SURVIVAL RATE
- 1950-10%
- PRESENTLY 75% CAN EXPECT TO REACH EARLY ADULT YEARS
- HIGHEST MORTALITY – FIRST YEAR OF LIFE

INCIDENCE
- FROM 1983 TO 1990 4.6 PER 10,000
- GRADUAL DECREASE
- 2 MAIN FACTORS
  1. ABORTION
  2. FOLIC ACID
- AFTER FOLIC ACID MANDATE
  1.9 PER 10,000 LIVE BIRTH

INTRA UTERINE CLOSURE
DECREASE INCIDENCE OF SHUNT-50%
DECREASE INCIDENCE OF ARNOLD CHIARI MALFORMATION

SPINA BIFIDA CLINIC CMH
- 1970
  - NEUROSURGERY
  - ORTHOPEDIC SURGERY
  - OTOLARYNGOLOGY
  - ORTHOTICS
  - PHYSICAL THERAPY
  - PHYSICAL MEDICINE/HAB
- 1976-2012
  - SPINA BIFIDA CLINIC
- 1989
  - MOTION ANALYSIS CENTER

FMS
- FUNCTIONAL MOBILITY SCALE
- FMS
- ABILITY TO WALK 3 SPECIFIC DISTANCES
  5 / 50 / 500 meters

ORTHOPEDIC CARE
START AT BIRTH
- No Quadriceps
- RGO or Parapodium
- FMS 2/2/1
- Most will stop walking by 11 to 13 years of age
- Obesity is common
- Adult 99% wheel chair mobility (FMS 1/1/1)

Functional Mobility Scale (FMS)

ORTHOPAEDIC TREATMENT OF PATIENTS WITH MYELOMENINGOCOELE AND THE ROLE OF EARLY ADAPTIVE MOBILITY
Vineeta T. Swarup, MD
Lauren Rosen, PT MPT MSSMS ATP/SMS
Lauro Machado Neto, MD
Luciano Dias, MD

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Functional Mobility Scale (FMS)
**Low Lumbar Level**
- Hip Flexors: Strong
- Knee Extensor: Strong
- Medial Hams: Strong
- Gluteus Medius: 2 or less
- Gluteus Maximus: 2 or less
- Gastrosoleus: 0

**Low Lumbar**
- Walk with AFO and Crutches at an average walking velocity 60% of expected
- Young: FMS 333
- 90% retain walking ability as adult
- FMS: 2
- Gluteus med/max strength < 2

**Sacral Level**

**High Sacral**
- Weak Gluteus Medius and Maximus (2 or >)
- Gastrosoleus strength < 3
- AFO(solid)
- Gluteus Lurch
- FMS 5/5/5 or 5/5/3 or 6/6/6
- Walking velocity 75%
- 94% retain walking ability as adult

**Sacral Level**

**Low Sacral**
- Less than 5%
- Strong Gluteus medius and maximus >3
- Strong gastrosoleus 3 or >
  - Do not need AFO
  - May need SMO
  - No gluteus lurch
  - Normal gait
  - FMS 6/6/6

---

**Functional Comparison between Shunt and No Shunt Patients with Myelomeningocele**

<table>
<thead>
<tr>
<th>Gait Analysis Parameters</th>
<th>Linear Parameters</th>
<th>Velocity</th>
<th>Cadence</th>
<th>Stride Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Shunt</td>
<td></td>
<td>94.4</td>
<td>93</td>
<td>103</td>
</tr>
<tr>
<td>Shunt</td>
<td></td>
<td>76.4</td>
<td>86</td>
<td>88.4</td>
</tr>
</tbody>
</table>

Group 3
- P <.0001 VELOCITY
- P =.003 STRIDE LENGTH

**Conclusion**

The functional mobility of no shunt patients was found to be better in our FMS study population in relation of the linear gait parameters and Functional Mobility Scale – FMS. Neurosurgeons should be aware of these differences and develop strict guidelines to when insert a shunt.

