Upper-Limb Orthotics

REHAB 442: Kinesiology and Biomechanics
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Upper-Limb Orthotics: Today’s Goals

• Differentiate functions of the arm versus the leg and implications for orthotics
• Recognize and describe purposes of orthotics used with the upper-limb
• Conceptualize and appreciate kinesiological or biomechanical principles applied through uses of upper-limb orthotics

Forces and the Upper-limb

• Observation and visualization of forces
  – Most important force?
    • Gravity
      – Arm: 5% of body weight (9 lbs of 180 lb body weight)
      – Hand: .6% of body weight (1.08 lbs of 180 lb body weight)
  – Other important forces?
    • Tissue resistance: Muscle tone, Healing soft tissue
  – Force on Force Contact?
    • Pressure, Shear
    • Line of force? Perpendicular
functions of the upper-limb

• different roles of arms versus legs
  – lower-limb:
    • discrete functions in relation to balance and gait, various components of mobility
  – upper-limb:
    • balance and mobility
    • multiple functions including reach (placement of hand), prehension (power grasp and precision grasp or pinch), transitional movements (in-hand manipulation), carrying (handling), and release

what about orthotics

• terminology (mosby)
  • orthotics: external appliances to support paralyzed muscles, promote specific motions, or correct musculoskeletal deformities.
  • splint: appliance to protect, immobilize, restrain, or support a part of the body.
  • brace: bind, or support and hold in a correct position to allow function.

• kinesiology definition
  – application of forces to correct abnormal forces acting on the limb—often to protect tissues, prevent abnormality, or promote function.
What about using Orthotics?

- **Lower-Limb Orthotics**
  - Operate to stabilize distal joints in extension or neutral position (so that weight can be taken through the limb).
  - Try to control body motion, momentum forces
    - Ground reaction forces (absorption)
    - Push-off forces (propelling)
  - Generally serve the “closed-kinetic chain” wherein distal stability supports proximal motion

(AFO-KAFO-HKAFO ⇒ WHEELS)

What about using Orthotics?

- **Upper-Limb Orthotics**
  - Operate to provide stability to proximal joints so that distal joints can be mobile
  - Try to promote motion by optimizing or balancing forces
    - Enhance placement of the hand (reach)
    - Enhance manipulation with the hand (grasp, transition, release)
  - Generally serve the “Open Kinetic Chain” wherein proximal stability supports distal mobility
Upper-limb forces

• Mechanically balanced forces
  – agonist and antagonist

• Synergistic mechanical actions
  – Redundant forces, as well as
  – Unique (independent) forces

Examples

– Tenodesis action of wrist and fingers
  • Grasp and release with long finger flexors and extensors
  • Extension of wrist creates some grasp by shortening of flexors, and flexion of wrist creates some release by shortening of extensors

– Shoulder Abduction
  • Deltoid (some Supraspinatus) Action
  • Little else works, replacing action is difficult
Upper-Limb Function

- Complex Tool
- Mobile off a stable trunk (Open Kinetic Chain)
- Proximal Stability for Distal mobility
- Assists with balancing of body
Purposes of Orthotics

- **Therapeutic**
  - Stabilize
  - Mobilize
  - Aid in healing
  - Prevent or reduce contracture development

- **Functional**
  - Stabilize proximally
  - Enable or maximize muscle action
  - Assist movement
  - Substitute for muscle action
  - Base for attaching functional tools

- **Static**
  - immobilization, pressure

- **Drop-out**
  - gravity stretch force

- **Articulated**
  - guide arc of motion

- **Dynamic**
  - stretch forces

- **Static Progressive or Serial**

Self-care, Work and Play Functions
Whole arm and hand
Purposes of Orthotics

Types of Orthotics

- **Permanent (relative)**
  - **Purpose**
    - Functional Use
  - **Materials**
    - Metals and High temperature plastics
    - Plaster molding
  - **Fabricator**
    - Orthotists
    - Occupational therapists

- **Temporary**
  - **Purpose**
    - Short term, therapeutic
  - **Materials**
    - Plaster-of-paris
    - Low temperature thermoplastics 135-180°
  - **Fabricator**
    - Occupational Therapist
    - Physical Therapist
Orthotics to Enhance Function

- Application of static or dynamic forces
- Lever action
  - First order
  - Second order
  - Third order
- Pressure distribution

Mechanical Advantage

- **First order**
  - balance around a fulcrum
- Second order
  - mechanical advantage
  - force over long lever arm
- Third order
  - mechanical disadvantage
  - force over short lever arm
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Pressure Tolerance

• Force through skin surface area ("2/3rds rule")
• Greater force needs greater surface area
• Perpendicular forces better than shearing forces
• Skin isn’t very flat- must contour or shape to surface
Orthotic Applications

- Combination of levers and pressures
  - Examples:
    - Shoulder slings
    - Mobile arm supports
    - Rancho slings
    - Wrist cock-up splint
    - Hand splint with attachments
    - Long/short opponens splints
    - RIC Tenodesis
    - Wrist driven flexor hinge splints
    - Others
Functional Uses of Orthotics

- Not easy!
- “Evidence”
- Function vs. Disruption?
- Long-term uses are not very common
- Promotes motor but impairs sensory capacity

Shoulder Slings

Third order lever disadvantage
Mobile Arm Supports

Second order lever advantage

Rancho-like Slings

Second order lever advantage
Wrist Cock-up

First order lever: Balance each side of fulcrum

Resting Hand Splint
Long Opponens

Short Opponens
RIC Tenodesis

Wrist Driven Flexor Hinge

Figure 64. Wrist-Driven Flexor Hinge Splint
Radial Nerve Palsy

- Forearm-based
- Hand-based

Upper-Limb Function

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Architecture of the hand

• Physiological Maintenance (homeostasis)
• Mechanical Advantage
• Function

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    • guide arc of motion
  – Dynamic
    • stretch forces
  – Static Progressive or Serial
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- Kinetec Maestra Portable Hand CPM
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UL Orthotics (Principles)

• Increase mechanical advantages
• Long and wide coverage (rolled edges) to displace pressures
• Allow all available prehension patterns
• Don't extend into boundaries of adjacent joints which are left free, only restrict necessary joints
• Allow normal anatomical properties (arches of hand, normal angle of tendon action)
• Eliminate friction/shear
• Apply correct force (100-300 grams= F x D)
• Use optimal rotational force (90°)
UL Orthotics

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  – Base for attaching a functional device
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