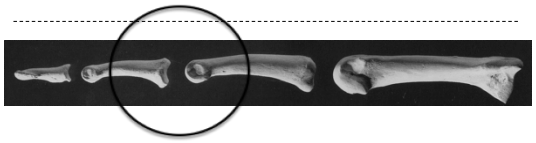

The Proximal Interphalangeal Joint

Emily Altman, PT, DPT, CHT, OCS

Thank You

- **Scott W. Wolfe, MD**
  - Attending Orthopaedic Surgeon, Hospital for Special Surgery
  - Chief Emeritus of the Hand and Upper Extremity Service, Hospital for Special Surgery
  - Director, Center for Brachial Plexus and Traumatic Nerve Injury, Hospital for Special Surgery
  - Professor of Orthopedic Surgery, Weill Cornell Medical College

2

Objectives

- Anatomy
- Biomechanics
- Soft tissue injuries
  - Ligament
  - Tendon
- Fractures/dislocations
- Surgical repairs
- Implications for rehabilitation

3

The PIP Joint

- The Fibonacci series
  - 0,1,1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144…..
- The center of the digit
- The epicenter of hand function
- Anatomical and functional locus of the finger
- A prime anatomical and functional region, not simply an articulation
- Critical for grasp

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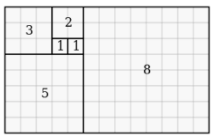
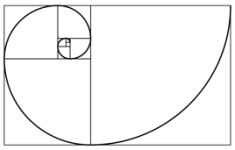
1, 1, 2 ,3 ,5 ,8 ,13 ,21 ,34 ,55 ,89 ,144……





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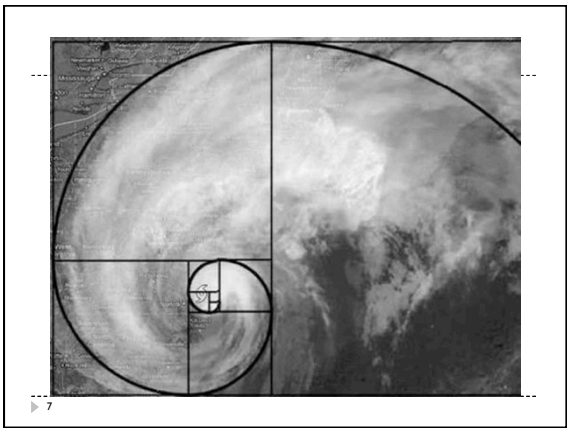
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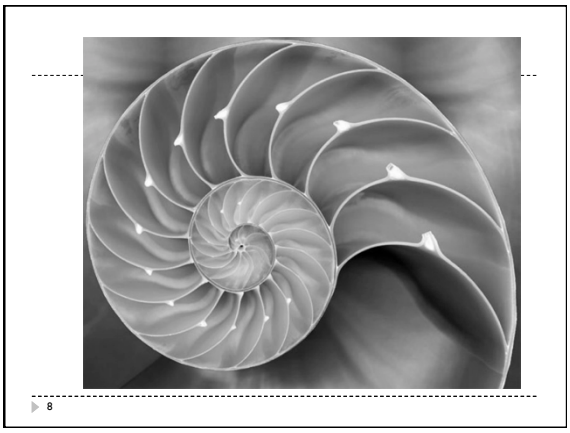
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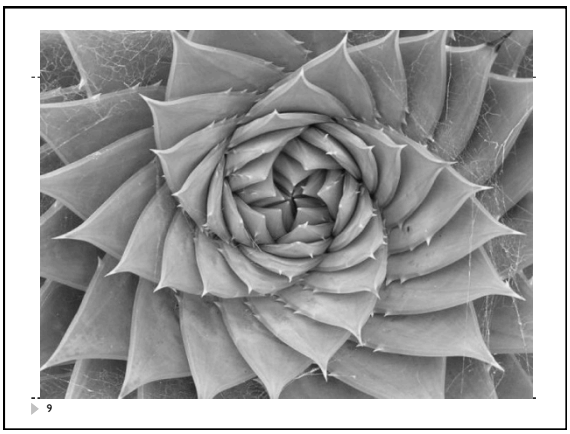
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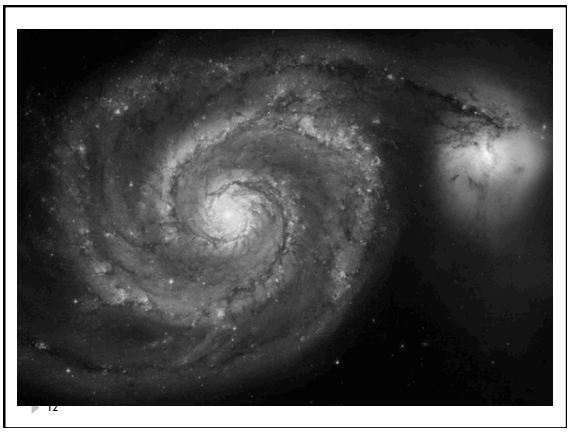
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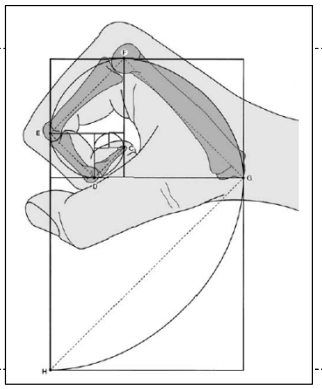

