Management of knee flexion contractures in patients with Cerebral Palsy

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Outline

1. Introduction
2. Natural history
3. Pathophysiology
4. Gait
5. Treatment
6. Non-operative
7. Surgical
8. Guided- growth
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Introduction

• UK incidence rate - 1 in 400 births

• 1,800 children diagnosed every year

• 30,000 children with CP in the UK

• 1 : 3 children with CP unable to walk
Brain injury

“Primary Effects”

“Secondary Effects”

“Tertiary Effects”

- Loss of selective muscle control
- Abnormal muscle tone and strength
- Impaired sensation & balance
- Abnormal muscle & bone growth
- Adaptive mechanisms
KNEE

• most common problem - contracture of the hamstring muscles
• progression to fixed knee flexion contractures

• directly related:
  – spasticity
  – relative decreased growth rate of the length of the muscle fibers
Natural History – early childhood

- Hamstring contractures - in early childhood

- Sitting children: the inability to sit for long periods

- Walking children: toe walkers with relatively extended knees in the jump gait pattern
Natural History – late childhood

• Sitting more difficult except when the knees are flexed to 90° or more.
• Gait pattern - develop more knee flexion, walking on the toes (often with ankle equinus)
• Fixed flexion contractures develop
Natural History – adolescence

- Crouched gait pattern develops (knees more flexion, feet collapse, hip flexion)
- Fixed knee flexion contractures deteriorate
- Tend to be worse in children who do not stand and spend all day sitting in a wheelchair (GMFCS 4 & 5)
Pathophysiology

• Most knee flexor muscles are two-joint muscles
Pathophysiology

- Spasticity – abnormal stretch & inhibits growth
- Leads to muscle contractures
- Biarticular muscles – more affected
- Main flexors affected: semitendinosus, semimembranosus and long head of the biceps femoris
- Secondary: gracilis, gastrocnemius
Semitendinosus and semimembranosus have different configuration and fiber lengths.

- Allows the motor control system to use a wider length–tension curve
Primary Pathology

- Decreased motor control & spasticity
  - increases stiffness
  - shortens the joint ROM over which there is active control
- Semitendinosus (shorter fiber lengths) - the most contracted muscle
- Then semimembranosus and biceps
Secondary Pathology

• Hamstring develop contractures – prevent full extension
• Fixed flexion contracture develop (contracture of the posterior knee capsule)
• Children always lie in bed or sit in a chair with the knees flexed or stand in a knee-flexed position – capsule does not stretch
Tertiary Pathology

- Severe contractures (more than 30°) - secondary changes can develop in the knee joint with flattening of the femoral condyles.
- Tibia to start to hinge against the condyles rather than rotating around the arc of the condyles.
Evaluation

- Monitoring - popliteal angle used to measure hamstring contracture
- Normal popliteal angles - increase with age (less than 45° - 50°)
- Difference of 15° - 20° - real difference between different examinations.
Evaluation

- Fixed knee flexion contracture - greater accuracy (within 5°) with the goniometer
- Examination under anesthesia – differentiate spasticity and contracture
Evaluation

• Ambulatory patients – Instrumented Gait Analysis
• Hamstring spasticity and contracture measured with popliteal angle
• Popliteal angle - little correlation with knee flexion during gait
Normal Gait

Gait cycle

Stance phase

Weight acceptance | Single limb support | Double support | Single support | Double support | Single support | Limb advancement

Swing phase
Normal Gait

The image depicts a graph showing knee flexion over the gait cycle. The graph illustrates the movement of the knee during walking, distinguishing between the left and right sides. The phases of the gait cycle are divided into two main categories: stance phase and swing phase. In the stance phase, there is weight acceptance, double support, single limb support, and finally, limb advancement. The swing phase includes double support and single support, leading to single support as the leg is lifted forward.
Gait

• Prerequisites of normal gait:
  1. stance phase stability
  2. swing phase clearance
  3. foot preposition in terminal swing
  4. adequate step length
  5. energy conservation

• Primary function of the knee
  – allow limb length adjustment
  – provide stability in stance phase
Gait

- Hamstrings spasticity and knee flexion contractures
  - knee stiffness
  - excessive knee flexion
- Gait inefficient
  - posterior pelvic tilt
  - short step length
  - poor knee extension in late swing
  - crouch gait
Initial Contact

Knee flexed – shock absorption

At Initial Contact the knee is in about 5 degrees of flexion, and knee flexion is already underway. This is ideal for absorbing the “shock” of Loading Response.
Mid-stance

Knee starts extending

Knee Range of Motion during Mid Stance

Very early in Midstance flexion ceases and the knee begins extending. Thus during Midstance the knee is mostly extending, reaching a position of about 8 degrees of flexion, for a total excursion of about 12 degrees.

