Paper I: Upper Limb prosthetics and orthotics and Spinal orthotics

# Chapter 9: Variations on Design in Upper Limb Orthosis

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# Objectives

- By the end of sessions, you will be able..

- To explain about the variations and functions of upper limb orthosis for designing and making the ULO

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# Shoulder Orthoses

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# Shoulder Orthoses

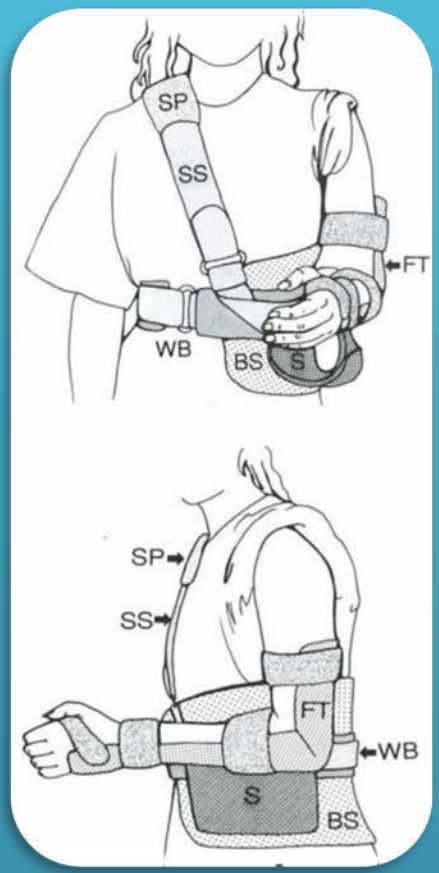



Fig. 1



Fig. 2



Fig. 3

**Common name**

- Shoulder dislocation Orthosis. (Fig.1)
- Shoulder Abduction Orthosis (Fig.2)
- Arm Abduction Orthosis (Fig.2)
- Air Plane Splint (Fig.3)

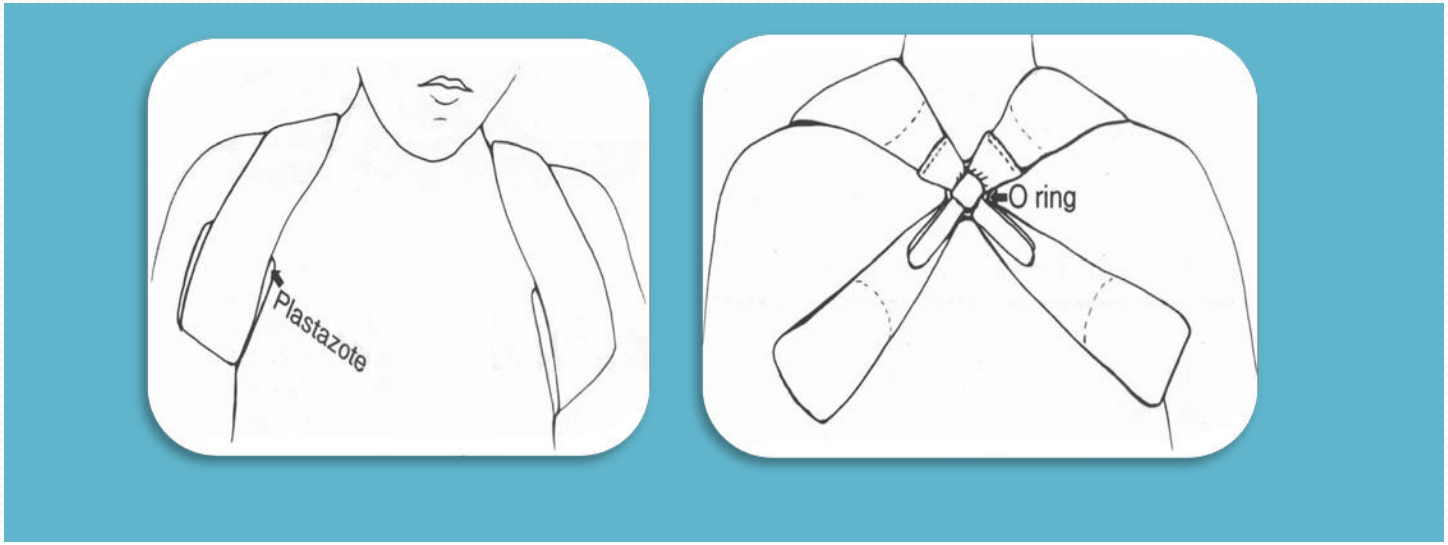
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# Shoulder Orthoses

| Indications | Positions |
|---|---|
| Axillary burns | As required by the condition |
| Rotator cuff repair | 45°abduction, Neutral rotation |
| Brachial plexus injury | 30°abduction, 30°flexion, 30°internal rotation |
| Shoulder adduction contracture | The desired amount of abduction |

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# Shoulder Orthoses




| | |
|---|---|
| Name of Orthosis | -Axilla wrap<br>-Clavicle strap brace<br>-Clavicular Orthosis |

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# Shoulder Orthoses

| **Objectives** | • To retract the scapulae<br>• To apply pressure to the axilla to prevent or correct hypertrophic scarring<br>• To stretch contracted tissues across the anterior chest<br>• To prevent or correct kyphotic posture |
|---|---|
| Indications | Biomechanical Function |
| Axilla burns or skin grafting | The orthosis restrict movement of the clavicle and to some extent inhibit scapular protraction while allowing free movement at the glenohumeral joint |
| Fracture of the clavicle | |
| Shoulder adduction contracture | |
| | |

# Shoulder Orthoses



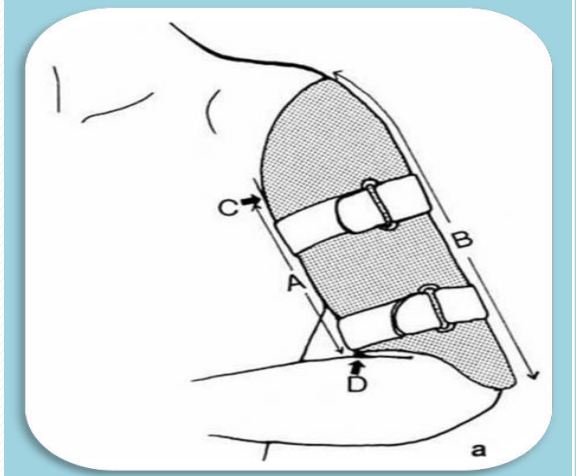
| | |
|---|---|
| Name of orthoses | - Static Shoulder-Elbow-Wrist Sling<br>- Arm Sling |

