ability or tolerance of sitting or standing
- Presence of scoliosis[18], pelvic obliquity[19], or significant leg length discrepancy[19]
- Deterioration in musculoskeletal measures[21] relating to the hip
  - » Change in muscle tone[22], including, but not limited to, increasing levels of spasticity[23]
  - » Reduced range of movement[21], reduced muscle length[21], development of, or increased asymmetry[24] of range of movement[21]
- Increased difficulty with perineal care/hygiene
- Onset of, or increase in pain[25] related to the hip

Referral to a pediatric orthopaedic surgeon should occur when:

- MP[9] is unstable[10] and/or progresses to greater than 30%
- There is pain[25] related to the hip
- Other orthopaedic conditions[26] are identified

The intention of hip surveillance[1] is that orthopaedic review[27] occurs at the appropriate time. Every child referred to orthopaedic services should be managed with an individual treatment plan[27] which may include ongoing hip surveillance[1].

Referral back to hip surveillance should occur following:

- The postoperative period for any child who has undergone surgery for hip management[27]
- An unplanned break in surveillance[1] for any other medical reason
- Neurosurgical interventions[28] such as selective dorsal rhizotomy[28], or intrathecal baclofen (ITB)[28]

Hip Surveillance after skeletal maturity and transition into adulthood

- As part of transition[29] the hip should be classified according to the Melbourne Cerebral Palsy Hip Classification Scale (MCPHCS)[30] (**Figure 7**)
  - » If MCPHCS[30] hip classification IV or V, refer for ongoing orthopaedic review[27]
  - » If MCPHCS[30] II or III advise regarding future hip health[31]
- Ongoing referral for orthopaedic review[27] should occur in the presence of pain[25], progressive scoliosis[18], significant pelvic obliquity[19] and/or deteriorating function[5]

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