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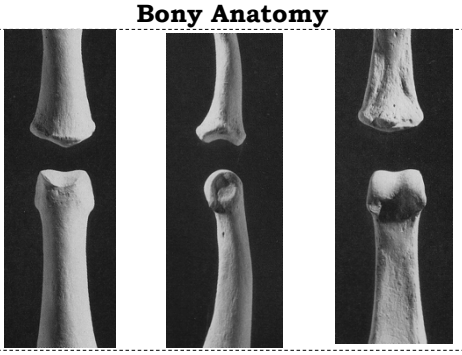
Bony Anatomy



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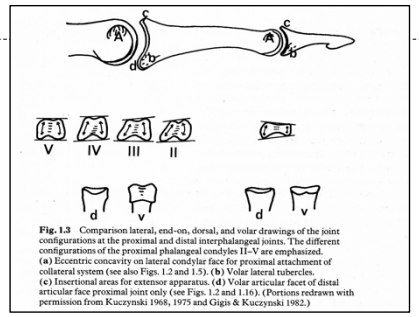

Fig. 1.3 Comparison lateral, end-on, dorsal, and volar drawings of the joint configurations at the proximal and distal interphalangeal joints. The different configurations of the proximal phalangeal condyles II–V are emphasized. (a) Eccentric concavity on lateral condylar face for proximal attachment of collateral system (see also Figs. 1.2 and 1.5). (b) Volar lateral tubercles. (c) Insertional areas for extensor apparatus. (d) Volar articular facet of distal articular face proximal joint only (see Figs. 1.2 and 1.16). (Portions redrawn with permission from Kuczynski 1968, 1975 and Gigis & Kuczynski 1982.)

Bowers WH, ed. The Interphalangeal Joints. Edinburgh: Churchill Livingston; 1987

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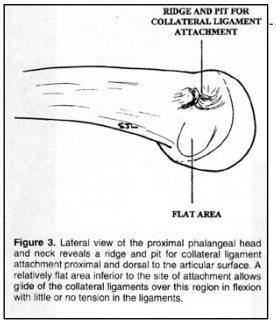

Figure 3. Lateral view of the proximal phalangeal head and neck reveals a ridge and pit for collateral ligament attachment proximal and dorsal to the articular surface. A relatively flat area inferior to the site of attachment allows glide of the collateral ligaments over this region in flexion with little or no tension in the ligaments.

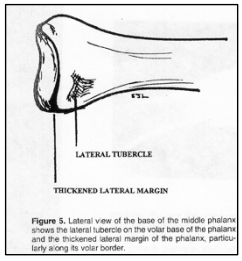

Figure 5. Lateral view of the base of the middle phalanx shows the lateral tubercle on the volar base of the phalanx and the thickened lateral margin of the phalanx, particularly along its volar border.

Bowers WH, ed. The Interphalangeal Joints. Edinburgh: Churchill Livingston; 1987.