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# Shoulder Orthoses

| **Objectives of arm sling** | • To immobilize the shoulder and elbow.<br>• To support the weight of the upper<br>• To prevent brachial plexus traction.<br>• To relieve pain and prevent shoulder subluxation |
|---|---|
| Indications | • Positions |
| *Shoulder subluxation (flaccid hemiplegia ) | This sling positions the shoulder in internal rotation and the elbow in approximately 90°flexion so that forearm is horizontal.<br><br>If desired, increase elbow flexion to position the hand above the elbow to help control hand edema. |
| Brachial plexus injury | |
| Rotator cuff injury | |
| Upper extremity trauma (crush injury) | |
| Shoulder surgery | |

# Shoulder Orthoses

| | | |
|---|---|---|
|  | Name of orthoses | - Circumferential Nonarticular Humerus-Stabilizing Orthosis<br>- Humeral fracture functional brace<br>- Sarmiento humeral brace |
| **Objectives** | To stabilize fracture to promote healing without immobilizing any joints | |
| **Indications** | Fracture of the humeral shaft | |

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# Elbow Orthoses

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# Indications

- Rheumatoid arthritis
- Elbow surgery; Ulnar nerve transposition/ repair, Tendon transfers,
- Burns
- Ulnar nerve entrapment
- Elbow injury or surgery; Multiple trauma, Intra-articular fractures, Triceps rupture,
- Tumor resection,
- Flexion contractures caused by; Intra-articular fractures, Multiple trauma, Capsular tightness,
- Postoperatively (total elbow arthroplasty/replacement)
- Inflammation of the common tendon origin of: Wrist extensor; lateral epicondylitis ***(tennis elbow)*** Wrist flexors; medial epicondylitis ***(golfer's elbow)***

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# Variation of Elbow Orthoses



Posterior articular elbow orthosis



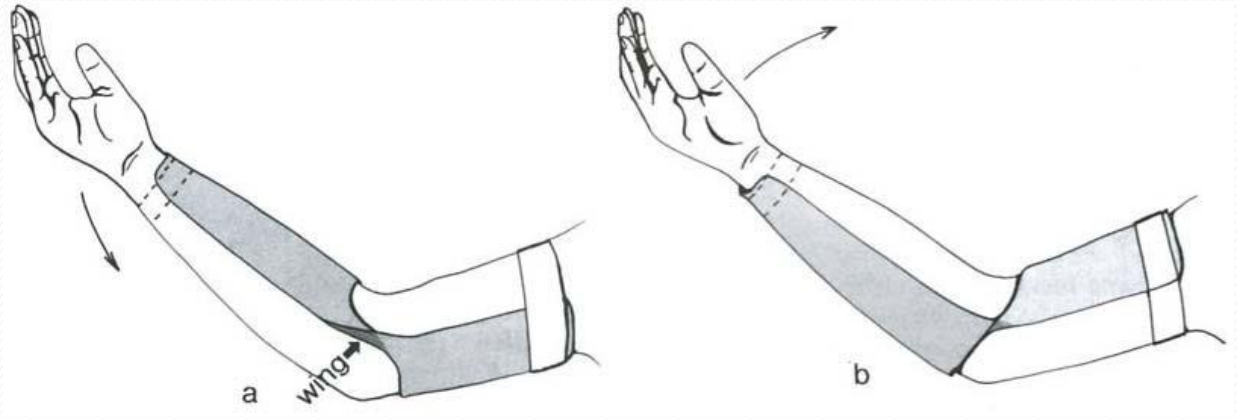
Circumferential articular elbow orthosis



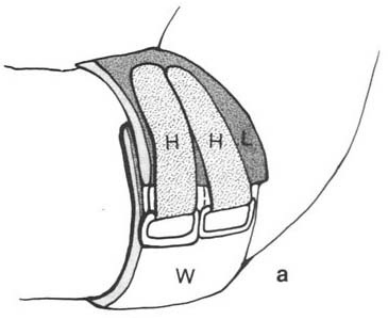
Posterior static elbow orthosis

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# Variation of Elbow Orthoses




Bisurfaced static elbow orthosis




Circumferential nona-rticular proximal forearm strap

# Variation of Elbow Orthoses

Spiral dynamic forearm-rotation thumb abduction strap

**Common names**

-Thumb abduction supination splint; and

- Forearm supination/pronation mobilization, thumb abduction mobilization



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# Variation of Elbow Orthoses

| | |
|---|---|
| **Objectives** | -To abduct the thumb and, to promote either supination or pronation depending on the direction in which the strap is wrapped.<br><br>-To reduce the tone of hypertonic muscles by abducting the thumb and forearm supination<br><br>-To assist weak muscle to promote functional use of the hand |
| **Indications** | Hyper tonicity or hypo tonicity; Forearm stiffness secondary to cast immobilization for wrist fracture |

# Wrist Hand Orthosis (WHO)

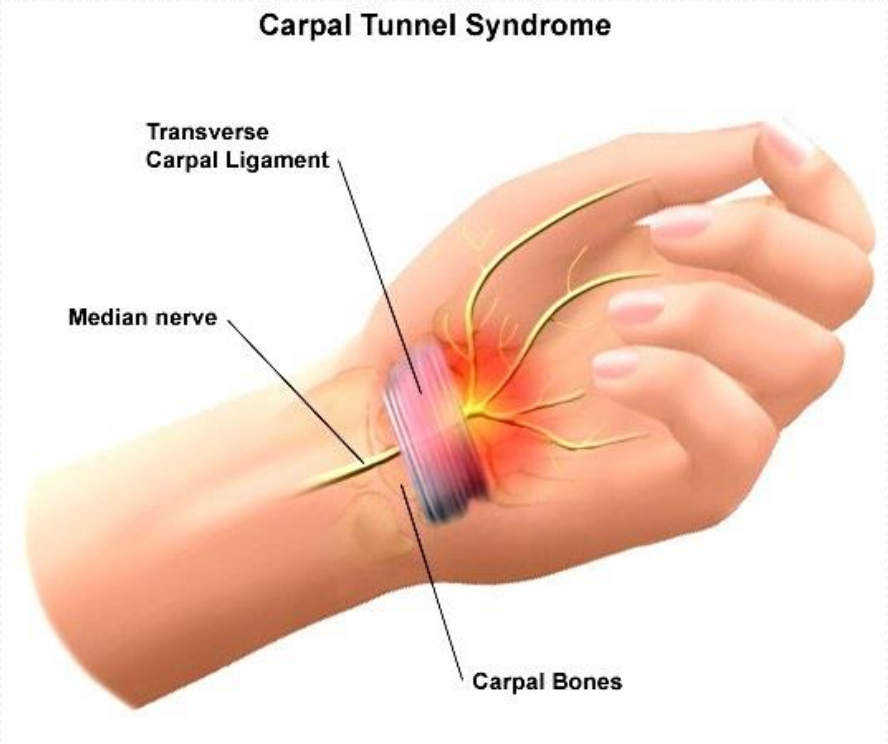
- Static WHO
- Dynamic WHO

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# CARPAL TUNNEL SYNDROME (CTS)

- **Definition**

Carpal tunnel syndrome is a common and quite painful disorder caused by compression of the median nerve in the carpal tunnel.