**Another Study**

- THE NUMBER OF SHUNT REVISIONS DOES NOT AFFECT THE WALKING SPEED AND FMS
- SHUNT INFECTION HAS A MAJOR EFFECT ON MOBILITY: SPEED AND FMS

**Hydrocephalus**

- 1985
  - A Review of 200 Children Closed at CMH
    - 92% Shunt
  - 2010
    - 65%
    - "The best shunt is no shunt"
Energy Expenditure

- Reciprocal or Swing Through?
- Reciprocal mimics able bodied gait, but many choose to walk with swing through gait

4-POINT X SWING

- SWING- 33% FASTER
- SWING- 33% LOWER ENERGY COST

Effect of Crutches (used lightly)

Effect of Crutches on Knee

- Low Lumbar Level
- Trunk movement increases knee varus moment
- Crutches decrease trunk movement
- Crutches decrease internal knee varus moment

Other Effects of Crutches

- Pelvic rotation from 7x to 4x w crutches
  - DMCN, 1997

Peak Trunk Obliquity

- MRI WILL SHOW SIGNS OF TETHERING IN ALL PATIENTS
- MOST COMMON SIGN SCOLIOSIS(30%)
- EARLY DEVELOPMENT

High Sacral Level

- TO USE CRUTCHES FOR LONG DISTANCE TO BE INTRODUCED EARLY
- DECREASE THE ABNORMAL STRESS AT THE KNEE JOINT

Tethered Cord

- MRI WILL SHOW SIGNS OF TETHERING IN ALL PATIENTS
- MOST COMMON SIGN SCOLIOSIS(30%)
- EARLY DEVELOPMENT
CLINICAL SIGNS
- Loss in muscle strength
- Foot deformity
- Spasticity
- Gait change
- Early scoliosis (< 6 yo)
- Back pain at site of closure
- Urological changes

Tethered cord
- Surgery is done to prevent further loss of function
- MRI
- Always rule out shunt mal function
- Skillful neurosurgeon

GAT ANLYSIS
- The use of gait analysis in spina bifida patients
  - Low lumbar
  - SACRAL
- Major influence in the selection of functional surgical procedures

DEFORMITIES THAT CAN AFFECT FUNCTION
- Hip contractures
- Knee contractures
- Rotational deformities - femur/tibia
- Foot deformities

WHAT HAVE WE LEARNED?
- Knee valgus stress / knee pain
- Hip dislocation and gait
- Low lumbar level / sacral level
- Crouch gait / KFC
- Knee valgus stress / ETT

GAIT ANALYSIS
- Muscle weakness (gluteus) cause
- Excessive pelvic obliquity
- Excessive pelvic rotation
- Any surgery that affect the pelvic motion will make the gait more difficult

GAIT ANALYSIS
- Any surgery that decrease the strength of power generation muscles
  - Ileopsoas
  - Gluteus
  - Hamstrings
  - Will affect gait

NOT TO DO
- Example
  - Ileopsoas transfer
  - Sharrard procedure
  - Decrease in hip flexion power
- Spinal fusion to the sacrum in low lumbar and sacral level patients

Overview
- Overall care of children with MM changed substantially in past 30 years
  - Neurosurgery, urology, orthopaedics, rehabilitation, allied health
- Orthopaedics:
  - Shift away from goal of radiographic improvement
  - Focus on function
  - Advent of gait analysis in late 80s

9/4/2013
Overview
- Focus on function
  - Spasticity
  - Tethered cord
  - Poor balance
- Functional outcome measures
  - Motion analysis
  - Oxygen consumption
  - Patient-based outcome assessments (instead of radiographic measures)

WHO ICF: outline for assessing needs of children with MM
- Disease process: MM
- Abnormalities in structure/ function
  - Activity restrictions
    - Affects walking, sitting, etc.
  - Limit play, school, etc.

Better understanding of MM
Improved patient outcomes

WHO ICF

Obesity
- Many patients with spina bifida have higher percentages of body fat compared to age-matched normal children
  [Mitra et al. JAMA 1980]
- Prevalence of obesity in spina bifida ~40%
  - Reported rates 29%-74%
  
  [Mitra et al. JAMA 1980]

Obesity
- Goal: assess differences between long-term function of low-lumbar and sacral level patients
  - Assess gait function over time
  - Does BMI affect long-term function?
- 21 patients
  - 9 low-lumbar/ 12 sacral
  - CGA at least 5 years apart

Obesity

Initial
Final
86.9%
81.2%

Initial
Final
69.5%
64.9%

Acc to CDC, BMI > 85th % = overweight
BMI > 95th % = obese

Obesity
- Sacral level patients
  - Tendency to maintain or improve gait parameters over time
  - 72% showed overall ↑ in velocity
  - 83% showed ↑ or maintenance in stride length
- Low-lumbar level patients
  - More unpredictable results, some showed improvement, some showed decline in gait parameters
  - 43% showed overall ↑ in velocity
  - 83% showed ↑ or maintenance in stride length

