ASSESSING GAIT IN CHILDREN WITH CP: WHAT TO DO WHEN YOU CAN’T USE A GAIT LAB

Robert M. Kay, MD
Vice Chief, Children’s Orthopaedic Center
Children’s Hospital Los Angeles

Professor of Orthopaedic Surgery
Keck-University of Southern California School of Medicine

Susan A. Rethlefsen, PT, DPT
Physical Therapist, IV
Children’s Hospital Los Angeles

I. Introduction and Overview
A. Natural history of motor function in CP
   a. First decade
      i. Typical significant ongoing improvements in all GMFCS levels up to age 6-8 years
      ii. Plateau common after age 6-8 years
   b. Second decade
      i. GMFCS I and II tend to be stable
      ii. GMFCS III, IV and V tend to deteriorate
B. When and in whom do you consider surgery? (1)
   a. Surgical decision
      i. NOT just based on contractures, malalignment and gait
      ii. Clinical history is critical – much is based on patient function, patient and family satisfaction and change over time
   b. Important questions for patient and family
      i. Are they satisfied with current status?
      ii. What are the main concerns?
   c. Typical criteria for surgical intervention
      i. Age 6 or 7-10 years
      ii. Child has plateaued for ~ 6 months
      iii. Non-operative intervention will not suffice
C. SEMLS vs. staged surgery?
   a. SEMLS (Gold standard)
      i. Maximizes alignment and biomechanics
      ii. One recuperation
      iii. Minimizes risk that uncorrected problems will exacerbate risk of recurrence and/or development of new deformities
iv. Less time off school for child and work for family

_N.B._ Do NOT operate on compensatory gait deviations!

E. Tools for assessment without a gait lab (including video)
   1. Static examination (As per below)
   2. Gait
      i. Barefoot and braced
      ii. May use video

II. Assessment
   A. Serial exams important
      a. Allows child to become familiar with examiners and comfortable in the environment
      b. There may be day to day variability in tone, ROM
      c. Consistent examiner if possible, or standardize methods
      d. Record measurements
   B. ROM
      a. Key measurements: Hip extension (Thomas test), hip abduction, popliteal angle, knee extension, dorsiflexion (knee flexed and extended, hindfoot inverted) (2)
      b. R1 vs. R2
         i. R1 – point of first catch, indicates spasticity, not contracture
         ii. R2 - measures fixed contracture
            1. May need slow, continuous stretch to reach R2
         iii. Crucial to measure R2, as this is what indicates need for Ortho surgery
         iv. May want to measure both, if tone management is a consideration
   C. Bony torsional measures
      a. Femoral anteversion (Trochanteric prominence angle test) (3)
      b. Tibial torsion (Bimalleolar angle, Thigh foot angle)
   D. Spasticity, selectivity, strength
   E. Videotaping
      a. Allows you to look in slo-mo and stop frame
      b. Allows you to view gait multiple times
      c. Provides documentation of pre-intervention gait (families and clinicians often forget what the child’s gait looked like preop)
      d. Important videotaping considerations
         i. Tape up clothing
         ii. Stickers on knees
         iii. Front and sides
         iv. Barefoot and braced
         v. With and without assistive devices
      e. Video playback software available online, upload videos from phone (can vary playback speed, take screen shots, draw angles, etc.)
         i. Coach’s Eye
         ii. Dartfish
         iii. Hudl
         iv. Kinovea (free)
F. Key components of gait to focus on:
   a. Stability in stance
      i. Hip/knee extension
      ii. Ankle dorsiflexion
      iii. Foot position
   b. Clearance in swing
      i. Hip flexion, ab/adduction in swing
      ii. Knee flexion in swing
      iii. Dorsiflexion in swing

III. Problems seen from the side (sagittal plane) during gait (1)

A. Hip flexion (with or without pelvic tilt)
   1. Visual gait assessment
      a. Things to look for include:
         i. Does the hip get into a trailing position
         ii. Is there anterior pelvic tilt/lumbar lordosis
   2. Physical exam (as above)
      a. Measure hip flexion contracture
   3. Radiographic tools
      a. No specific imaging
      b. Hip screening as per protocol
   4. Things we can take from the gait lab to the “real world”
      a. Visual observation tends to overestimate hip flexion during gait
      b. ~50% with CP and ≥10° HFC, do not exhibit excessive hip flexion during gait (4)
      c. Excessive hip flexion during gait often due to downstream (knee and foot/ankle) problems
   5. Treatment pearls
      a. Fractional lengthening to preserve hip flexor power
      b. May go from medial approach if also lengthening hip adductor