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# CARPAL TUNNEL SYNDROME (CTS)

- **Causes**
  - Trauma
  - Fractures
  - Repetitive motions,
  - Rheumatoid arthritis,
- **Symptoms**
  - numbness, “pins and needles”, weakness and pain in the palm on the radial side of the hand.
  - The thenar muscles can become weak and opposition of the thumb may be affected as will finger flexion on the radial side.

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# CARPAL TUNNEL SYNDROME (CTS)

- **Treatment of CTS**
  - Reduce the aggravating factors (eg. control the repetitive motions)
  - Anti-inflammatory medication / cortisone injection
  - Orthotic devices
  - Surgical release of the flexor retinaculum (Carpal tunnel release) for chronic cases.

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# CARPAL TUNNEL SYNDROME (CTS)

- **The aims of orthotic intervention include:**
  - Immobilize the wrist in an extended position.
  - Immobilize finger flexion, if it is a severe case of CTS.
  - Worn acutely to reduce inflammation and pain.
  - Usually worn for several weeks acutely, but may be worn long term or for a specific activity.

- **Orthotic Options**
  - Wrist hand orthosis (WHO) with the wrist positioned in the functional position, however allowing full ROM of the fingers and thumb.
  - The WHO can generally be custom made or prefabricated depending on the severity of the condition.





# RHEUMATOID ARTHRITIS (RA)

- **Definition**
  - RA is a systemic autoimmune disease that involves inflammation of the lining of the joints (synovium) and sometimes organs too.
- *In the upper limb, RA affects the wrist, MCP and PIP joints.*

- **Clinical Signs**
  - limited and often painful ROM
  - ulnar deviation of the fingers)
  - enlarged joints,
  - muscle weakness
  - decreased dexterity

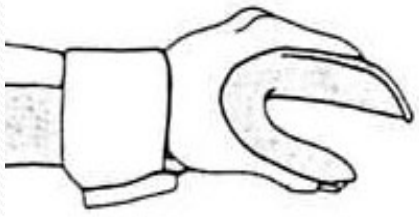


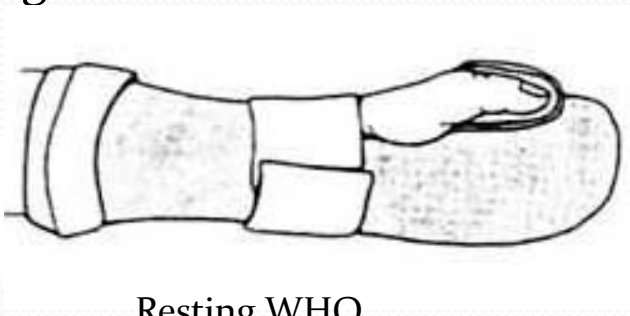
# RHEUMATOID ARTHRITIS (RA)

- **Aim of orthotic treatment**
  - To reduce or prevent deformity of wrist and fingers (typically ulnar deviation),
  - provide support for weakened muscles and attempt to achieve functional position of the wrist.
  - Trying increase function and decrease pain.

- Orthoses are typically worn seven days per week during the day time, to protect the joints while they are being used.

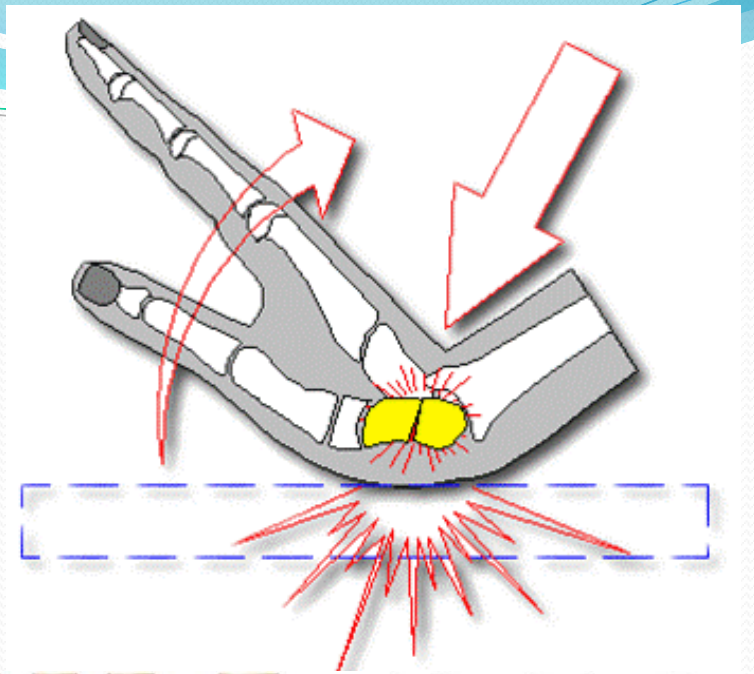
- To prevent further progression, the orthosis may be worn at night-time to prevents the tendons from tightening overnight which enables ease of finger function in the morning.