Obesity

Our role as providers:
- Guide patients’ and families’ expectations regarding ambulatory prognosis according to lesion level
- Must appropriately counsel all patients with spine birth defects at an early age to help avoid obesity
- At each visit, review benefits of physical activity, adaptive sports programs, etc
- Start nutritional counseling early
- Importance of multi-disciplinary approach

BMI: Body Mass Index

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity

Obesity
Low bone density
- 11-30% patients with MM experience fracture
- 19% patients with a fracture
- Review of 482 patients
- 7 year study period
- Thoracic level patients = 6 higher risk than sacral
- DEXA, femoral-neck z scores differed significantly according to level of lesion
- Lower bone index in patients with higher level of lesion

Low bone density
- 24/37 (65%): z scores below 2 SD
- 29% had experienced a fracture
- Sample too small to correlate z scores with fracture
- DEXA scan useful in this population
- Nonambulatory patients more likely to have low bone density for age
- Recommendations: monitoring of BMD in patients with MM
- Identify patients who can benefit from directed bone health program:
  - Adequate calcium intake, maintaining vitamin D,
  - Weight-bearing program

Lower extremities and gait analysis
- Deformities that can affect function
  - Hip contractures
  - Knee contractures
  - Rotational deformities – femur/tibia
  - Foot deformities

Hip contractures: Etiology
- Muscle imbalance
  - E.g. low lumbar level, badda normal strength
  - Relatively greater strength in hip flexors/ adductors leads to hip deformity
  - Type severity of contracture depends on degree of muscle imbalance present
- Positioning
  - Especially in high levels of involvement – rely on wheelchair for mobility
- Spasticity
  - Tethered cord syndrome

Hip contractures
- Can affect function more than subluxation/ dislocation
- Untreated
  - Pelvic obliquity
  - Compensatory spinal deformity
- Gait analysis:
  - Unilateral hip flexion/ adduction contracture
  - Pelvic obliquity
  - Asymmetrical gait: compensatory scoliosis

Hip flexion contracture
- Most common in low lumbar level
- Rare in sacral level
- ↓ Velocity
- ↑ Upper extremity demand
- ↑ Anterior pelvic tilt

Hip flexion contracture: Treatment
- First 2 years of life: hip flexion deformity tends to decrease
  → Treatment rarely indicated in this group
- >2 years of age:
  - Specific treatment recommendations based on functional level of involvement

Treatment: Thoracic, High-Lumbar
- Flexion contracture < 30-40°
  - Often minimal if does not interfere w/ orthosis, use of ambulation
- Flexion contracture > 30-40°
  - If patient attempts to walk w/ RGO
    → Very short stride length
    → Increased lumbar lordosis
- Treatment indicated:
  - Facilitate use of orthosis for standing/ walking
  - Provide adequate ROM to sit comfortably in wheelchair/ lie supine in bed
Treatment: Ileofemoral approach
- Start with:
  - Tensor fascia lata
  - Sartorius
  - Rectus femoris
  - Iliopsoas
- If needed, anterior capsulotomy of hip joint

Treatment: Thoracic, High-Lumbar
- Very severe cases: contracture > 60°
- If pressure sores are a problem and soft tissue release alone is not enough:
  - Hip flexor lengthening +
  - Proximal femur extension osteotomy
  - AO blade plate for fixation

Hip flexion contractures can cause major functional impairment
- In patient who walks with AFOs + crutches
  - HFC > 20°
  - Can cause significant anterior pelvic tilt
  - Decreased walking velocity
  - Increased demand on upper extremities
  - Greater energy cost

Hip displacement
- Radical change in goals of treatment:
  - Previously, goal = anatomic location of hip joint
  - Dissection transfer, external oblique osteotomy, YOVO
  - Many studies have shown poor functional outcomes
  - Now, goal = maximum function, emphasis on gait!
    - A level pelvis and a good range of hip motion are more important for function than reduction of the hips. The goal of treatment should be maximum function, not radiographic reduction of the dislocated hips.” Feiwell, 1978

Motion analysis has now shown how correct Feiwell was
- 3D Motion analysis study: 20 patients (low-lumbar)
  - Examined influence of unilateral hip dislocation on gait
  - Community ambulators with solid AFOs + crutches
  - Patients divided into 2 groups:
    - No contracture / symmetric hip contracture
    - vs
    - Unilateral hip contracture
  - Pelvic and hip kinematics assessed to determine symmetry of motion between involved vs. non-involved side
  - Various gait parameters, pelvic motion

