Upper Limb Orthoses

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Outline
1. Why prescribe upper limb orthoses
2. Review prehensile function and grasp patterns
3. Consider orthotic mechanical principles
4. Describe indications and goals for UL components and orthoses

What do we use our upper limbs for?

Basic ADLs
- Self-feeding
- Dressing
- Bathing
- Toileting

Movement:
- Reaching
- Prehension
- Manipulation

Mobility needs
- Transfers
- Transitional movements
- Crutch walking
- Wheeled mobility

Why prescribe UL orthoses?

- Patient’s perspective
  - Hand function is a priority (Snoek et al., 2004).
  - Recovery of even partial arm and hand function impacts independence and QOL (Anderson, 2004).

- Aging Effects on UL Function
  - Pain
  - Contractures
  - Upper limb musculoskeletal injuries
Criteria for Efficient Prehensile Function

1. Stable wrist
2. Two opposing digits
   - Thumb opposition
     - Abductor Pollicis Brevis
   - Opponens Pollicis and superficial head of FPB
   - Stable index and third finger
   - Moveable ring and small finger
3. Palmar mobility
4. Sensation
5. Pain free

What is this prehension pattern?

a. Cylindrical
b. Tip
c. Lateral/key
d. Three jaw chuck
e. Hook
f. Spherical
ULO Mechanical Principles

- Force vectors
- Lever arms
- Torque
- Pressure over skin
- Surface contours
- Stress concentrations

ULO Mechanical Principles

- Force vectors (3 point force)
- Lever arm
- Pressure distribution (materials and design)

• Corrective Force Torque > Internal Joint Torque

Terminology

<table>
<thead>
<tr>
<th>Static</th>
<th>Dynamic</th>
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<tbody>
<tr>
<td>Therapeutic</td>
<td>Therapeutic</td>
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<tr>
<td>- Static FO, thumb spika, HO, WHO, RO, SEO, SEWO</td>
<td>- Dynamic FOs, WHO, EO</td>
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<tr>
<td>Functional</td>
<td>Functional</td>
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<tr>
<td>- Task specific WHO and HO</td>
<td>- Ratchet WHO, Wrist driven WHO, MAS</td>
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IP Joint Instability

- Diagnoses
  - Ligament strain: M-L instability at IP joint
  - Mallet finger: Extensor tendon avulsions of the distal phalanx
  - Arthritis
    - Boutonniere deformity: Central slip disruption of the PIP joint
    - Volar plate avulsion of the PIP
  - Fractures: phalanx
- Orthotic Goal
  - Immobilization of the affected joint(s)
- Orthosis: Static finger splints
IP Joint Contracture

- Pathology
  - Arthritic fingers: swan neck or boutonniere’s
  - Post-operatively
  - Normal motor, sensory and potential for ROM
- Goals
  - Properly position joints, decrease inflammation, rest and support weakened structures, to improve function through better stability and position, to prevent joint contractures and to aid post-op
- Orthosis: Static or dynamic finger splints
Tenderness at 1st MCP or CMC joint

- Pathology
  - Arthritis: joint inflammation and tenderness
  - Strength and sensation normal
  - ROM limited by pain
- Goal
  - Pain relief through joint immobilization
- Orthosis: Thumb spica

Thumb Spica

 Courtesy of Health Products for You

Finger MCP Joints

- Signs/Symptoms
  - Ulnar peripheral nerve palsy
  - RA: MCP Joint subluxation
- Goal
  - Avoid MP extension contracture
  - Pre-position the hand for grasp
- Orthosis: “Knuckle bender” dynamic hand orthosis with MP Stop (lumbrical bar)
Intrinsic Musculature Weakness

- Findings
  - Inability to position the thumb in opposition
  - Strong wrist extensors
- Goal
  - Maintain a functional position of the hand and prevent deformities
- Orthosis: basic opponens
  - Various attachments can be added for eating, reading or grooming

Weakness or paralysis of wrist and hand musculature

- Pathology
  - C1-5 quadriplegia with 0 wrist extensors and an intrinsic minus hand
- Goal
  - Provide light-weight support of the wrist, position finger/thumb in opposition, maintain functional architecture, prevent wrist/hand deformities
- Orthosis: Long Opponens WHO