16

Ligamentous Anatomy

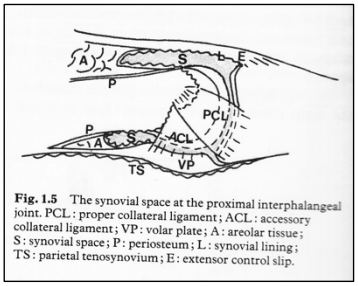

Fig. 1.5 The synovial space at the proximal interphalangeal joint. PCL: proper collateral ligament; ACL: accessory collateral ligament; VP: volar plate; A: areolar tissue; S: synovial space; P: periosteum; L: synovial lining; TS: parietal tenosynovium; E: extensor control slip.

Bowers WH, ed. The Interphalangeal Joints. Edinburgh: Churchill Livingston; 1987.

17

Lateral Stability

- Dynamic: compression of bicondylar articulation
  - Muscle force alone can stabilize the joint
  - Resisted muscle force→nears "physiologic fusion"
  - Lateral stability increases as long as compressive forces remain perpendicular to the axis of motion.
  - Very stable even in the absence of supporting capsular structures
  - Depends on integrity of osseous configuration of the joint

18

Lateral Stability

- Passive: capsular system
  - Toward flexion
    - Oblique course of the PCL + trapezoidal shape of the condyles of P1 improves capacity of the PCL to stabilize
    - 60° to full flexion: PCL is the major stabilizer
    - Muscle force is a less effective stabilizer at end ranges of flexion

19

Lateral Stability

- Passive: capsular system
  - In terminal extension
    - PCL is lax
    - ACL and volar plate become major stabilizing elements
      - ACL fibers are tightened over the condyles
      - Volar plate is held firmly under the joint
      - Longitudinal tension in the volar plate is maximized

20

Lateral Stability

- Between full extension and 60 degrees of flexion
  - Joint may see 7-8° of lateral motion before PCL develops enough tension to resist applied lateral force
- Failure of lateral capsular support = sequential
  - Rupture of volar fibers of the PCL, progressing to dorsal fibers
  - Failure from proximal phalanx
  - Then PCL-ACL junction
  - Then volar plate (fails distally)

21

Volar Capsule/Volar Plate

- Static restraint to PIP joint extension
- Movable floor for the flexor sheath
- Midline access for the vascular feeders to the vincular system
- Proximal attachment resembles a swallow's tail which attaches firmly to bone just inside the walls of the A2 pulley. Confluent with proximal origins of C1 pulley
  - Check rein ligaments bridge the retrocondyler space
  - In this space, transverse arterial feeders proceed medially, join and form a vincular feeder
- Distal end is attached strongly only at is lateral margins
- Central 80% is loosely attached to the periosteum

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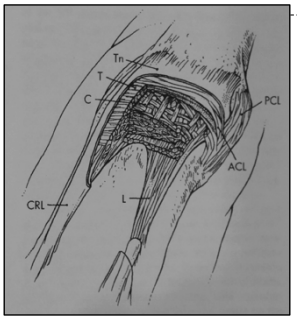

Layers: palmer to dorsal
1. Tenosynovial layer
2. Transverse fibers
   •Continuous with ACL
3. Basketweave of fibers
4. Longitudinal fibers

23

- Extrinsic finger extensors exert powerful stress on the volar plate in final extension via their insertion on the dorsal tubercle of the middle phalanx
  - See PIP joint hyperextension if volar plate is injured
- Volar plate is involved in both boutonniere and swan neck deformities

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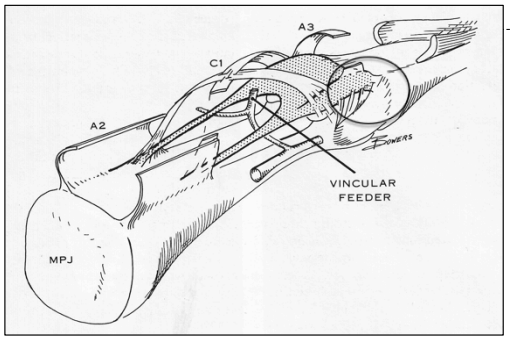

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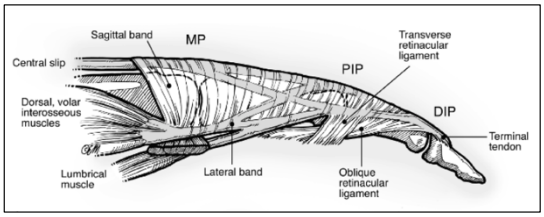

