SURGICAL TREATMENT OF SPASTIC CEREBRAL PALSY

Chin Youb Chung, M.D.

Department of Pediatric Orthopedic Surgery
Seoul National University Children's Hospital
Seoul National University Bundang Hospital
Cerebral Palsy

- Fixed, nonprogressive brain lesion(s)
  - No active disease at present

- Disorders
  - Primary
    - Musculoskeletal system
      - Lack of motor control
  - Others
    - MR, convulsion, sensory dist., speech impediments, defect of hearing, eyesight, etc.
Cerebral Palsy: Etiology

- Prenatal
- Natal
  - Prematurity
- Postnatal
Cerebral Palsy: Physiologic Classification

- Spastic type (50 - 75%)
- Dystonic type (25%)
  - Hypertonic or choreoathetoid
  - Athetoid
  - Rigidity
  - Tremor
- Ataxic type
- Mixed type
Cerebral Palsy: Geographic Classification

- Hemiplegia
  - One side of body
- Diplegia
  - L/E >> U/E
- Quadriplegia (Total body)
  - Both U/E, L/E, Trunk
- Others
  - Paraplegia
  - Triplegia
  - Monoplegia
Abnormalities Due to CNS Damage

- **Primary abnormalities**
  - Spasticity
  - Muscle imbalance
  - Poor equilibrium

- **Secondary abnormalities**
  - Muscle contracture
  - Joint deformity
  - Bony deformity
Muscle Growth

- Satellite cell: M-T junction
- Pre-requisite
  - Muscle stretching
Mechanisms of Muscle Contracture

- **Primary abnormalities**
  - Spasticity & Imbalance between agon./antago.
    - Strong agonist - no stretching - no growth
    - Weak antagonist - overstretching - overgrowth

- **Time & skeletal growth**

- **Muscle contracture**
SURGICAL TREATMENT OF CEREBRAL PALSY

THE PAST

Where were we then?
Causes of Poor Results

- Poor Understanding of the pathophysiology
- Poor understanding of normal gait
- Little understanding of pathologic gait
- Surgery by eye observation & static P/E
The Diving Syndrome

Staged correction of one muscle group at a time
Results of Surgical Treatment

- Long periods of immob. after each intervention
- Childhood is a series of surgeries & recoveries.

Happy Birthday!!! in the Hospital
Results

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

- Physical examination
- Gait analysis
  - Video
  - Kinematics & Kinetics
  - Dynamic EMG
  - Energy consumption
  - Muscle length simulation
  - 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)
Indications of Surgical Treatment

- Spastic type >> Athetoid type
- Rarely indicated for ataxic type
- Athetoid type
  - Fixed bony deformity
  - Joint subluxation or dislocation
  - Scoliosis
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
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

- **Technique**
  - Z-plasty
  - Strayer
    - Save soleus
    - Siverskiöld (+)
  - 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

\[\text{Crouch gait}\]
Varus

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

Invertor

Dorsiflexor

Evertor

Plantarflexor
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, TA  Triple osteotomy
Iatrogenic Problem

- Total transfer: reverse deformity
  - PB transfer – hindfoot varus
  - TP transfer – hindfoot valgus
  - PL transfer – dorsal bunion and forefoot supination
- TP to dorsum: should not be done

Split transfers are better
Planovalgus

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

Dorsiflexor

TA EHL EDL PT

Invertor

TP FDL FHL

Plantarflexor

SOL GAS PL PB

Evertor
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)
Gait Disturbance

- Lever arm dysfunction
- Diminished plantarflexion-knee extension couple
- Pain in talonavicular joint
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 sliding osteotomy
- Calcaneal lengthening
Calcaneal lengthening

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

- Postop management
  - SL cast : 6 wks
  - Wt bearing : 7 wks
X-ray Findings

Pre-op.

Post-op.
Surgical Treatment
Around The Knee
Crouch Gait

- Weak triceps
- Hip flexion contracture
- Hip extensor weakness
- Dynamic hamstring spasticity
- Hamstring tightness
Jump Gait

- Crouch gait + tip-toeing
- Triceps contracture
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
  - plasty
  - itendinosus: intramuscular, Z-plasty,
  - y, embranosus: fascial lengthening
  - s: fascial lengthening
Hamstring Lengthening:

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

- Over-lengthened hamstring
  - Need crutch
  - Intractable lordosis and back pain

- Remedy
  - No real remedy
  - Intramuscular psoas lengthening
  - Abdominal strengthening
  - Rectus femoris transfer
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
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

- **P/E**: lack of 15 - 20° full extension
  - Thomas test
  - Staheli's test
Hip Flexion Contracture

- **Kinematics**
  - Inadequate hip extension
  - Anterior pelvic tilt
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 postero-superior wall
- Increase Volume

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

- Internal hip rotation (increased. f. 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
Increased Femoral Anteversion

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

- **Bilateral**
  - Bilat. Intoeing
  - Diplegia, Quadriplegia
3D reconstruction CT

- Accurate
- Any position
- Problem
  - Radiation
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
Femoral derotation osototomy

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

- **Site**
  - Intertroch
  - Supracondylar

- **Medial hamstring lengthening**

- **Hemiplegia**
  - Do underderotate

- **Diplegia and quadriplegia**
  - Don’t underderotate
  - Goal 5-10° - controversy
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
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<th>Left</th>
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<tr>
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<td>60</td>
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<td>Popliteal Angle</td>
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<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
Thank you!
Thigh-Foot Angle

- Interanal tibial torsion: “-”
- External tibial torsion: ”+”
- Normal range
  - 0° ~ 20° (av. 10°)
- Caution!
  - Equinovarus
  - Planovalgus
Transmalleolar Angle

- **Normal range**
  - $0^\circ \sim 40^\circ$ (av. $20^\circ$)

- **TMA = TFA + 10^\circ**

- **More practical**
  - Foot deformity
Computed Tomography

- Relatively accurate
- Need secure immob.
- Problem
  - Severe coxa valga
  - Cutting level
Iatrogenic Problem

- Primum Non Nocere! (First Do No Harm) *(Hippocrates)*
- If you don’t know the gait pathology, don’t try to treat!

"It's time we face reality, my friends...we're not exactly rocket scientists."
Calcaneal lengthening

Preop

Postop
Dr. Rang’s Birthday Syndrome

Childhood is a series of surgeries & recoveries.

Usually not smiling or walking by this time
Cerebral Palsy: Incidence

- 0.6 - 7 / 1000 live birth
- Athetoid type
- Spastic type & Ataxic type
- Hemiplegia
- Diplegia or Quadriplegia
Split Transfer of T.P & T.A

T.P split transfer

T.A split transfer
Possible Current Approach to Varus (II): Severe equinovarus

Triple osteotomy
Triple arthrodesis