Basic HO Opponens

- Abduction bar
- Opposition post

Long Opponens WHO

- C-bar
- Opposition post
Long Opponens WHO

Good extensors but no grasp

- Findings
  - Wrist extensor strength 3+ or better and good proximal strength; Finger flexor strength absent
  - C6 and C7 quadriplegia
  - Motivation of the patient

- Goal
  - Allow grasp through support of the wrist, positions finger/thumb in opposition, maintains functional architecture

- Orthosis: Wrist driven WHO
  - May interfere with wheelchair propulsion

Wrist Driven - WHFO

No Extension or Flexion Strength

- Findings
  - Shoulder strength of 3+ or better (or use with MAS)
  - C5 quadriplegia with no hand or wrist extension/flexion strength
  - Motivation

- Goal
  - Allow grasp and release of objects

- Orthosis: Ratchet WHO

Tenodesis orthosis, flexor hinge splint

Adjustable actuating lever

Thumb post

Finger piece

Photo Courtesy of Ann Yamane
Ratchet - WHFO

Photo Courtesy of Ann Yamane

Wrist/Hand Pain or Minor Weakness
• Signs/Symptoms
  – Compression of median nerve; incomplete motor/sensory loss (i.e. Carpal Tunnel Syndrome)
• Goal
  – Relieve pain through immobilization
  – Wrist positioned in neutral flexion/extension
• Orthosis: Wrist hand orthosis; “cock-up splint”

Static WHO – Cockup Splint

Short Cockup Splint

Long Cockup Splint

Ulnar drift
• Signs/Symptoms
  – Rheumatic joints and muscle imbalance
  – Prior to ulnar drift and palmar subluxation
• Goal
  – Maintenance of MP joint alignment
• Orthosis: Ulnar deviation orthosis
Flexion of wrist and fingers

- Findings:
  - Motor and sensory may be present or absent
  - CVA: Flexion synergy
  - Lower Brachial Plexus Injury: Motor deficits

- Goal
  - Prevent contractures
  - Stabilize wrist and fingers in neutral position

- Orthosis: Static Wrist Hand Finger Orthosis
  - Wrist may be positioned in flexion; MCP positioned in flexion; IP joints extended; Thumb in opposition
Supporting WHO Research

- Pain (Phys Ther 1998)

Early intervention, multidisciplinary approach and include patient in the plan of care.

PNI: Position depends on diagnosis

<table>
<thead>
<tr>
<th>Orthosis</th>
<th>Position</th>
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<tr>
<td>Radial N. Injury</td>
<td></td>
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<tr>
<td>Wrist immobilization orthosis</td>
<td>Wrist in 30-40° extension</td>
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<tr>
<td>MCP extension WHO</td>
<td>Wrist in 30-40° ext; MCPs in dynamic ext</td>
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<tr>
<td>Tenodesis orthosis (Wrist driven orthosis)</td>
<td>Dorsal base using tenodesis effect with</td>
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<tr>
<td>Ulnar N. Injury</td>
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<tr>
<td>Elbow orthosis</td>
<td>Elbow in 30-45° flexion</td>
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<tr>
<td>Anticlaw orthosis</td>
<td>4th and 5th MCPs in 30-40° flexion</td>
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<tr>
<td>Median N. Injury</td>
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<tr>
<td>Dorsal or solar WHO</td>
<td>Wrist in neutral</td>
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<tr>
<td>Ulnar gutter WHO</td>
<td>Wrist in neutral</td>
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<tr>
<td>Thumb web spacer orthosis (C bar)</td>
<td>Thumb in 40-45° palmar abduction</td>
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(Coppard Lohman 2014)
Wrist and Finger Extension Weakness

- Signs/Symptoms
  - Post-op after finger joint resection arthroplasty
  - Radial Nerve Injury at elbow
- Goal
  - Stabilize wrist
  - Control motion in the desired plane and range
  - Assist flexion/extension without hyper-motion
- Orthosis: dynamic WHFO with outriggers and bands
Task Specific Orthoses or Universal Splint

- Signs/Symptoms
  - Deformity or weakness that prevents prehension
- Goal
  - To perform a specific task
- Orthosis: task specific orthosis