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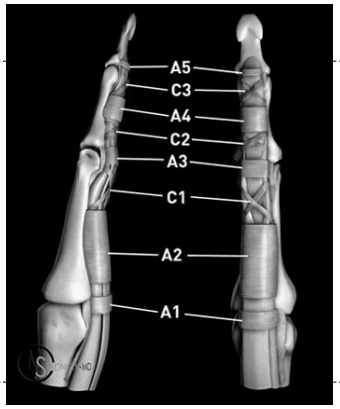

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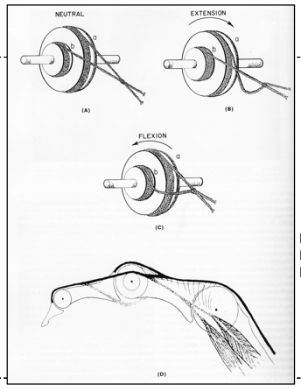


Bowers WH, ed. The Interphalangeal Joints. Edinburgh: Churchill Livingston; 1987

28

Structure	Function	Chronic Contracture	Chronic Instability
Proper Collateral ligament	1) Resists lateral displacement in pinch and grip 2) Provides stable linkage for force transmission across joint	Extension contracture	1) Lateral instability in pinch, grip 2) Asymmetric joint tracking
Volar Plate	1) Resists hyperextension 2) Increases moment arm for flexors 3) Resists lateral stress in full extension	Flexion contracture	1) Hyperextension/ swan neck 2) Locking in hyperextension 3) Recurrent dorsal dislocation 4) Extension contracture
Accessory Collateral Ligament	With volar plate, resists lateral stress in full extension	Flexion contracture	
Oblique Retinacular Ligament	Extends DIP as PIP is actively extended	Flexion contracture	

29

Volar Plate Injuries

- Surgical management is rare
- Hyperextension force: stresses volar plate and ACL
- Treated with splinting in slight flexion. AROM of the PIP joint is permitted

30

Dislocations

- Dorsal, Volar, Lateral
- Named for position of the middle phalanx in relation to the proximal phalanx
- Acute Dorsal PIP dislocation
  - Hyperextension/axial load
  - In pure dx: collateral ligaments remain intact, volar plate is sheared off base of the middle phalanx
  - Can see small avulsion fragment
  - Early protected motion
  - Buddy straps

31

32

Volar Dislocation

- Uncommon
- Injury to central slip + one or both collateral ligaments.
- Splint in extension

33

34

Lateral Dislocation

- Result from a rotatory force
- Collateral ligament, dorsal capsule, volar plate
- At least a partial avulsion of the volar plate from the middle phalanx
- More then 20° of deformity on gentle passive testing in extension indicates complete collateral ligament disruption
- Buddy strapping once reduced
- Unable to reduce→interposition of lateral band

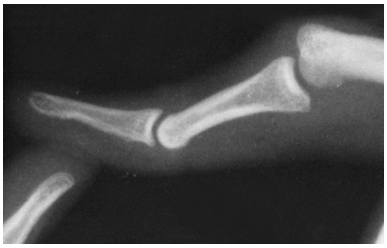
35

Rotatory

- Complex dislocation
- Collateral ligament tear caused by lateral stress combined with a volar-directed force
- Head of the proximal phalanx pierces between the central slip and the lateral band
- Once reduced:
  - No PIP extension lag→short term immobilization
  - Yes PIP extension lag→strict extension splinting

36

Rotational



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If Stable

- Central Slip Avulsion
  - Strict PIP extension splinting 6-8 weeks
  - DIP AROM
- Volar Plate Avulsion
  - Dorsal splint in slight flexion
  - PIP AROM into flexion
- Collateral Ligament Injury
  - Buddy strapping

38

Deformities

- Swan neck
  - Common in RA
    - Loosening of ligaments and joint capsules
    - Imbalance at MP joint
      - Loss of extensor moment
      - Tendon subluxation
  - Chronic mallet finger
  - Increase in moment arm of extension at the PIP joint
  - Fire FDP→ DIP flexion and PIP remains hyperextended (can't over come extensor moment arm)
  - Attenuation of volar plate
  - Attenuation of transverse retinacular ligament
  - DIP extension lag