Treatment: Thoracic, High-Lumbar
- Hip flexion contractures can cause major functional impairment
- In patient who walks with AFOs + crutches
  - HFC > 20°
  - Can cause significant anterior pelvic tilt
  - Decreased walking velocity
  - Increased demand on upper extremities
  - Greater energy cost

Treatment: Low-Lumbar, Sacral
- Hip flexion contractures can cause major functional impairment
- In patient who walks with AFOs + crutches
  - HFC > 20°
  - Can cause significant anterior pelvic tilt
  - Decreased walking velocity
  - Increased demand on upper extremities
  - Greater energy cost

Hip adduction contracture
- Surgical treatment indicated:
  - When contracture interferes with function
    - Adductor longus and gracilis
    - Myotomy
  - Part of adductor brevis if needed
    - Protect obturator nerve
  - Goal = at least 60° abduction

Severe recalcitrant cases:
- Subtrochanteric valgus osteotomy of the proximal femur
  - May be necessary to achieve sufficient abduction to improve pelvic obliquity

GROUP I:
- Unilateral contracture
- 70% patients = symmetric gait pattern
- Vs
- 30% patients = asymmetric gait pattern

GROUP II:
- Bilateral contracture
- 20% patients = symmetric gait pattern
- Vs
- 80% patients = asymmetric gait pattern

No difference in stride length, cadence, walking velocity or LLD between groups
In both groups, walking speed = 60% of normal
Corresponds to velocity of low lumbar patients without hip dislocations
Hence, unilateral hip instability does not influence walking velocity

Conclusions:
- Gait symmetry corresponds to absence of hip contractures or bilateral symmetrical hip contractures
- NO RELATION to presence of hip dislocation
- Reduction of hip is unnecessary

Conclusions:
- Challenges efficacy of surgery to relocate hip
- Since hip instability in these patients has minimal effect on gait symmetry
- If contractures are causing gait asymmetry
  - Address contractures surgically (Treat the FUNCTIONAL deformity)
- Gait symmetry will likely be restored

In contrast to low lumbar patients who walk with crutches:
- In sacral level patient who walks with no support:
  - Hip instability can lead to lever arm dysfunction
  - Trunk – pelvic lurch due to loss of fulcrum
  - Pelvic obliquity
  - Gait asymmetry
  - Functional abductor strength can be compromised

Muscle weakness – gluteus
Tethered cord
We are finding more and more dislocated hips in these patients
- 5 patients in past 2 years
- Lodging at times in pre- and post-natal CA
Need for screening AP pelvis in sacral level patients?

Soft tissue lengthening
- Varus derotational osteotomy of proximal femur
- Closing wedge osteotomy
- Femoral shortening if needed
- Derotation if needed
- Goal = Neck shaft angle 110-120°, anteversion 10-20°
- Capsulotomy
- Anulusplasty

Low-lumbar level
- If contracture exists, causing asymmetrical gait:
  - Treatment with soft tissue release indicated to improve gait
  - No attempt should be made to reduce hip joint

Sacral level
- If dislocations present in a child who walks with no support:
  - Consider possibility of tethered cord
- Surgical indications indicated to correct lever arm dysfunction
- Soft tissue release, open reduction, VCRO, pelvic osteotomy

Less common than flexion contracture
- Often bilateral and present at birth
- Associated with hip dislocation, equinovarus
- Unopposed quadriceps weak hamstrings

Treatment:
- Serial casting program
- Goal = 90° flexion
- Initiate early
- Maintain ROM with bracing/physical therapy
- Surgical indications:
  - Persistent extension contracture interfering with gait, sitting, using wheelchair, performing activities
Knee extension contracture: surgical treatment

V-Y quadriceps lengthening
- At least 90° flexion at surgery
- Anterior oblique incision
- Extensor mechanism divided above patella with inverted V
- Anterior capsulotomy if needed
- Suture quadriceps in 45° flexion
- LLC at 45° flexion x 2-3 weeks then physical therapy

Quadriiceps plasty results
- Improvement in gait, sitting
- Parsch and Manner DMCN 1976
  - Very good results in 9/10 patients
- Dias JPO 1982
  - 13/15 patients maintained at least 90° flexion at 43 months f/u