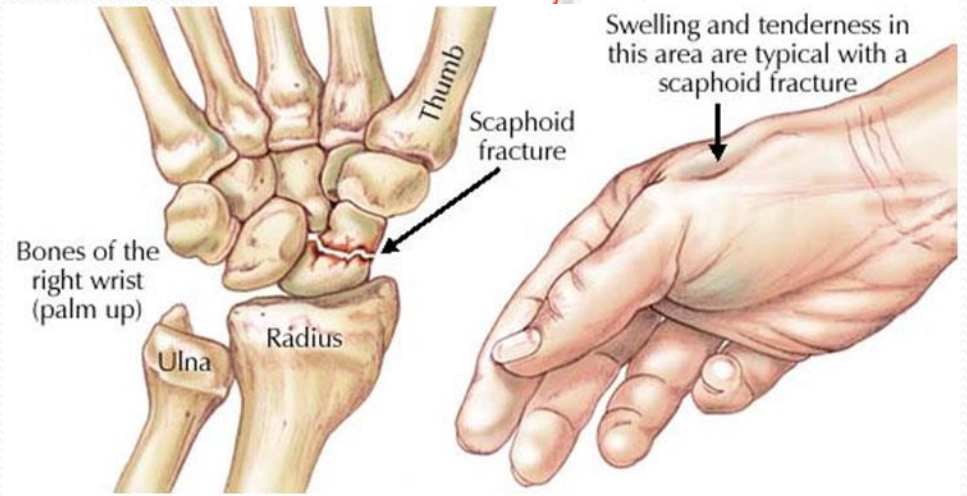


Resting WHO

# Scaphoid fracture



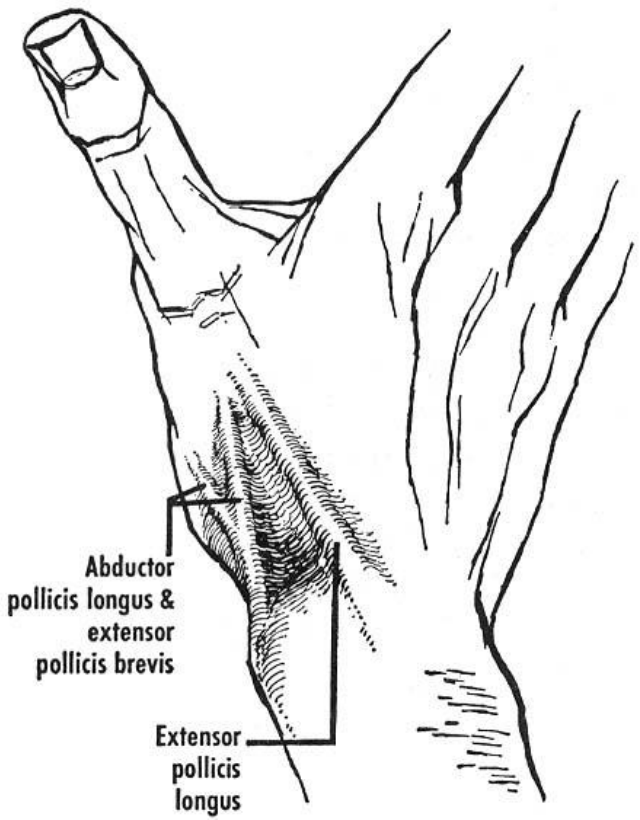
- is commonly caused by trauma such as falling on an outstretched wrist, and often occurs in a motorcycle accident.
- A scaphoid # is often difficult to diagnose from an x-ray, but will cause pain at the base of the thumb and pain during gripping.




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# Scaphoid fracture

- **Symptoms**
  - Little swelling evident.
  - Pain at the base of the thumb: pain can often be replicated when pressure is applied within the anatomical snuff box. The anatomical snuff box
  - Painful when attempt to grip an object.




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# Scaphoid fracture

- **Aims of Orthotic Management and Orthotic Options**
  - In the acute phase of treatment, plaster bandage or fiberglass cast is applied for 6-8 weeks.
- The cast should have the following features:
  - Neutral wrist flexion and extension, and slight radial deviation.
  - The thumb should be in a functional position and the IP joint free motion.
  - Full ROM of 2nd-5th MCP joint flexion

- After the cast is removed and the immobilization is required



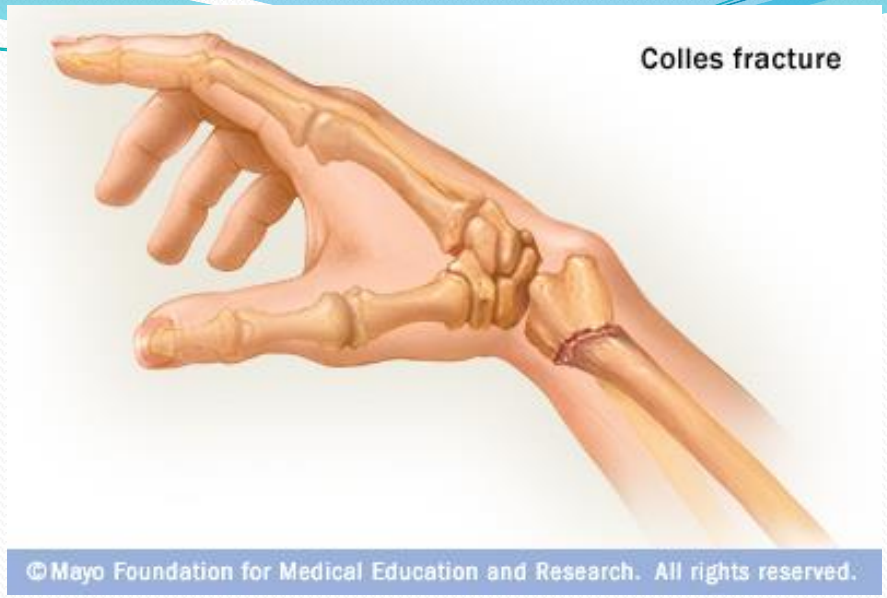


Static WHO - Cock-Up Splint

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# Colles fracture

- Definition
  - A Colles fracture is a fracture of the distal radius and may also involve the distal ulnar. The fracture is typically dorsally placed and angulated







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# Colles fracture

- **Symptoms**
  - The wrist is normally positioned in extension and radial deviation, with a supination twist.
  - Pain upon palpation around the ulnar and radial styloid processes.
  - Swelling of the wrist joint.
  - An inability to hold or lift objects with any significant weight.

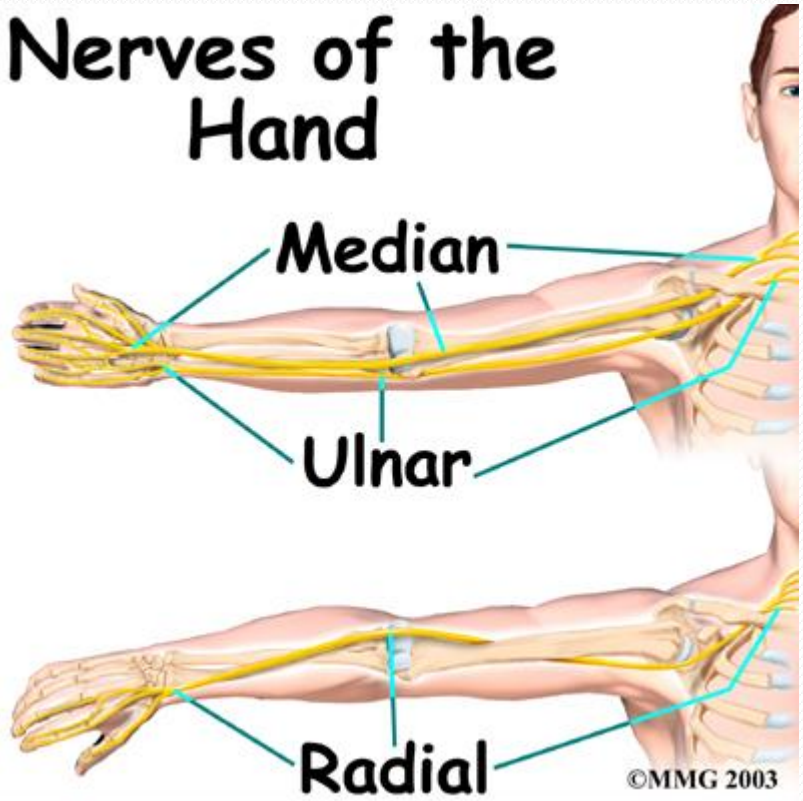
- **The aim of orthotic treatment**
  - Immobilise the wrist for 6-8 weeks.
  - Typically, a fibreglass cast is used initially in the position
    - Slight flexion
    - Ulnar deviation
    - Pronation
  - The fracture cast should allow full MCP joint and thumb ROM.