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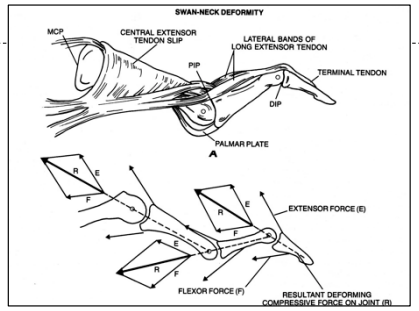

Nordin M, Frankel VH. Basic Biomechanics of the Musculoskeletal System. Malvern, PA; Lea & Febiger:1989

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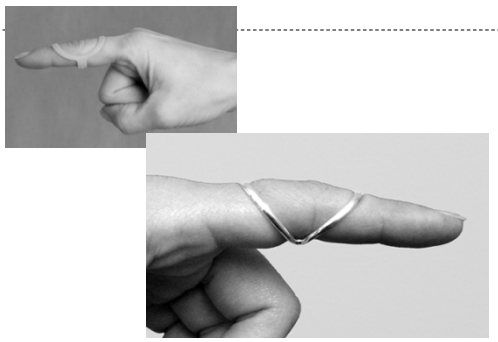

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Deformities

- Boutonniere
  - Rupture or failure of the tendon complex over the dorsum of the PIPJ
  - Lateral bands carry full force of the extrinsic extensor tendon
  - Lateral bands fall palmarly
  - PIP joint is left entirely without extensor tendon

42

- Elson's test for acute boutonniere
  - PIP joint passively flexed over edge of table
  - Pt asked to actively extend PIPJ against resistance
  - If ruptured: feel no power of PIP extension and feel significant extension power or even see hyperextension of the DIP joint
  - Pain may limit test

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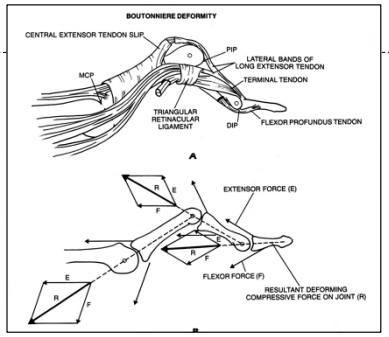

Nordin M, Frankel VH. Basic Biomechanics of the Musculoskeletal System. Malvern, PA; Lea & Febiger:1989

44

Acute Treatment-Boutonniere

- Full time extension splinting of PIP joint: 6-8 weeks
- +/- DIP free for DIP flexion exercises
  - Hourly to draw lateral bands into correct dorsal alignment
- Night splinting for additional 4-6 weeks

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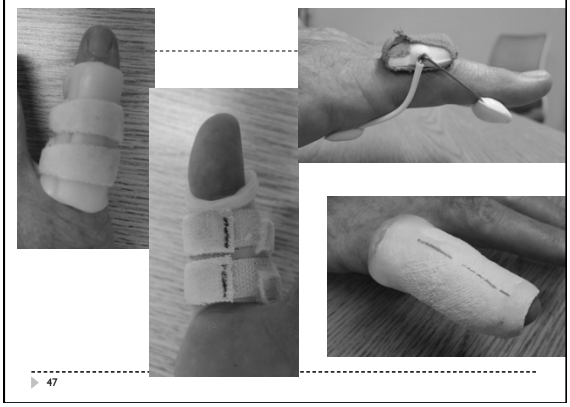

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- Pseudo-boutonniere
  - Avulsion of the proximal attachments of the volar plate
  - Oblique hyperextension injury
  - Calcification appears at site of the avulsed proximal attachment 3-6 months post injury
  - Hyperextension of the DIP joint is less severe

48

- Attritional Boutonniere
  - Attenuation of intact extensor tendons over the PIP joint
  - Tendons intact but functionally ineffective
  - RA, Dupuytrens, palmar skin contractures, intrinsic paralysis, flexor tendon surgery