KFC - etiology

Multifactorial:
- Positioning
- Underlying quadriceps weakness + prolonged time sitting
- Spasticity due to tethered cord
- Part of crouch gait:
  - Quadriceps weakness
  - Paralysis of gastrocnemius and soleus
  - Flexion at knee

Knee flexion contracture

- Non-ambulatory: does not have major impact on mobility or transfers
- Ambulatory: KFC leads to crouch gait
  - Crouch gait has high energy cost
  - More flexion = more oxygen cost = less gait efficiency
- Flexion > 20°
  - Interferes with orthotic fitting
  - E.g. High level patient who walks with RGO
  - Can prevent upright position, ambulation

Clinical exam vs gait

Mean, Dias JPO 2005:
- Compared KFC in clinical exam and during gait
  - Low lumbar and sacral level: KFC or AFO + crutches
  - KFC measure clinically and at 2 points in gait cycle
- Both groups:
  - Knee flexion in gait >>> degree of clinical KFC
  - Take into account when planning treatment!

KFC: Surgical Indications

- Non-ambulatory: interferes with sitting, standing to transfer or chair-to-bed transfer
- Ambulatory:
  - Low-lumbar or sacral level: KFC > 15-20°
  - Knee flexion at mid stance <30°
  - Pre-op GA important in the decision!
  - If GA not available: knee flexion during gait is 2x that seen in clinical exam
- Surgical treatment indicated for KFC > 15°

KFC: Surgical Treatment

- Radical knee flexor release
  - Selective lengthening of hamstrings
  - Release of gastrocnemius from femoral condyle
  - Posterior capsulectomy
- Etiology different than in CP
  - In MM, contracture of posterior knee capsule is most important
- Important to correct any HFC at same time!
Radical knee flexor release

- Transverse incision
  - 1 cm above posterior flexor crease
- Thoracic, high-lumbar:
  - All medial/lateral hamstrings tendons are divided and resected
- Low-lumbar, sacral:
  - Selective lengthening to preserve some flexor power

Radical knee flexor release

- Gastrocnemius origin released from medial/lateral femoral condyles
- Extensive capsulectomy
  - Leave PCL intact
- Wound closure with interrupted, non-absorbable suture
  - LLC with knee extended x 3 weeks
    - If cannot fully extend, do cast change at 1 week
    - Knee immobilizer at night + PT

KFC Treatment

If flexion deformity persists after release:

- <20° → Anterior hemiepiphysiodesis
- >20° → Supracondylar femur extension osteotomy

Anterior hemiepiphysiodesis

- Spiro et al. JPO 2010:
  - 10 spina bifida patients
  - Bilateral fixed KFC > 20°
  - Anterior femoral epiphysiodesis with staples
- Mean pre-op KFC: 20.3°
- Mean post-op KFC: 5.3°
- Correction rate = 0.9°/month
- Has also been described using "8-plates"

Supracondylar femur osteotomy

- Patients with >20° after surgical release
- Older patients who maintain ability for community ambulation but are limited by fixed KFC
- Fixed with AO blade plate
  - Technique: Stout, Novacheck, et al.

Radical knee flexor release: RESULTS

Moen, Swaroop, Dias et al. CORR 2011

- 20 knees: low-lumbar or high-sacral
- KFC > 15°
- All had dynamic gait analysis pre- and post-surgery

<table>
<thead>
<tr>
<th>Pre-op</th>
<th>Post-op</th>
</tr>
</thead>
<tbody>
<tr>
<td>KneeFDC</td>
<td>20°</td>
</tr>
<tr>
<td>KT at initial contact</td>
<td>20°</td>
</tr>
<tr>
<td>Minimum KT SLS</td>
<td>45°</td>
</tr>
<tr>
<td>Walking velocity</td>
<td>72%</td>
</tr>
</tbody>
</table>

Knee valgus stress

- Low-lumbar, sacral levels
- Likely to instability, pain, arthritis in adulthood
  - 50% community ambulators < 20 years of age
  - 24% had significant knee symptoms
- Weakness of hip abductors, gastrocnemius → characteristic gait pattern:
  - Abductor lurch
  - Knee in valgus/extension during stance
  - Swivel push-off on fixed pronated foot
  - ↑ Stress on knee ligaments
  - ↑ Stress on articular surfaces

Radical knee flexor release: RESULTS

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Knee valgus stress

- Internal hip rotation
- Lateral trunk motion
- Knee flexion

Gait analysis: improved understanding identification of multiple factors: "valgus stress"