Shoulder Weakness

- Findings
  - Absent or weak elbow flexion, shoulder flexion, abduction and external rotation, limited endurance
  - E.g. MD, Polio, Cervical spinal cord lesion, Guillain-Barre, ALS
  - Some residual muscle strength (MMT at least poor or grade 2) and coordination of elbow flexion (can be used for C5 quad)
  - Adequate strength and ROM to move the MAS: neck, trunk, shoulder girdle and elbow
- Goal: Assist shoulder elbow motions
- Orthosis: MAS

Mobile Arm Support (MAS)

Balanced forearm orthoses

DAS (Dynamic Arm Support, Assistive Innovations Corp, Newark, NJ, USA)

WREX - Wilmington Robotic EXoskeleton

ARMON (Assistive Innovations Corp, Newark, NJ, USA)
Elbow ROM and Stability

- **Signs/Symptoms**
  - Stable fractures, post-trauma or post-surgery, elbow dislocation, predisposition for contracture, strains, sprains and muscle trauma, avoidance of elbow contractures
- **Goal**
  - Immobilization for soft tissue repair or bony callous formation, reduce soft tissue contractures
- **Orthosis: Elbow orthosis**
  - May be fabricated with turnbuckle and/or locking joints

Post-Op Shoulder

- **Signs/Symptoms**
  - Post rotator cuff repair, anterior-posterior capsular repairs and post-manipulation
  - Axillary burns
- **Goal**
  - Protect soft tissues; Prevent contractures; Limit motion at glenohumeral joint, maintain abduction position
- **Orthoses**
  - Shoulder abduction pillow
  - Airplane orthosis
Shoulder Abduction Pillow

Airplane

Long-term Shoulder Elbow Support

• Signs/Symptoms
  – Brachial plexus injury, painful subluxing shoulder joint
• Goal
  – Unweight the arm to support the shoulder joint
• Orthosis: Gunslinger

Gunslinger

Photo Courtesy of Trulife
Givmohr Sling

- Reduction of subluxation in sitting and standing.
- Reduction of shoulder pain.
- Dynamic joint compression of shoulder, elbow and wrist during standing and ambulation to facilitate return.

http://www.givmohrsling.com/

Sport Sprain

- Signs/Symptoms
  - Shoulder Sprain
  - AC separation
- Goal
  - Limit motion at the end range, allow movement and activity
- Orthosis: Shoulder orthosis

Shoulder Stabilizer

Sawa Shoulder Stabilizer

Photo Courtesy of Smith & Nephew, Inc.

Questions

- What is the most famous fracture of the radius?
  a. Scaphoid
  b. Colles
  c. Lunate
- Which carpal bone is most frequently fractured?
  a. Scaphoid
  b. Colles
  c. Lunate
- Which carpal bone is most frequently dislocated?
  a. Scaphoid
  b. Colles
  c. Lunate
Fractures

- Signs/Symptoms
  - Mid-humeral fracture
  - Forearm fracture
- Goal
  - Immobilization
- Orthosis: Humeral fracture orthosis or forearm fracture orthosis

Humeral Fracture Orthosis

Varus deformity during healing due to upward force at elbow.
New Technologies

- Neuromuscular arm dysfunction: Myopro arm orthosis with myoelectric control, from a patient’s biceps and triceps, controls an elbow wrist hand orthoses
  - Muscle re-education
  - Maintain or increase ROM

- Tremors: WOTAS (wearable orthosis for tremor assessment and suppression)

Side Effects

- Decreased muscle strength and endurance after immobilization
- Skin breakdown

Patient education and follow-up are critical
  - Purpose of the splint, donning/doffing, care
  - Break-in schedule to develop skin tolerance
  - Targeted training

Summary

- Why?
  - Basic ADLs, Mobility Needs, Functional tasks
  - Anticipate future rehab needs (e.g. aging, overuse)

- How?
  - Mechanical principles

- What?
  - Patient-specific orthosis
  - Targeted training
References

- Atlas of Orthoses and Assistive Devices

Manufacturers

- Restorative Care of America: http://www.rcai.com/index.html
- Texas Assistive Devices: http://www.nabler.org/N-AblerII/N-Abler_III_WHO.htm
- Health Products for You: http://www.healthproductsforyou.com/
- DonJoy: https://www.djoglobal.com/our-brands/donjoy
- Trulife: http://trulife.com/all-products/orthotics
- Givmohr: http://www.givmohrsling.com/