SURGICAL TREATMENT OF CEREBRAL PALSY

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THE PAST

Where were we then?
Causes of Poor Results

- Poor Understanding of the pathophysiology
  - Normal gait
  - Pathologic gait
- Multi-staged surgery
  - Visual observation (one-dimensional)
  - Static P/E
The Diving Syndrome

Staged correction of one muscle group at a time
Dr. Rang’s Birthday Syndrome

Childhood is a series of surgeries & recoveries.

Usually not smiling or walking by this time
Surgical Evaluation

- Physical examination
- Gait analysis
  - 2D Video session
  - 3D Kinematics & Kinetics
  - Dynamic EMG
  - Energy consumption
  - Muscle length
  - Various indices
  - Foot pressure
- Other evaluation
  - X-ray and CT
- EUA (exam under anesth.)
Gait analysis for ambulatory CP

- Elucidate problems of inter-linked joints
- Differentiate primary deformities from secondary compensation
- Evaluate Lever arm dysfunction
- Safely perform single stage multilevel surgery
Realistic Goal of Surgery

- **Ambulatory**
  - Better Function
  - Better Appearance

- **Non-ambulatory**
  - Pain
  - Facilitate care-giving
    - Hygiene
    - Posture
  - Mobility(?)
Pattern Recognition

Group I
True equinus

Group II
Jump gait

Group III
Apparent equinus

Group IV
Grouch gait

Group V
Asymmetric gait

Diplegia (Graham)
Pattern Recognition

Hemiplegia (Winters)

Group I
Drop foot

Group II
True equinus

Group III
Equinus/jump knee

Group IV
Equinus/jump knee/hip flexion

Hemiplegia (Winters)
Surgical Treatment of Foot & Ankle Deformities
Equinus

- **Ambulator**
  - Stance phase instability
  - Forefoot callosities
  - Ankle sprain
  - Knee flexion contracture
  - Knee hyperextension

- **Non-Ambulator**
  - Shoeing problems
  - Wheelchair footrest
Operative Methods

- **Technique**
  - Z-plasty
  - Strayer
    - Save soleus
    - Siverskiold
  - Baker’s Tongue in groove
  - Triple hemisection
  - Heel cord advancement

- **Goal**
  - Ankle DF 10° with knee extension
Iatrogenic Problem

- Over-lengthened Soleus
- Ignore Knee and Hip flexion contracture
- Ignore Lever arm dysfunction

Crouch gait
Varus

- Weight bearing instability
- Diminished stride length
- Inversion during swing
  - interfere foot clearance
- Pain
- Lever arm dysfunction
- Others
  - Shoe fitting
  - Shoe wear
  - Cosmesis
Varus

- TP spasticity- *hindfoot varus, stance phase*

- TA spasticity- *forefoot varus, swing phase*

- Peroneal underactivity (weakness)

- Transverse Plane Abnormalities
  - Severe femoral anteversion or internal tibial torsion
    - Cause roll over of the foot
    - Pseudovarus
Operative Methods

- **Forefoot varus**
  - Split transfer of TA
  - 1st metatarsal osteotomy
    - Metatarsus primus equinus

- **Hindfoot varus**
  - Split transfer of TP
  - Split transfer of TP & TA
  - Dwyer osteotomy
  - 1st metatarsal osteotomy

- **Severe equinovarus**
  - Triple osteotomy
  - Triple arthrodesis

Split transfer of TP

Triple osteotomy
(Quadruple osteotomy)
Planovalgus

- Stance phase instability
- Medial callosities
- Hallux valgus
- Shoe wear
- Pain
- Lever arm disease
Dorsiflexor

Invertor

Plantarflexor

Evertor

Muscle Actions

TA  EHL  EDL

FDL  FHL  SOL  GAS  PL  PB  TP
Planovalgus

- Valgus
  - PB spasticity
  - Achilles spasticity
  - TP weakness

- Transverse Plane Abnormality
  - External tibial torsion
Pathomechanism

- Equinus contracture + Peroneal spasticity

- Restriction of 2nd rocker -- Midfoot break
  --Dorsolateral sublux. of navicular
  --Lateral rotation of calcaneus
  --Talar head falling plantar-medially

- Relative or actual shortening of lateral column (calcaneus)
Calcaneal lengthening

- Modified Evans’ CL
  - TAL
  - PB lengthening
  - Save PL and CC joint

- Postop management
  - SL cast: 6 wks
  - Wt bearing: 7 wks
Surgical Treatment Around the Knee
Hamstring Contracture

- Crouch/Jump gait
  - Increased knee flexion at initial contact & terminal swing
  - Inadequate knee extension at terminal stance

- Pelvis tilted posteriorly
Hamstring Lengthening

- **Indications**
  - Excessive knee flexion at initial contact and during stance
  - Increased popliteal angle (true angle)

