Lower and Upper Limb Orthotic Devices

Heikki Uustal, M.D.
Medical Director,
Prosthetic/Orthotic Team
JFK - Johnson Rehab Institute

Lower Limb Orthotic Goals
- Stabilize weak or paralyzed segments
- Support damaged or diseased joints or segments
- Unload distal segments
- Control abnormal or spastic movements
- Limit or augment motion across joints

Orthotic Issues to Consider
- Biomechanics of the device (3-point control across a joint)
- Durability of the materials
- Tissue tolerance to pressure
Lower Limb Orthotic RX

Goal = Functional Ambulation

Primary Factors:
- Trunk Control
- Weight Shift
- Advance The Leg

Concerns:
- Apraxia
- Tone
- Ataxia
- Sensation
- Neglect
- Edema

Ortho Shoe Parts
AFO
Ankle Foot Orthosis

- Metal
- Plastic
- Carbon
- Hybrid

Components of a Metal AFO

- Calf band
- Uprights
- Ankle joints
- Stirrup (solid or split with caliper box)
- Additional shank if needed
- T-strap if needed
- Shoe (preferably leather sole)
Stirrup Attachment to Shoe (solid or split stirrup)

Single Channel Ankle Joint (common names)
- Single Channel
- Posterior Channel
- Klenzak
- Dorsi-assist
- Single Adjustable

Single Channel Ankle Joint
DF assist       PF stop
Single Channel Ankle Joint
(DF assist and PF stop)

Dual Channel Ankle Joint
(common names)
- Dual channel
- Bi-cal
- Double adjustable

Dual Channel Ankle Joint
DF assist and PF stop
Dual Channel Ankle Joint
DF assist/stop       DF/PF stop

Dual Channel Ankle Joint video
(posterior spring, anterior pin)

Plastic AFO Trimlines
- PLS (posterior leaf spring)
- JBM (just behind malleolus)
- Mid-malleolar
- Anterior malleolar
- Bi-valve shell
Plastic AFO Trimlines

Plastic AFO with 3 point inversion control

Hinged Plastic AFO with pre-flexed Tamarack joint
**Off-loading AFOs**
- Total contact devices for plantar ulcers or Charcot Joint
- Off-load 30-50% plantar surface
- Patellar-tendon-bearing devices with bi-valve shell
- Calf-corset design devices with lace or velcro closure

**Total Contact Orthoses**
(Crow walker, Cam walker)

**PTB Orthoses**
- Bi-valve
- Calf-corset
Arizona style brace

Ground Reaction Orthosis

Peroneal Nerve Injury

Findings - Flaccid footdrop
Dorsiflexor and evertor weakness
Mild sensory loss dorsum of foot
Normal tone; no edema
Orthosis - Plastic "PLS" design AFO
¾ footplate, 5º DF
**Flaccid Footdrop**

**Footdrop with AFO**

**Polio Involving Foot/Ankle Only**

Findings - Flaccid footdrop
- Poor medio-lateral control
- Marked muscle atrophy
- Sensation intact, no edema
- Small foot, shortened limb

Orthosis - Double metal upright design AFO
- Posterior channel ankle joints
- Custom orthopedic shoe with lift
Charcot Foot with Neuropathy

Findings - Weakness in DF/PF/inver/ever
- Sensation absent
- Bony destruction of midfoot
- ROM limited

Orthosis - Patellar-Tendon-Bearing-Orthosis (PTBO)
- Calf-corset design or Bivalve Plastic
- Dual channel ankle joint
- Custom orthopedic shoe with insert

Charcot Foot
Charcot-Marie-Tooth Disease

Findings - Absent DF/PF/inver/ever
- Sensation intact
- Muscle atrophy
- ROM normal, no edema
Orthosis - Plastic AFO, mid-malleolar trim
- ¾ footplate, 3-5° DF

CVA with Hemiplegia

Findings - DF weakness, M-L instability
- PF and inversion increased tone
- Protective sensation
- Controlled edema
- ROM to neutral only
Orthosis - Plastic AFO, mid-malleolar trim
- Full footplate, 0° DF
- 3-point inversion control

CVA with spastic hemiplegia

CVA with spastic hemiplegia
CVA With Hemiplegia

Findings -  DF weakness, M-L instability
          PF and inversion tone
          Sensation absent
          Fluctuating edema

Orthosis -  Double upright metal AFO
          Posterior channel ankle joint
          Lateral T-strap
          Orthopedic extra-depth shoe with insert

Traumatic Brain Injury

Findings -  Marked spasticity and extensor tone
          Weakness DF/PF/inver/ever
          Sensation intact
          No edema
          ROM to 3º DF with vigorous stretch

Orthosis -  Plastic AFO, ant. malleolar trim
          Full footplate, tone-reducing design
          3º DF, add ankle strap

TBI with spastic equinovarus
Multiple Sclerosis – Progressive Type

Findings - Weakness DF/PF/inver/ever
- Sensation protective
- Tone increased
- No edema
- ROM to 3º DF