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# Radial nerve injury

- Causes
  - Mid-shaft humeral,
  - shoulder dislocation, proximal radius fracture, or
  - compression in the axilla due to crutches or ‘Saturday night palsy’.




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# Radial nerve injury

- The location of the injury determines the deficits.
- Radial nerve injury can lead to paralysis of:
  - triceps (elbow extension),
  - brachioradialis (elbow flexion),
  - supinators (forearm supination) and
  - the extensors of the wrist and digits
- Injury can lad to Sensory loss
  - the posterior surface forearm
  - lateral three-and-a-half digits (to the nail bed of the thumb, and to the
  - PIP joints of the other digits).

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# Radial nerve injury

- Orthotic intervention will aim to
  - achieve a functional position, prevent
  - wrist-drop or assist with extension,
  - provide thumb support, and assist
  - finger extension.



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# Radial nerve injury

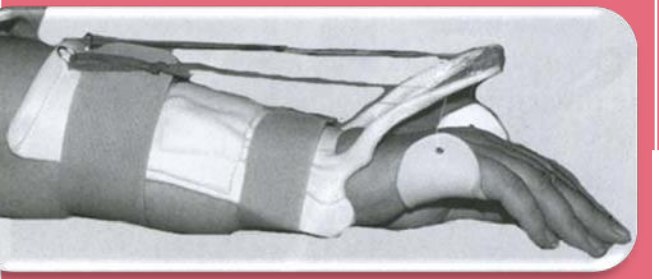


Fig. A

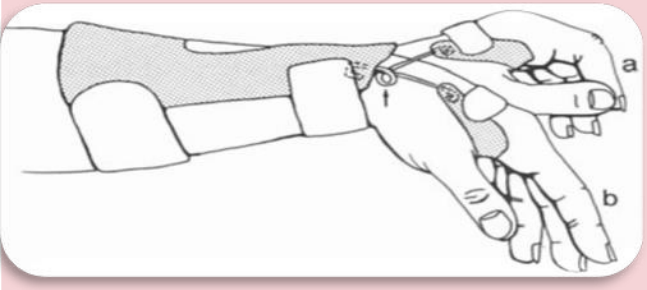



Fig. B

| | |
|---|---|
| **Name: (Fig. A)** | **. Dorsal Forearm-Based Dynamic Outrigger Wrist Assistive-Extension Orthosis** |
| Name: (Fig. B) | . Dorsal Forearm-Based Dynamic Joint-Aligned Coil-Spring Wrist Assistive-Extension Orthosis |
| Objectives: | • To passively extend the wrist while allowing active wrist flexion<br>• To prevent wrist flexion contracture |
| Indications: | . Weak or paralyzed wrist extensors, such as Radial nerve palsy |

# Radial nerve injury



Fig. A

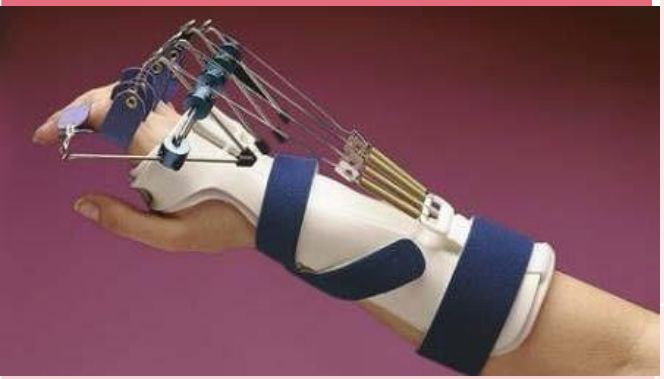


Fig. B

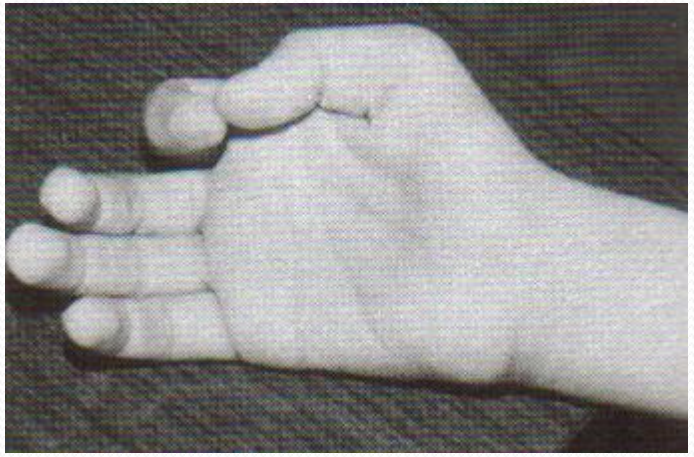
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| **Name: (Fig. A)** | **. Dorsal Forearm-Based Dynamic Outrigger Assistive MCPs Extension Orthosis** |
| Name: (Fig. B) | . Dorsal Forearm-Based static wrist, Dynamic Outrigger Assistive MCPs Extension Orthosis |
| Objectives: | . To assist MCP joints extension(Fig. A)<br>. To assist MCP joints extension while preventing wrist flexion contracture |
| Indications: | . Paralyzed wrist extensors, Radial nerve palsy |

# Static Hand and Thumb- based Orthotics

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# Median nerve injury

- Common locations of injury
  - The cubital fossa of elbow,
  - Wrist (palmer surface).
- Proximal median nerve injuries lead to
  - loss of wrist flexion strength,
  - ulnar deviation of the wrist
  - loss of thumb opposition (Fig 29),
  - loss of finger flexion
  - index and middle finger
  - interphalangeal joints
- Distal median nerve injuries the fingers are still able to flex, but thumb opposition is often lost.
- The deformity of the hand is commonly referred to as “ape hand”.