Motion = 12 deg extension
Terminal swing

Knee Range of Motion during Terminal Swing

During most of this phase the knee continues extending, reaching or almost reaching the neutral (0 deg) position. Then the motion is reversed and the knee begins flexing, so that at the end of Terminal Swing a position of about 5 degrees of flexion has been achieved.

Motion = 20 deg extension
5 deg flexion

knee extending in preparation for initial contact
Example

- 11 y/o boy, spastic diplegia, GMFCS I
- Tight hamstrings

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<th>Uni</th>
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Video
Kinematics

Knee Flex-Extension

Angle [deg]

Cycle [%]

Flex

Ext
Indications of treatment
Non-Walking patients

1. Prevent development of fixed contractures
2. Reduction of Pain
3. Improve sitting position
4. Allow standing transfers
5. Facilitate hygiene and care
Indications of treatment
Ambulatory patients

1. Prevent development of fixed contractures
2. Reduce Pain
3. Maintain/Improve gait efficiency & physical function
4. Improve gait appearance
Goals of treatment ambulatory patients

1. Improve Mobility: Walk longer distances
2. More physically active
3. Participation in sports/recreational activity
4. Improve the appearance of gait
5. Improve fitness & endurance: Less tired
6. Better stability / Less tripping / Fewer falls
Treatment

Orthopaedic Surgery
Orthotics
Physiotherapy
Spasticity Management
Non-operative

- Physiotherapy
- Orthotics
- Spasticity Management
  (Botulinum toxin, SDR)
Surgical Management

• Ambulatory vs Non-Ambulatory
• Treatment Goals
• Age
• Severity of contractures
• Appropriate surgical “dose”
Distal Hamstring Lengthening

• Medial Hamstrings – Rare lateral

• Fractional lengthening preferred

• Do not over-lengthen!

• Caution
  – may cause or exacerbate anterior pelvic tilt
  – recurvatum (back-kneeing)
Example

- Hamstring lengthening alone
- The knee more extended in stance but less flexion in swing (stiff knee gait)
Semitendinosus Transfer to the Adductor Tubercle

- Knee flexion in stance
- Contracture (5-20 degrees)
- GMFCS III - IV
Posterior knee capsulotomy

- Mild contractures
- Always with hamstrings and medial head gastrocnemius lengthening
Supracondylar Extension Osteotomy and Patellar Tendon Shortening

- Severe contractures
- Severe crouch gait with patella alta
Guided Growth

- Temporary & reversible epiphysiodesis allowing differential growth
- Extra-periosteal, non-locking plate, serves as a tension band
Guided Growth

• Indications:
  – Fixed knee flexion deformity (> 10 degrees)
  – 24 months or more predicted growth remaining

• The plates are applied outside the periosteum and the effects are reversible once removed

• Once the corrected - remove the proximal screw if the patient has growth remaining so reapplied if necessary in the future
• The plates - medial and lateral to the sulcus (intracapsular, but not articular) in order to avoid irritation of the patella.
Problems

• No long term studies
• Prominent (local bursitis) – dystonic or mixed movement disorder
• These symptoms abate as the legs gradually straighten
• Caution – patients crawl on knees
Advantages

- Early and full weight bearing
- Rapid return of knee motion
- Minimally invasive
- Advancement of the patellar tendon is usually not required
Surgical Technique
Surgical Technique
Example 1

• 13 y/o boy with spastic diplegia and knee flexion contractures
Example 2

- 14 y/o boy with spastic diplegia GMFCS II and stiff knee gait, frequent tripping
Pre-op Gait Analysis
Example 2

- Underwent SEMLS
  - Bilateral femoral derotation osteotomies
  - Bilateral patella pull downs
  - Medial hamstrings releases
  - Rectus femoris release
  - Bilateral gastro soleus recessions
Post-op Gait Analysis
Knee Flex-Extension

Knee Flex-Extension (deg)
Example 3

- 13 y/o boy with spastic diplegia GMFCS II with severe crouch
Pre-op Gait Analysis
• Underwent SEMLS
  – Bilateral distal femoral extension - derotation osteotomies
  – Bilateral patellar advancement
  – Bilateral supramalleolar derotation osteotomies
Post-op x-rays
Post-op Gait Analysis
Post-op Gait Analysis

Knee Flexion/Extension

Ext Deg Fix

0
25
50
75

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shaping futures
Summary

• Surgical treatment for knee flexion contractures requires:
  1. Thorough pre-op evaluation & planning
  2. Realistic goals and expectations
  3. Team approach
  4. Appropriate timing of surgery
  5. POST-OP REHAB
  6. Post-op evaluation of outcomes meaningful to patients and family
Thank You
Any Questions?
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