Orthosis - Plastic AFO, just-behind-malleolus trim, 3/4 footplate, 3º DF

Alternate – Consider metal AFO for progressive type

AFO options

MS with footdrop and stiff knee
KAFO
Knee-Ankle-Foot-Orthosis

- Metal design
- Plastic design
- Carbon design
- Hybrid designs

Knee Joint Options

- Free knee
- Drop lock
- Bail lock
- Trigger lock
- Ratchet lock
- Offset
- Trick knee

Drop lock  Offset with lock
Stance Control Orthoses

- New generation of KAFO’s that lock the knee joint automatically in stance, but allow knee flexion in swing
- Electronic or mechanical feedback from ankle and/or knee to determine stance phase
- Currently available by central fab directly from manufacturer

CVA with Hemiplegia

Findings - Weakness at knee and ankle
- Some extensor tone
- Sensation protective
- No edema
- Ankle ROM to 3º DF

Orthosis - Plastic KAFO with "Trick Knee" joint
- JBM trim, 3º DF
Traumatic Brain Injury

Findings - Marked spasticity and flexor tone
Knee flexion contracture 45°
Ankle ROM to neutral
Strength – flexion synergy only
Sensation protective
No edema
Orthosis - Plastic KAFO with ratchet knee joint
Mid-malleolar trim, neutral ankle

Polio Involving Knee And Ankle

Findings - Weakness at knee and ankle
M-L instability at knee and ankle
Marked muscle atrophy
Sensation intact, no edema
Small foot, shortened limb
Orthosis - Metal KAFO with drop lock knee joint
Knee cap, dual channel ankle joint
Custom orthopedic shoe with lift

Guillain-Barre-Syndrome

Findings - Weakness at knee and ankle bilaterally
Low tone, good hip extension/flexion
Sensation intact, no edema
ROM is normal
Orthosis - Plastic KAFO with offset knee joint
JBM trim, neutral ankle
Spinal Cord Injury – T12 Level

Findings - Paralysis both legs
Good trunk and arm control
Sensation absent, Mild edema
Tone is increased

Orthosis - RGO – reciprocal gait orthosis
Hybrid metal and plastic design HKAFO’s with droplock knee joints and plastic AFO at neutral

Alternate - Craig-Scott metal KAFO’s with droplock knee joints and dual channel ankle joints

RGO reciprocal gait orthosis

Hip Joints

Adjustable Abduction Hinge
Lateral Hinge
Orthopedics Hinge
Hip Abduction Orthosis (prevention of hip dislocation)

Knee Orthoses

Biomechanical Issues
- Medio-lateral instability (ligament tear)
- Medio-lateral deformity (arthritis)
- Anterior-posterior laxity (ACL/PCL)
- Hyper-extension (genu recurvatum)

Knee Orthosis Designs
Upper Limb Orthoses

Functional Goal = Prehension
Primary Factors: Thumb opposing fingers
- Effective pinch
- Gross grasp
- Positioning the hand in space

Rheumatoid Arthritis
IP Joints
Findings - “Swan Neck” deformity with hyperextension at PIP and flexion at DIP
“Boutonnière’s Deformity” with flexion at PIP and hyperextension at DIP
Orthosis - Metal ring finger orthosis
Finger Ring Orthosis at DIP to control swan neck

Distal Median Nerve Injury

Findings - Weakness at thumb
  Sensory loss on palmar surface
  Loss of thumb opposition
Orthosis - Short opponens orthosis

Short Opponens Orthosis
MCP Joint Contracture

Findings - Extensor contracture at MCP joint

Orthosis - “Knuckle Bender” dynamic hand finger orthosis

Knuckle Bender Orthosis

Carpal Tunnel Syndrome

Findings - Compression of median nerve
Incomplete motor / sensory loss at thumb

Orthosis - Wrist – hand orthosis
“Cock-up splint”
**Wrist Cock-up Splint**

**Mechanical flexor/extensor assist**

**Finger Flexor/Extensor Tendon Injury and Repair**

Findings - Restrictions on ROM at wrist, MCP and IP joints per surgical protocol

Orthosis - Hybrid wrist-hand-finger orthosis with static stabilization of wrist and limited dynamic control of MCP’s and fingers
Flexor Tendon Repair

Radial Nerve Injury at Elbow
Findings - "Wrist Drop"
- Motor deficit at wrist extensor and finger/thumb extensors
- Sensory deficit at dorsum of hand

Orthosis - Dynamic wrist-hand-finger orthosis with extension assist at wrist and fingers using outriggers and bands

Dynamic WHFO for Radial Nerve Injury
Spinal Cord Injury C6 Level

Findings – Wrist Extensors Intact
Long Finger Flexors and intrinsics absent

Orthosis - RIC Tenodesis Orthosis
Alternate – Flexor Hinge Orthosis

Tenodesis Effect
Thank You