- **Procedure**
  - Gracilis: intramuscular or Z-plasty
  - Semitendinosus: intramuscular, Z-plasty, transfer to add. mag.
  - Semimembranosus: fascial lengthening
  - Biceps: fascial lengthening
Hamstring Lengthening:

- **Goal**
  - Politeal angle 15°
- **Hamstring shift**
  - Bilat. PA vs Uni. PA
- **Outcome**
  - Improved step length
  - Improved knee extension
Stiff Knee Gait

- Co-spasticity of rectus femoris and hamstrings
- Hamstring weakness in stance
- Knee muscular tightness
Stiff Knee Gait

- **Kinematics**
  - Inadequate knee flexion in swing
  - Delayed amount and rate of flexion

- **Dynamic EMG**
  - Abnormal firing of rectus femoris in swing phase
Rectus femoris transfer

- **Indications**
  - Decreased and/or delayed peak knee flexion in swing
  - EMG activity in swing phase
  - Duncan Ely test (+)
  - Associated hamstring lengthen.
- **Transfer site**
  - Gracilis
  - Sartorius
- **Outcome**
  - Improved knee motion in swing
  - Improved foot clearance
  - No rotation effect
  - Transfer >> Release
Crouch Gait

- Weak triceps
- Hip flexion contracture
- Hip extensor weakness
- Dynamic hamstring spasticity
- Hamstring tightness
- Extension moment of knee
Jump Gait

- Knee flexion
- Equinus(?)
- No evidence of extension moment
Treatment Principle  *(Gage 2005)*

- Correct all residual LAD
- Lengthen contracted muscles
  - Usually biarticular muscles
  - DHL, IMPL
- Correct fixed contracture
  - SCO
- Shorten elongated patellar tendon
  - Tuberosity advancement in mature patients
  - Patellar advancement
- Floor reaction type AFO
Patellar advancement

- **Technique**
  - Midline incision
  - Patella tendon plication
  - Wire reinforcement

- **Postop care**
  - Immobilization: 6 wks
  - Wire removal: 4 mns
  - AFO: until maturity
Surgical Treatment Around The Hip
Hip Flexion Contracture

- Hip flexor tightness
- Hip flexor spasticity
- Anterior pelvic tilt
- Crouch
Hip Flexion Contracture

- **Cause**
  - Psoas: major
  - Iliacus
  - Rectus femoris
  - Other anterior muscles
- **P/E:** lack of 15 - 20° full extension
  - Thomas test
  - Staheli's test
Operative Methods

- Nonambulator
  - Anterior release
    - TFL, RF, Psoas
    - Caution: hip extension contracture

- Ambulator
  - Iliopsoas Z-lengthening or Recession (Bleck)
    - weakness
    - Require protection
  - Intramuscular psoas lengthening over the pelvic brim
    - Preserve strength
    - No protection
  - Botox injection and stretching
    - Patient with significant weak flexor
Scissoring

- **Cause**
  - Adductor spasticity / contracture
  - Weak abductors
  - Pelvic obliquity
  - LLD
Operative Methods

- Adductor transfer to ischium
- Obturator nerve ant. br. neurectomy
  - Only for nonamulator
  - Abduction contracture
  - Wide abduction & E/R gait
- Adductor tenotomy
  - Percutaneous or Open, desired abduction > 40°
  - Indications
    - limited abduction in hip flexion
    - Hip subluxation
    - Loss of abduction following varus osteotomy
  - Proximal adductor longus tenotomy and distal gracilis tenotomy are sufficient for ambulator
Iatrogenic Problem

- **Cause**
  - Obturator neurectomy
  - Hip I/R mistaken for adductor contracture

- **Remedy**
  - SemiT to add. Mag.
  - RF to biceps
  - Correct femoral retroversion
Hip Instability: Paralytic Subluxation & Dislocation

- **Etiology**
  - Muscle imbalance around the hip
    - Adduc, Flx >> Abduc, Ext
  - Poor Posture
  - Lack of standing & walking
  - Primitive reflex pattern
Operative Methods

- Subluxation
  - FVDO
  - FVDO + PO
- Dislocation
  - FVDO + PO
  - OR + FVDO + PO
- Pelvic osteotomy
  - Post. Defect
  - Dega type osteotomy

OR(Capsulorrhaphy) + FO + PO
Dega Pelvic Osteotomy

- Cover all anterior, superior and posterior wall
- Increase Volume

Post-op 1 yr
Pathologic Gaits due to Torsional Problems
In-Toeing Gait

- Internal hip rotation (increased flexion antever.)
- Internal tibial torsion
- Posterior/anterior tibialis spasticity
- Foot drag
Torsional Problems

