ORTHOPEDIC MANAGEMENT OF THE AMBULATORY CHILD WITH CEREBRAL PALSY

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DISCLAIMER

Neither speaker has any financial interest or conflict of interest related to this talk.
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OBJECTIVES

• Analyze the impact of common musculoskeletal impairments on the gait of children with cerebral palsy.
• Describe the clinical assessment of musculoskeletal impairments of the lower extremity.
• Describe common orthopedic surgical procedures for the lower extremity.
• Discuss the importance of consistent and intensive post-surgical rehabilitation and its contributions to the client’s outcomes.
Meet Our Stars

Jack
13yo, GMFCS II
Twin gestation, born at 30 weeks

Ed
14yo, GMFCS III
Born at 33 weeks, 4lb 8oz

Cerebral Palsy

• A movement disorder produced by injury to the immature brain.
  – Static encephalopathy
• 1 in 303 children in the United States (CDC)

Common Classifications

• Topographically
• Motor Manifestation
• GMFCS
• Etiology
GMFCS

Five gross motor curves that translate into levels representative of mobility.

Be Systematic and Consistent observational gait analysis

What works for me:
• Get the big picture: scan from top to bottom and make non-biomechanical observations
• Look in the sagittal plane, proximal ↔ distal
• Look in the frontal plane, proximal ↔ distal
• Look in the transverse plane, proximal ↔ distal

Let's Watch

Observations about Jack's gait.
Let's Watch

Observations about Ed's gait.

Instrumented Gait Analysis

- **GaitRite** – Spatiotemporal parameters of gait (stride length, % Stance, % Swing, foot progression etc.)
- **EMG** – Bi-lateral collection of Rectus Femoris, Semitendinosus, Tibialis Anterior, and Lateral Gastrocnemius
- **3-D Motion Capture** – Kinematic and Kinetic analysis (10 Motion Analysis Eagle cameras and 4 AMTI force platforms)

EMG

Temporal analysis of motor unit recruitment

Consistency of EMG bursts from one step to the next
**Clinical Assessment**

Allows for comparisons between static and dynamic measurements.

**Clinical Assessment: Jack**
Clinical Assessment: ED

Selective Voluntary Motor Control Assessment

Subjective assessment of patients ability to isolate lower extremity joints

Video allows for SVMC scoring by multiple clinicians

Output shows the score at each joint for a particular movement

Total score for each leg is provided for quick reference
Making Clinical Decisions

- Analysis of all information:
  - Clinical
    - Physicians, therapists
    - Gait analysis
  - Non-clinical
    - Family support
    - Family expectations and goals

“There is no orthopaedic problem in cerebral palsy that cannot be made worse by surgery.”
- Jim Gage
**What are the Options for Surgery**

- Lengthen muscles
  - Strayer gastrocnemius lengthening
- Shorten/tighten muscles
  - Patellar tendon advancement (after distal femur extension osteotomy)
- Transfer muscle insertions/origins to change their action
  - Rectus transfer
- Reduce spasticity
  - SDR/baclofen pump/Botox
- Correct lever arm dysfunction
  - Restore the levers – *FIX THE BONES*

**Anteversion**

- This is the “rule” in spastic diplegia
- They never stand erect enough to remodel their fetal anteversion
- Post-natal deformity from spastic internal rotators (anterior gluteals)
- Anteversion produces lever arm dysfunction at the hip and internal rotation gait at the knee
- “The greater trochanter is in their back-pocket” – Jim Gage

**Anteversion**

- Compensated by internal femur rotation and/or excessive pelvic lordosis (anterior pelvic tilt)
- When a child walks with the hips in flexion, the gluteus minimus acts as a hip flexor and internal rotator
- Lever arm dysfunction secondary to anteversion reduces the moment of the hip abductors
Anteversion

- Distorts normal hip moments
- Produces pseudo-adduction deformity
- Usually associated with external tibial torsion and/or pes valgus
- Easily corrected but usually ignored

Anteversion

- Intertrochanteric osteotomy – functionally lengthens psoas by medializing the shaft
- Blade plate allows stable fixation so that spica cast is not necessary
**Short Lever Arm**

- Subluxated hip and/or coxa valga
- Bilateral femoral osteotomy preserves leg length equality (this osteotomy shortens the femur)
- Varus rotational osteotomy restores lever lengths and corrects anteverision
- Weak hip abductors – lots and lots of strengthening post-op

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**Bilateral Varus Rotation Osteotomy**

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**Flexible Lever Arm**

- Remember the rubber crowbar trying to lift a stone...
- This is what happens in pes planovalgus
- The plantarflexors are weak and the ground reaction force is unable to generate an effective plantarflexion/knee-extension couple
**Pes Planovalgus**