- External tibial torsion
- Internal hip rotation
- Lateral trunk motion
- Knee flexion
Knee valgus stress: Treatment

- Correct rotational deformities
- Indicated in patients > 6 years
- Leads to significant improvement in knee stress and pain
- May prevent late degenerative changes
- Correct KFC, hindfoot valgus
- Encourage use of AFO + crutches
  - ↓ Pelvic obliquity/rotation
  - ↑ Stance-phase stability
  - ↓ Stress at knee joint

FOOT DEFORMITIES – 95%

- CLUBFOOT-1/3
- CALCANEVALGUS-1/3
- HINDFOOT-VALGUS
- ANKLE-VALGUS
- VERTICAL-TALUS
- CAVUS
- CAVOVARUS- LIPOMENINGOCELE
- VARUS
- SUPINATION
- ADDUCTION

CLUBFOOT - PONSETI

- TORONTO
- SAINT LOUIS
- PERSONAL EXPERIENCE
- 50% GOOD RESULTS
- NEED LONG FOLLOW UP
- REMEMBER THE DIFFERENCES

PONSETI

- MM
- AFO SPLINT INSTEAD OF THE PONSETI BAR
- NO ACTIVE DORSIFLEXION/ EVERSION
- TRY IT BUT ....

CLUBFOOT

- SX AT 10 TO 11 MS
- PRE-OP CASTING
- RADICAL PMRL
- TENDON RELEASE
- ANTERIOR TIBIAL TENDON

PMRL- RADICAL RELEASE

- CINCINNATI INCISION:
  - WIDE EXPOSURE
  - ACCESS TO ALL ANATOMICAL STRUCTURES
- EXTENSIVE PROCEDURE
- HIGHLY TECHNICAL
- DO BE DONE BY AN EXPERIENCE ORTHOPEDIC SURGEON

CLUBFOOT

- BEST RESULTS - LOW LUMBAR AND SACRAL LEVEL
  - 80%
  - HIGH LEVEL 50%
- RESIDUAL DEFORMITIES:
  - FOREFOOT - ADDUCTION (MOST FREQUENT)
  - HINDFOOT VARUS

ADDUCTION DEFORMITY

- MOST COMMON
- PROCEDURES
- CUBOIDEDEOISTOMY
- CUBOIDE/CUNEIFORM DEOISTOMY

TN AND CC JOINT NORMAL
AGE > 5 TO 6 yo

CUBOID DETECTION
WEDGE HOMOGRIFT
DOUBLE OSTEOTOMY – RESULTS = 90% GOOD
TALECTOMY
- SALVAGE PROCEDURE
- EXCELLENT RESULTS
- LATERAL COLUMN SHORTENING (closing wedge osteotomy cuboid)

SUPINATION DEFORMITY
- MUSCLE IMBALANCE INVERTORS & EVERTORS

CALCANEUS
- CALCANEovalgus
  - 30%
  - MUSCLE IMBALANCE
  - PROGRESSIVE
  - EARLY TREATMENT
  - ANTERIOR RELEASE
  - LATERAL COLUMN SHORTENING

ANTEROLATERAL RELEASE
- OUTPATIENT SURGERY
- SLC FOR 2 WEEKS
- AFO SPLINT
- NO PLACE FOR ANTERIOR TIBIAL TRANSFER

VARUS DEFORMITY
- Dwyer Osteotomy Os Calcis

ANTEROLATERAL RELEASE
- 90% GOOD RESULTS
- WHEN DONE EARLY THE VERTICAL POSITION OF THE CALCANEUS RETURN TO NORMAL
- 10% WILL DEVELOP AN EQUINUS DEFORMITY AND NEED A TENDO ACHILLES EXCISION

ANY FOREFOOT DEFORMITY MUST BE ADRESSED AT THE SAME TIME
- SUCH AS
- FOREFOOT ADDUCTION
- FOREFOOT SUPINATION
- ANY MUSCLE IMBALANCE MUST BE CORRECTED
VERTICAL TALUS - SURGICAL TREATMENT

- ONE STAGE PROCEDURE
- HINDFOOT
- MIDFOOT
- CINCINNATI INCISION

The surgery is very similar to the clubfoot surgery. The main difference is the rotation of the talus, dorsiflexion instead of internal rotation.