- Physical exam
  - Rotational Profile (Staheli 1985)
    - Foot progression angle
    - Medial rotation
    - Lateral rotation
    - Thigh-foot angle
    - Transmalleolar angle
  - Foot evaluation
- Image
Femoral anteversion

- G. Trochanter Palpation Method *(Ryder 1953, Ruwe 1992)*

- Procedure
  - Prone position
  - Palpate G. trochanter
  - External rotate limb until G. T. reaches most lateral
Computed Tomography

- Relatively accurate
- Need secure immob.
- Problem
  - Severe coxa valga
  - Cutting level
3D reconstruction CT

- Accurate
- Any position
- Problem
  - Radiation
Increased Femoral Anteversion

- **Unilateral**
  - Compensatory pelvic rotation
  - Hemiplegia

- **Bilateral**
  - Bilat. Intoeing
  - Diplegia, Quadriplegia
Femoral derotation osteotomy

- **Indication**
  - 20-30°: never
  - 30-40°: rarely
  - 40-50°: usually
  - 50-60°: almost always

- **Hemiplegia**
  - Do not overderotate

- **Diplegia and quadriplegia**
  - Do not underderotate
  - Goal 5-10° - controversy

- **Weight bearing**
  - 3 wks vs imme. POP
Tibial Torsion in CP

- **Causes**
  - Generally result from poor clearance

- **Problem**
  - Abnormal foot progression angle
  - Lever arm disease
    - Impaired plantar flexor moment arm
      - PF/KE couple
      - Push off
  - External > Internal in diplegia, quadriplegia

- **Correction for small tibial torsion (>15°)**
  - controversy
Operative Methods

- Supramalleolar osteotomy
Case
HISTORY

- F/5+6
- CP, spastic diplegia (essen. hemi, Rt.)
- Product of 32 wks GA., B.W.: 2.1kg.
- Incubator for 1 month
- Independent community ambulator
## Physical Examination

<table>
<thead>
<tr>
<th></th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anteversion</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td>Ely test</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Popliteal Angle</td>
<td></td>
<td></td>
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<tr>
<td>Unilateral</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>T. P.</td>
<td>Spastic</td>
<td>normal</td>
</tr>
<tr>
<td>Heel</td>
<td>Varus</td>
<td>neutral</td>
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Pre-operative Gait
Gait lab
Surgeries

- **Right side**
  - Intertrochanteric FDO
  - Distal hamstring lengthening
  - Z-plastic lengthening of Tendo-Achilles
  - TP split transfer to PB
  - Plantar fasciotomy
  - Foot medial release

- **Left side**
  - Intertrochanteric FDO
  - Distal hamstring lengthening
  - Foot medial release
Post-operative Gait
Join our team!!

- Neuromuscular ds.
- Foot and ankle.
- Deformity correction
- Pediatric orthopaedics
- Trauma

Thank you very much!!!
Results

- Not treated dynamic deformity, but treated static deformity.
- CP is a dynamic disease
Surgical Treatment

- Spastic type >> Athetoid type
- Rarely indicated for ataxic type

**Athetoid type**
- Fixed bony deformity
- Joint subluxation or dislocation
- Scoliosis

**Non-remedible problem**
- Selective motor control
- Balance
Surgical Evaluation

- Physical examination
- Gait analysis
  - Video
  - Kinematics & Kinetics
  - Dynamic EMG
  - Energy consumption
  - Muscle length
  - Various indices
  - Foot pressure
- Other evaluation
  - X-ray and CT
- EUA (exam under anesth.)
Gait analysis benefits:

- Allow study of multiple interlink joint levels
- Differentiate primary deformities from secondary compensation
- Safely perform MLEP (multiple lower extremity procedure)
Equinus

- **Kinematics**
  - Persistent PF
  - Loss of 1st rocker
  - Inversion of 2nd rocker
  - Knee extension in stance

- **Kinetics**
  - Double bump pattern
  - Loss of ankle dorsiflexion moment in initial stance
  - Knee flexion moment in stance
  - Decreased A2 power generation
Operative Methods

- Primary problems
  - TAL
  - PB lengthening

- Poor clearance of foot
  - Rectus femoris transfer

- Extra-articular subtalar arthrodesis
  - Green-Grice subtalar arthrodesis
  - Dennyson and Fulford method

- Calcaneal slinding osteotomy
- Calcaneal lengthening
Gait Disturbance

- Lever arm dysfunction
- Diminished plantarflexion-knee extension couple
- Pain in talonavicular joint
Equinus

- **Kinematics**
  - Persistent PF
  - Loss of 1st rocker
  - Inversion of 2nd rocker
  - Knee extension in stance

- **Kinetics**
  - Double bump pattern
  - Loss of ankle dorsiflexion moment in initial stance
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