B. Crouch gait
   1. Visual gait assessment
      a. Check foot/ankle and hip position
      b. Toe walking in AFO’s?
      c. Look for lever arm dysfunction
   2. Physical exam (as above)
      a. Popliteal angle
      b. Knee flexion contracture
      c. Patella alta?
   3. Radiographic tools
      a. Only if considering osseous surgery
      b. AP and lateral knee x-rays
         i. Patella alta?
         ii. If considering anterior hemiepiphysiodesis, look for open growth plates

3
4. Things we can take from the gait lab to the “real world” (5)
   1. Calcaneal crouch – increased ankle dorsiflexion and hip flexion
   2. “Jump gait” – ankle in equinus from swing until stance, but gets to near normal by terminal stance
   3. “Apparent equinus” – ankle in neutral
5. Treatment pearls
   a. Medial lengthening suffices in most patients
   b. Genu recurvatum much more common if medial and lateral hamstring lengthening performed(6)
   c. Bony surgery (anterior hemiepiphysiodesis or distal femoral extension osteotomy) may be needed in adolescence and/or recurrent deformity go from medial approach if also lengthening hip adductor

C. Genu recurvatum
   1. Visual gait assessment
      a. Timing of recurvatum?
      b. Is this a plantarflexion/knee extension couple?
   2. Physical exam (as above)
      a. Popliteal angle
      b. Knee hyperextension?
      c. Hamstring weakness?
   3. Radiographic tools
      a. Not applicable
   4. Things we can take from the gait lab to the “real world”
      a. Recurvatum is a difficult problem
      b. Treat the equinus
      d. Distal rectus femoris transfer can sometimes help with recalcitrant recurvatum

D. Stiff-knee gait
   1. Visual gait assessment
      a. Foot clearance problems?
      b. Genu recurvatum in stance?
      c. Is gait velocity very slow?
   2. Physical exam (as above)
      a. Duncan-Ely (prone rectus) test (7)
   3. Radiographic tools
      a. Not applicable
   4. Things we can take from the gait lab to the “real world” (8)
      a. Distal rectus femoris transfer (DRFT) results better in patients with positive Duncan-Ely test
      b. Results best in GMFCS I and II
   5. Treatment pearls
      a. Semitendinosus is best recipient for DRFT
      b. Only do in GMFCS I and II
      c. Surgical pearls:
         i. Rectus is most easily separated from rest of quads proximally
      e. Free up rectus as far proximally as possible
E. Equinus
1. Visual gait assessment
   a. Timing/severity of equinus?
   b. Is it compensatory?
2. Physical exam (as above)
   a. Silfverskiöld test
   b. Start with hip/knee flexion to avoid extensor tone
   c. Check for cavus ("equinus" may be due to cavus rather than ankle equinus)
3. Radiographic tools
   a. Not applicable for equinus
      i. May use if concomitant foot deformity (Weight bearing AP/Lateral foot x-rays)
4. Things we can take from the gait lab to the “real world”
   a. Observers overestimate equinus on visual gait assessment
   b. Static “equinus” may stretch out during gait
   c. Many children with equinus will have decrease in equinus (and may even develop crouch) with age as they gain weight, even without heelcord surgery
5. Treatment pearls
   a. Heelcords are better too tight than too loose
   b. If heelcord lengthening needed, do a gastrocnemius recession whenever possible
   c. Calcaneal gait reported in 30-40% following Achilles lengthening
      i. Greatest risk of overlengthening is with percutaneous Achilles lengthening

IV. Problems seen from the front and back during gait (1)
A. Coronal plane
1. Issues seen during gait
   a. Varus and valgus at the hips, knees
      i. Visual gait assessment
         1. “Visual” valgus of knee
         2. Look for malrotation, hip adduction and knee flexion
      ii. Physical exam
         1. Intermalleolar distance for genu valgum
         2. Torsional profile if concerned with visual valgus
      iii. Radiographic tools
         1. Standing AP hip to ankle x-ray
      iv. Lessons to take from the gait lab to the “real world”
         1. Genu valgum is often overestimated due to internal hip rotation and knee flexion
         2. Genu valgum is not always associated with an abnormal coronal plane moment at the knee
3. Coxa valga is often overestimated on radiographs if the hip is externally rotated when the x-ray is taken