PMLR VERTICAL TALUS

- EXCELLENT RESULTS
- LONG TERM FOLLOW UP
- HIGHLY TECHNICAL SURGERY
- KODROS/DIAS JPO

NEW APPROACH IDIOPATHIC VERTICAL TALUS

- DOBBS
- 4 FEET
- GOOD RESULT

HINDFOOT VALGUS

- FREQUENTLY ASSOCIATED WITH EXTERNAL TIBIA TORSION
- COMMON TO DO
- MEDIAL SLIDING OSTEOTOMY
- DEROTATION OSTEOTOMY TIBIA

VALGUS DEFORMITY

- PROBLEMS
- PRESSURE SORE OVER THE MEDIAL MALLEOLUS
- VALGUS STRESS KNEE JOINT
- FOOT BECOMES UMBRACEABLE

KNEE VALGUS MOMENT

![Knee Valgus Moment Graph]

ANKLE VALGUS

- FIBULA GROWTH PATTERN
- GASTROSOLEUS STRENGTH
- PROGRESSIVE SHORTENING

ANKLE VALGUS TREATMENT

- MILD NO TREATMENT
- MODERATE HEMIEPiphysiodesis CANULATED SCREW
- 8 PLATE
- YOUNG <11 Y.O.
- SEVERE VARUS OSTEOTOMY (LUBICKY)

ANKLE VALGUS

- NOT TO DO
- TENDOACHILLES-FIBULA TENODESIS
- POOR RESULTS
- EQUINUS DEFORMITY
- STRETCHING OF THE TENDON
VARUS OSTEOTOMY DISTAL TIBIA
- LUBICKY J PO
- MEDIAL SLIDING OSTEOTOMY OS CALCIS
- NO SUBTALAR FUSION

HINDFOOT VALGUS
- MEDIAL SLIDING OSTEOTOMY
- EXCELLENT PROCEDURE
- PRESERVE SUBTALAR MOTION
- AFTER 3 WEEKS K WIRE REMOVAL
- WEIGHT BEARING
- TOTAL TIME IN CAST – 6 WEEKS

HINDFOOT VALGUS FOREFOOT ADDUCTION
- DOUBLE “C”
- MEDIAL SLIDING CANCANEUS
- OPEN WEDGE CUBOID

CAVUS FOOT HINDFOOT NORMAL FOREFOOT SX
SURGICAL TREATMENT
- MEDIAL PLANTAR RELEASE
- JONES PROCEDURE
- OSTEOTOMY MEDIAL CUNEIFORM
- OSTEOTOMY FIRST METATARSAL
- TENDON TRANSFER

CAVO VARUS
- RIGID
- MUSCLE IMBALANCE
- CONTRACTURES
- BONE PROCEDURES

CAVOVARUS RIGID
- SOFT TISSUE
- Calf LENGTHENING
- PLANTAR RELEASE
- POSTERIOR TIB LENGTHENING
- ANTERIOR TIB TRANSFER
- JONES TRANSFER
- HIBBS

FOOT DEFORMITIES
- TENDO EXCISION
- AVOID ARTHRODESIS
- TRIPLE/GRICE
- OSTEOTOMIES

FINAL GOAL = SUPPLE PLANTIGRADE BRACEABLE

TRIPLE C RIGID HINDFOOT VARUS CAVUS
- CALCANEUS
- CUBOID
- CUNEIFORM

Adult care
- Unique issues
- Challenges in access to appropriate care

Orthopaedic care:
- 46 patients with sacral level involvement
- 89% maintained community ambulation
- Guiding principles:
  - Aggressive treatment of tethered cord syndrome
  - Surgical correction of musculoskeletal deformities
  - Avoidance of arthrodesis at the foot

Selber, J PO Pediatr Orthop 1998
Adult care
- Cohort study: 84 patients
  - Mean age 31y
- 42% normal IQ, 58% had higher IQ
- 3% college degree
- 56% unemployed
- 38% lived independently
- 23% had been married – 9 normal offspring
- 31% thoraic – all used wheelchairs
- 45% lumbar – wheelchair part-time
- 24% sacral – all walked

Roach et al
Clin Orthop 2011

Adult care
- Cohort study: 84 patients
  - Mean age 31y
- 54% had experienced a pressure sore
  - 4 patients required major extremity amputations
- Spinal fusions protected sitting balance
- Hip surgery did not produce congruent hips
  - Occasionally led to debilitating stiffness

Roach et al
Clin Orthop 2011

Adult care
- Pressure sores:
  - 87 adult patients
  - 82% had pressure sore in past 5y
- Sores mostly located on feet in areas of impaired sensation
- Significantly higher risk for sores in patients with:
  - Memory deficit
  - Arnold-chiari
  - History of previous sores
- Patients at risk should be monitored closely and educated on program of skin inspection/care

Plaum et al
Cerebrospinal Fluid Res 2006

Orthotic Devices are used to maintain alignment, prevent deformities, and facilitate independent mobility.