# Median nerve injury



Dynamic anti-claw deformity splint or Spring wire knuckle bender

- **Aim:**
  - to passively extend PIPile permitting active flexion

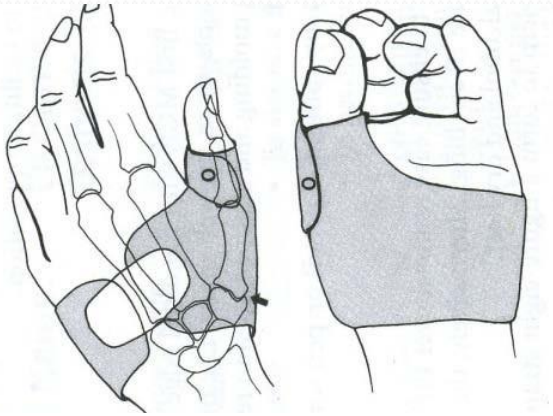


Circumferential Hand-Based Dynamic Joint MCP Assistive-Flexion and Thumb Assistive-Opposition Orthosis

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# Median nerve injury

- To position the thumb in functional position, while allowing unrestricted motion of Wrist, thumb IP and finger MCP
- To immobilize the first CMC and MCP
- To relieve CMC pain
- To prevent or correct a first web space contracture

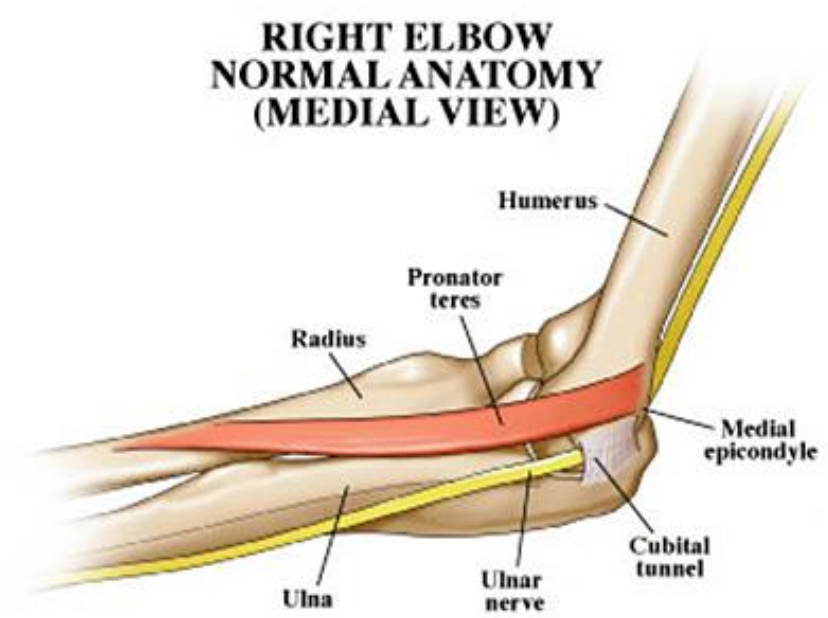


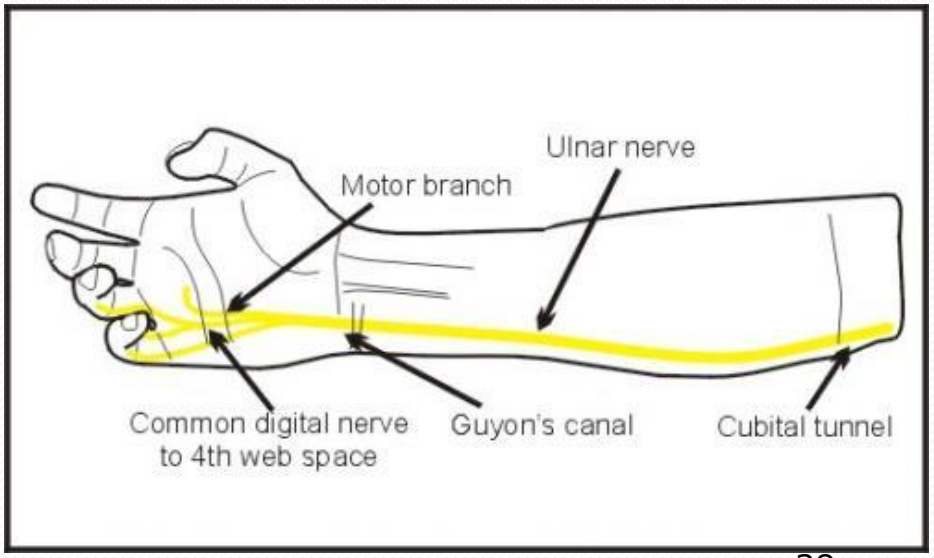
Short opponens Splint

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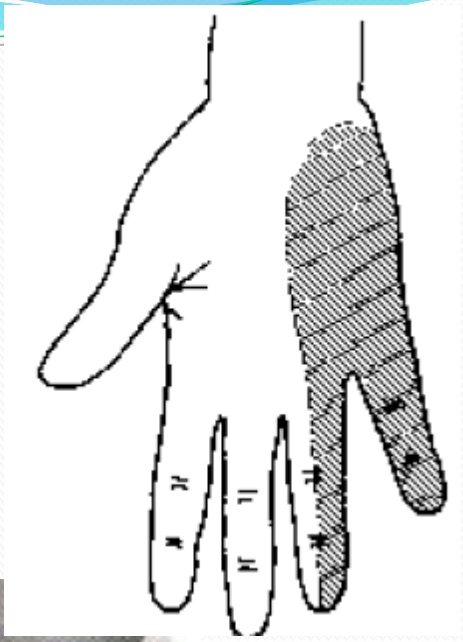
# Ulnar nerve injury

- most commonly occurs via an elbow injury, such as dislocation, fracture, or swelling to the cubital region.
- Pressure in the axilla can also lead to ulnar nerve injury, as can a trauma injury to the wrist.



# Ulnar nerve injury



- loss of MCP flexion to 4th and 5th fingers.
- Muscles in the hypothenar eminence will not work



- Sensory deficit will be seen on the palmer and dorsal regions of the medial hand around fingers 4 and 5.