- **Goals:**
  - Realign medial column and lengthen lateral column
  - This corrects forefoot varus and hindfoot valgus
- **Subtalar arthrodesis** (often done for pes planovalgus) does not correct the forefoot deformity

**Pes Planovalgus**

- **Corrections involves:**
  - Os calcis lengthening with tri-cortical allograft
  - Talo-navicular arthrodesis (in older) or talo-navicular joint capsular reefing (in younger, but stretches out over time)
  - +/- tibialis posterior tendon shortening
- Often associated with tight gastrocnemius and over-stretched soleus, so gastrocnemius recession is part of the corrective procedure.
**Pes Planovalgus**

- [Image of a foot withPes planovalgus](image)

**Positional Lever Arm Dysfunction**

- This is the most difficult of all...
- Multiple etiologies
  - Muscle contracture
  - Muscle weakness
  - All other types of lever arm dysfunction
- Solution to this problem leads into the solution to crouch gait...so we need to talk about crouch gait for a minute

**Crouch Gait**

- Once the plantarflexion/knee extension couple is lost, crouch will invariably progress
- Progression is most rapid during adolescence when their power to mass ratio falls rapidly
- I know of no way to get these kids upright without multiple lower extremity procedures
- It’s not the hamstrings!
**But what about the hamstrings?**

- Conventional popliteal angle measurement
- Modified popliteal angle measurement (corrects anterior pelvic tilt)

**Hamstring length vs excursion**

- Delp et al (1996), Hoffinger et al (1993), Thompson et al (2001), and Rhie et al (2013) have all shown that the majority of patients with cerebral palsy in crouch gait have hamstrings of adequate length.
- Crouch gait is due to inadequate hamstring excursion rather than inadequate length.
- Surgical lengthening of the hamstrings should not be undertaken on the basis of static clinical examination alone.

**When does crouch gait occur?**

- Usually just prior to or during adolescent growth spurt.
- Precipitating factors:
  - Lever arm dysfunction.
  - Weakening of plantarflexors and proximal muscles (core, gluteals).
    - Tendo-achilles lengthening.
    - Moro, beta, Galili pump.
  - Hinged AFO’s in kids with proximal weakness and loss of the PF/KE couple will induce crouch.
  - Laws of physics - power to mass ratio falls as we grow.
Remedy for Fixed Knee Flexion Contractures

- Distal femur extension osteotomy (if >25-30 deg or skeletally mature)
  - Patellar tendon advancement to correct patella alta
- Anterior distal femur hemiepiphyseodesis (guided growth; if <25 deg and skeletally immature)

Distal Femur Extension Osteotomy

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The anterior wedge of bone has been removed.

After the blade-plate is reduced to the femoral shaft, the knee is in full extension.

Patellar tendon redundancy is typically seen after the extension osteotomy and is contributed to by preoperative laxity of the quadriceps mechanism as well as shortening of the femur when the anterior wedge of bone is removed.
A T-shaped periosteal incision just distal to the tibial tubercle apophysis allows the elevation of medial and lateral periosteal flaps.

The patellar tendon is sharply divided from its attachment site, the cartilaginous apophysis.
Distal Femur Extension Osteotomy

Guided Growth
**Single Event Multiple Level Surgery**

- Simultaneous correction of multiple deformities
  - Perhaps should not do proximal and distal femur osteotomies at same time...too many moving parts!
- Understanding the role of lever-arm dysfunction
- Understanding the biomechanics of gait
- A team approach:
  - Surgeons
  - Pain management
  - Rehab/PT/OT
  - Orthotics

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**My Approach to the Problem...**

- Correct rotation of the femur and/or tibia
- Add distal femur anterior hemiepiphyseodesis if young and fixed knee flexion contractures present
- Correct the foot (bone and soft tissue)
- Address knee excursion issues by addressing hamstring and rectus spasticity/contraction
- Botox Rectus, HS, and Gastroc for post-op comfort and to facilitate therapy
- If too old for hemiepiphyseodesis, distal femur extension osteotomy done at time of HW removal a year later

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**Therapy Considerations**

- Casts removed and PT started approx 6 weeks post-op
- Ground reaction AFO (if can get knees straight) or solid ankle AFO
- Stages of recovery:
  - Healing: 6-8 weeks
  - Strengthening: 3-6 months
  - Re-learning: 12-18 months
  - It's a long road...
Post-Op Rehab and Bracing

- Stress ROM, strength, gait and balance training
- 2-3x/week for first 6 months, then weekly until gait plateaus
- A daily home program
- Recurrence of contractures and deformity must be treated promptly and vigorously

Outcomes/What Did We Learn?

Thank you!!

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REFERENCES