Ambulatory outcome and choice of orthosis is dependent upon:
- Motor level ("functional level")
- Balance
- Upper extremity strength & control
- Orthopedic deformities
- Age, height, weight
- Motivation/cognition
- Spasticity/flaccidity
- Effectiveness of PT program
- Environmental factors

Orthotic Devices

EARLY ORTHOTIC MANAGEMENT:
Positional Arotric Foot Orthoses (PAFOs) for foot deformities

CALCANEUS:
- Equinus

TOTAL BODY SPLINT

Standing Frame
- Introduce at 11-15 months of age
- Requires head control and plantigrade feet
- Thoracic to high sacral level
- Used when child developmentally ready and showing interest in pulling to stand
- Use 2 to 3 hours/day, 20 to 30 minutes at time

Advantages
- Relatively inexpensive
- Allows for growth
- Easy to don and doff
- Facilitates initial upright weight bearing
- Allows hands free play in standing
- Promotes development of head and trunk control

Simple Wedge
To control Hip Abduction

Standing Frame

Advantages
Thoracic-high lumbar level Parapodium

- Used when patient has poor sitting balance
- Can use for standing or forward mobility

Reciprocating Gait Orthosis (RGO)

- Introduced around the age of 2
- Requires good sitting balance to sit without hand support
- Advantages:
  - Ambulation is more consistent with natural gait and more energy efficient compared to parapodium
  - Child does not need hip flexor power
  - Provides dynamic stretching to lower extremities
  - Some children can achieve hands-free standing balance

Isocentric Joint

- Simulates natural gait
  - Lateral weight shift
  - Extension of upper trunk
  - Hip extension occurs on stance leg
  - This leads to hip flexion and subsequent forward limb progression on the swing side

RGO

- If there is a knee flexion contracture of 10 degrees or more
- Thigh cuffs are needed

HKAFO

- Can lock hip joint to prevent hip flexion and excessive lordosis
- Start with walker and progress to crutches
- Reciprocal or swing to gait

HKAFO vs. RGO

- High lumbar lesion demonstrated no difference between HKAFO and RGO in respect to oxygen cost
- Thoracic level more energy efficient with RGO

KAFO

- Use if quadriceps are functionally 3/5 or less
- Use if there is instability of the knee in the coronal plane
- Knee joints may be free depending on sagittal plane stability

Solid Ankle AFO

- Requires functional quadriceps strength of 3/5 or better
- Prevents foot drop and allows foot clearance with weak or absent dorsiflexors
- Provides stability by controlling forward progression of the trunk with a weak or absent gastrosoleus

Advantages

- Facilitates upright alignment/mobility
- Protects ankle-foot complex
- Can affect knee alignment
- Facilitates developmental progression
- Eliminates or reduces knee flexion in stance
- Relatively low-profile orthotic device
Ground Reaction
AFO
-use for crouch control
-can use if knee flexion contractures are no greater than 5 degrees
-carbon reinforcement
-ankle plantarflexion
-requires gait practice

Twister Cables with AFOs
-for control of in-toeing or out-toeing

Advantages:
- Hip and knee joints are free in the sagittal plane

Disadvantages:
- Cables often damage clothes
- Frequent maintenance and replacement depending on child's level of activity
- Difficult to fit

Need to consider ankle/foot position and proximal lower extremity alignment when taking an AFO impression

THERATOG


- 40 patients with normal tibial torsion, 18 patients excessive external torsion (ETT)
- normal TT group significantly greater knee extension than ETT group
- TFA > 20° compromises the effectiveness of the AFO at the knee

The AFO and Tibial Torsion
- AFO improves knee kinematics and kinetics in patients with less than 20° external tibial torsion

The AFO & Tibial Torsion
- AFO improves knee kinematics and kinetics in patients with less than 20° external tibial torsion

Summary – Solid AFO
- Benefits of Solid AFO (properly aligned at 90°)
  - Stabilizes ankle & hindfoot
  - Compensates for weak plantarflexors in stance
  - Compensates for weak dorsiflexors in swing
  - Improves foot progression
  - Improves quadriceps activity
  - Improves knee extension