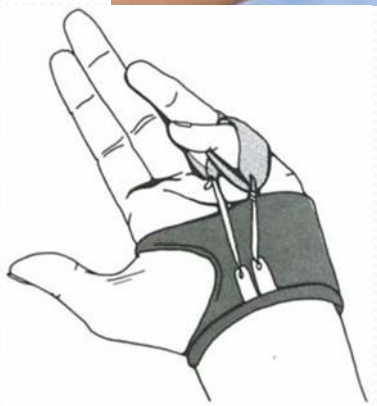
- Deformity of hand is called " claw hand"

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# Ulnar nerve injury



- Orthotic intervention may be required to prevent contracture to the 4th and 5th fingers
- To correct hyperextension of the fourth and fifth MCPs
- To prevent shortening of the MCP collateral ligaments

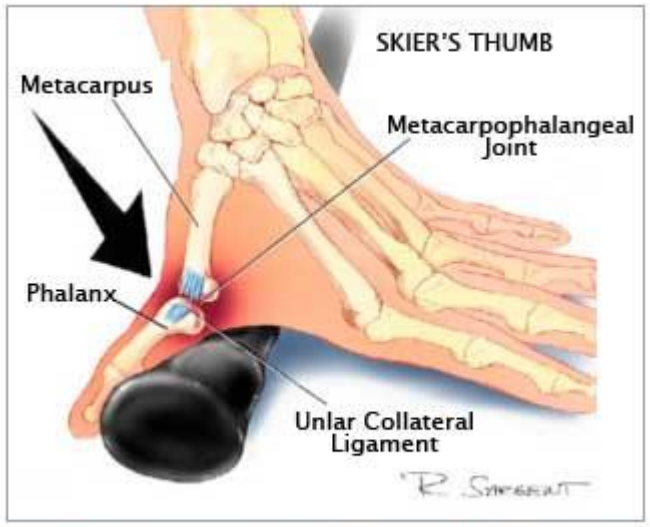


- Circumferential Hand-Based Dynamic D4-5 MCP Assistive-Flexion orthosis

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# Gamekeepers thumb/ skiers thumb/ ulnar collateral ligament injury

- Definition
  - an injury due to excessive abduction force applied to the 1st MCP joint from repetitive stress or trauma.
- Orthotic aim
- The aim of orthotic
  - immobilize the 1st MCP joint in a functional position, whilst still allowing IP joint range.



MECHANISM OF INJURY RESULTING IN A SKIER'S THUMB



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# Bennett's fracture

- Fracture of the CMC joint of the thumb from axial abduction force.
- Often the Trapezium is subluxed when a Bennett's fracture occurs.
- An orthosis will be used post-operatively to immobilise the thumb during bone healing, such as the Thumb spica splint
- Wrist, 30-degree extension; IP joint, free







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# Boxers fracture

- fracture to the neck of the 5th metacarpal bone from a compressive force by trauma to the fist, or a fall onto the hand while it is clenched

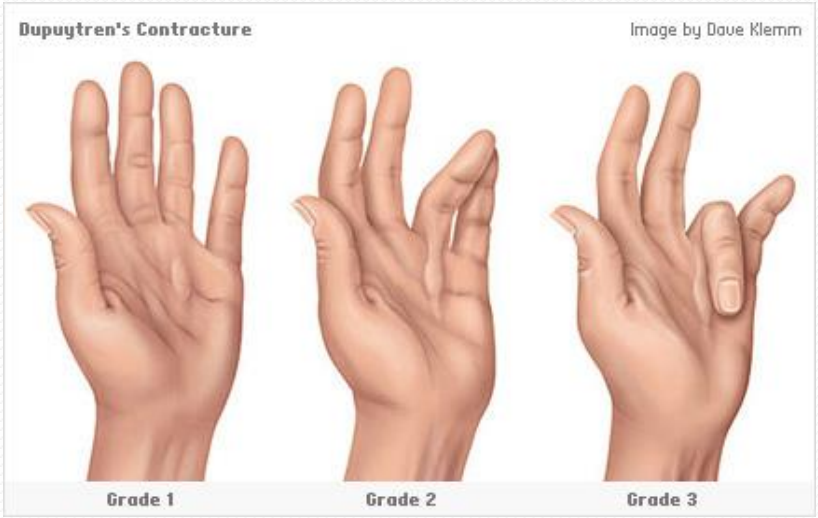







# Dupuytren's contracture

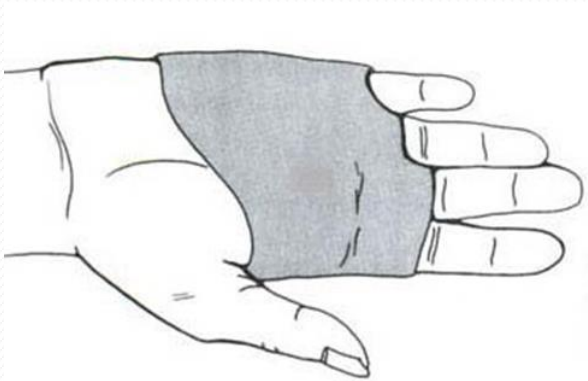
- Thickening and shrinking of the palmar fascia under the skin of the palm, causing finger flexion.
- Orthotic treatment can be similar to treatment of ulnar nerve injuries




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# Dupuytren's contracture

- Keep the MCPs in slight flexion or neutral
- To promote stabilization of the tendon at the MCPs volar subluxation
- To prevent or correct MCP ulnar drift
- To maintain Surgical release of Dupuytren's contracture



Volar or Circumferential Hand-Based Static MCP Stabilization Orthosis or (MCP Protection Splint)

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# Finger-based static orthosis

- Mallet finger splint
- Boutonniere splint
- Swan neck splint

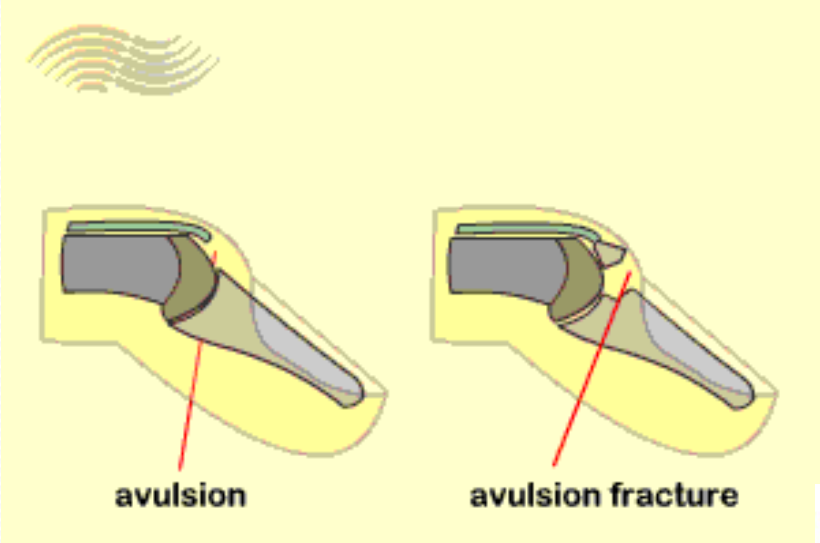
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# Mallet finger





- An injury that occurs due to a sudden flexion force on the DIP joint.
  - Avulsion of the extensor tendon.
  - Avulsion fracture of the base of the distal phalanx.