v. Treatment pearls
1. Coxa valga typically needs treatment to maintain hip alignment and integrity
   a. The amount of correction can only be determined x-rays done with good technique/positioning
2. Genu valgum/varum do not frequently require treatment in children with CP

b. Foot and ankle deformities (varus and valgus) (1)
   i. Pes varus
      1. Visual gait assessment
         a. Timing/severity of varus
         b. Varus of both hindfoot and forefoot?
      2. Physical exam
         a. Flexibility of varus deformity
         b. “Confusion test”
      3. Radiographic tools
         a. Weight bearing AP/Lateral foot x-rays can be obtained, but often not very helpful
     4. Lessons taken from the gait lab to the “real world”
        a. Causative muscles
           i. Anterior tibialis, posterior tibialis and combined anterior and posterior tibialis each account for about 1/3 of varus feet (9)
           b. Dynamic pedobaragraph data do not always correlate with visual assessment of deformity severity
      5. Treatment pearls
         a. Avoid whole tendon transfers of the anterior and posterior tibialis in CP
         b. I prefer tendon transfer to peroneus muscles (tertius or brevis) for 2 reasons
            i. No button complications
            ii. Tensioning of transfer is easier
   ii. Pes valgus
      1. Visual gait assessment
         a. Valgus foot with “too many toes”
         b. Foot progression angle typically more external than knee progression
         c. Pes valgus looks worse if genu valgum also present
      2. Physical exam
a. Check that lateral malleolus is distal to medial malleolus (if not, then worry about ankle valgus)
b. Flexibility of deformity (especially if midfoot break)
c. Thigh foot angle (both with foot corrected and uncorrected)

3. Radiographic tools
   a. Weight bearing AP/lateral foot x-rays

4. Lessons to take from the gait lab to the “real world”
   a. Make sure the deformity is pes valgus, rather than ankle valgus
   b. Dynamic pedobaragraph does not correlate perfectly with clinical assessment
   c. Pes valgus makes foot progression external
      i. It “masks” internal tibial torsion
      ii. It makes external tibial torsion look worse

5. Treatment pearls
   a. Treat ankle valgus, if present
   b. Calcaneal lengthening osteotomies seem to have a higher rate of late pes varus than do sliding osteotomies
   c. For severe midfoot break, consider talonavicular fusion
   d. After fixing the valgus hindfoot, assess the midfoot/forefoot for fixed supination deformity
   e. When doing foot and tibia corrections, fix the foot first and then reassess the tibia

B. Transverse plane (10)
   1. Intoeing/outtoeing
      a. Visual gait assessment
         i. Look at both foot progression angle and knee progression angle
            1. Internal knee progression angle means some problem above the knee (trunk, pelvis and/or hip)
            2. Internal foot progression angle could be at any level
         ii. Compare foot and knee progression angles
            1. If they are not the same, there is some malalignment below the knee
      b. Physical exam pearls
         i. Test hip rotation in extension
         ii. Do not exert force on foot when checking thigh-foot angle
         iii. I find thigh foot angle correlates better with the need for correction than does transmalleolar angle
      c. Radiographic tools
         i. I don’t find these necessary
ii. Some like to do rotational studies with CT, MRI or EOS
d. Lessons to take from the gait lab to the “real world”
i. 1/3 of those with CP and intoeing have 2 or more causes of
intoeing (rate is ½ for those with unilateral CP) (11)
   1. Always look for multiple causes of intoeing
   ii. Intoeing is rarely due to a varus foot in children with bilateral
   CP, but common in those with unilateral CP
e. Treatment pearls
   i. Femoral osteotomies
      1. Comparable results following proximal versus distal
         femoral osteotomies
      2. Distal osteotomies can be done if no significant coxa
         valga and hip displacement
      3. Correction
         a. Should be 1.5 – 2:1 deformity seen during gait
         b. Should have more external than internal hip
            rotation in OR after derotation
   ii. Tibial osteotomies
      1. Distal osteotomies are safest
      2. Correction
         a. Should be 1:1 deformity seen during gait
         b. Aim for thigh foot angle of 0-5° in OR

V. Case examples
   A. “Simple” patient assessment
   B. “Moderate” patient assessment
   C. “Complex” patient assessment

VI. Questions / Discussion
REFERENCES