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# Mallet finger

- The aim of orthotic treatment is to
  - repair the fracture and reattach the avulsed tendon.
  - Immobilise the DIP joint in as much extension as possible to allow the avulsion or fracture to heal.
  - Allow free ROM of the PIP joint, as movement at this joint has little impact on healing.
  - Immobilisation is usually 6-8 weeks; 24hours/7days.



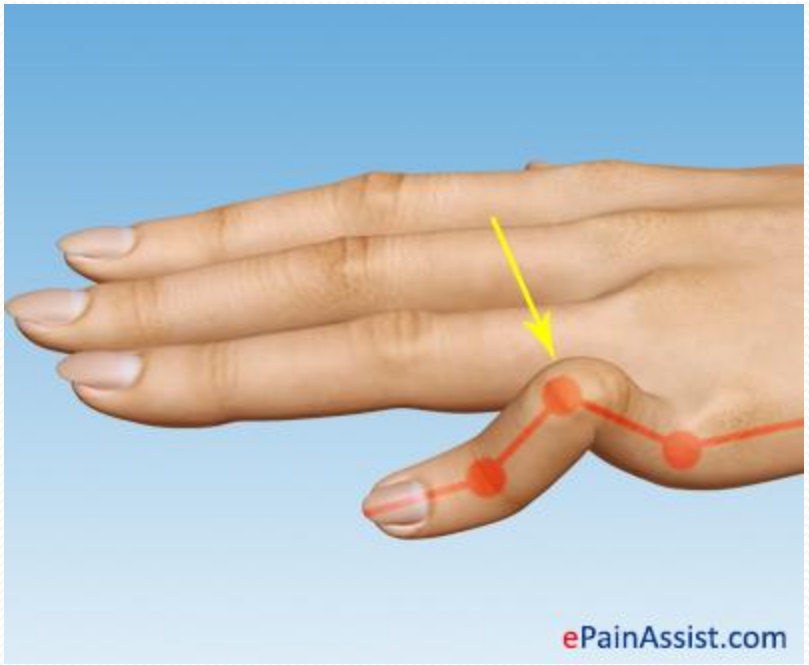
**Mallet finger splint; Hammer finger splint**

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# Boutonniere deformity

- A disrupted central slip in a phalange, leading to PIP flexion and DIP hyperextension.

- This is caused by
  - Dorsal trauma over the PIP
  - Rheumatoid Arthritis, or flexion again resistance.




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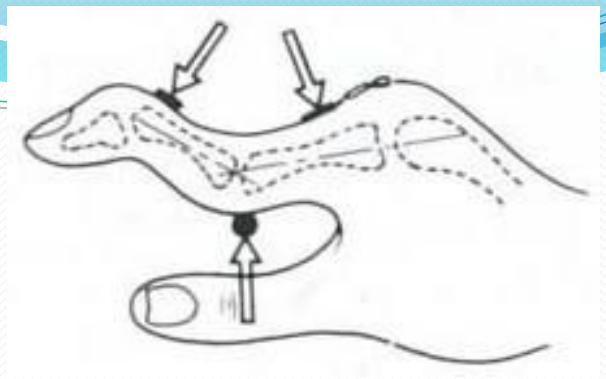
# Boutonniere deformity

- An orthosis is the primary treatment for Boutonniere deformity, and involves immobilising the PIP in extension and allowing at the  MCP and DIP joints

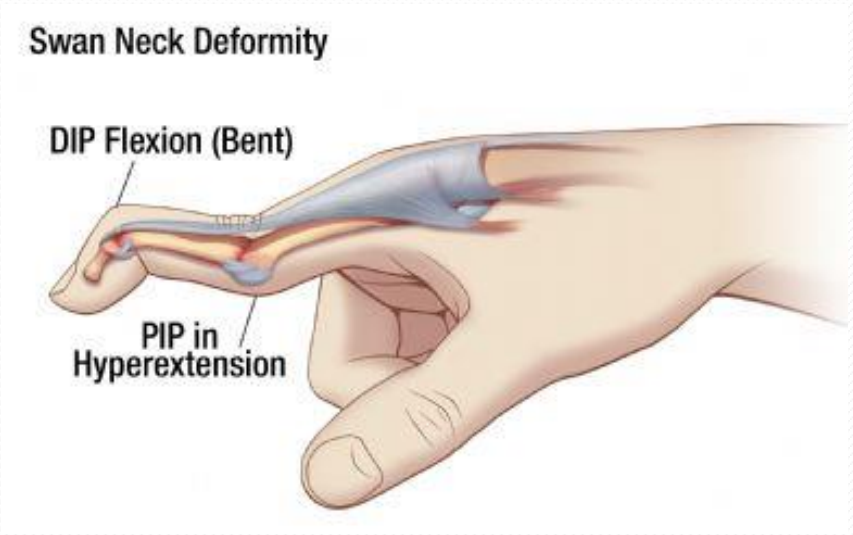


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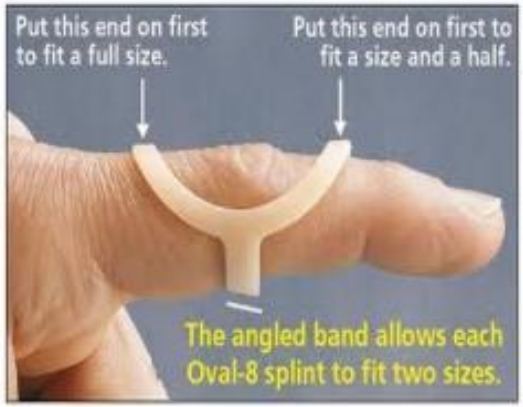
# Swan neck deformity



- The PIP joints is hyperextended and the DIP joint is flexed due to an imbalance between the flexors and the extensors.




- This deformity is often seen in RA
- Apply Three point pressure system to Immobilize the PIP joint in flexion in (25-30 degrees)
- Allow full ROM at the MCP and DIP joints




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# References


- Pat McKee and Leanne Morgan: Orthotic in Rehabilitation~Splinting the Hand and Body~, F.A.Davis. 1998
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- Linda J. Miner, Virginia S. Nelson: Upper Limb Orthoses, Orthotics ~Clinical Practice and Rehabilitation Technology~, Churchill Livingstone. 1995


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