49

Intra-Articular Fractures

- Head of the proximal phalanx
  - Avulsion fractures
    - Fleck of bone pulled off from the insertion of collateral ligament
  - Condylar fractures (bicondylar, unicondylar)
    - Most are oblique fractures: fragment slides proximally, leaving step in articular surface
    - Highly unstable
    - Require surgery
    - Can be challenging to fix

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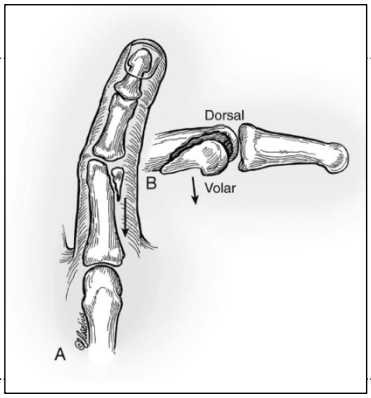

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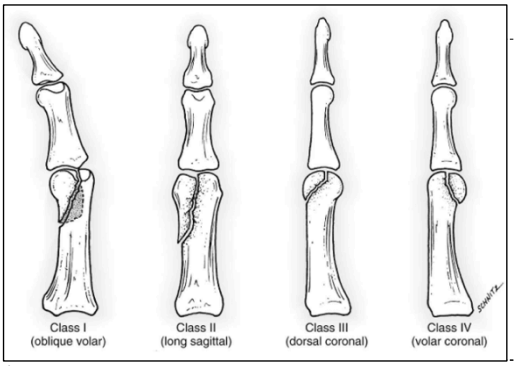

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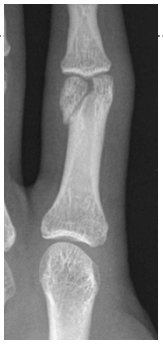


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Intra-articular Fractures

- Avulsion Fractures--base of the middle phalanx
  - Dorsal lip avulsion fracture
    - Bony boutonniere: avulsion of central slip
    - Hyperflexion injury
    - Immobilization in extension
  - Volar lip avulsion fracture
    - Common injury of the PIP joint
    - Hyperextension injury
    - Volar plate pulls off distal insertion with piece of bone
    - Comminution is rare
    - Splint immobilization (dorsal block splint in slight flexion)
    - Avulsion is often missed

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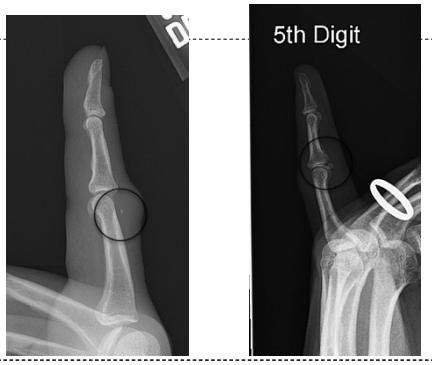

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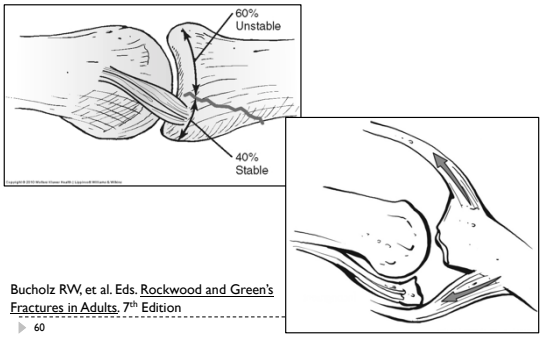
Dorsal Fracture Dislocation

- Volar fracture fragment, dorsal subluxation of P2
  - Axial load the slightly flexed PIPJ
  - Impaction shear fracture
  - Larger fragment than avulsion fracture, comminution
  - Reduce, splint in flexion. Extension is unstable position

59

Volar Fracture/Dorsal Subluxation



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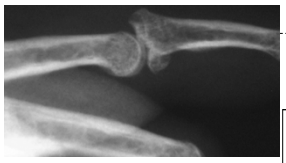

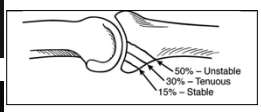

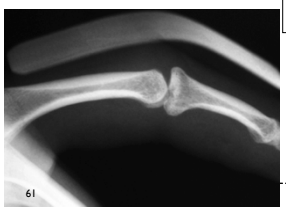

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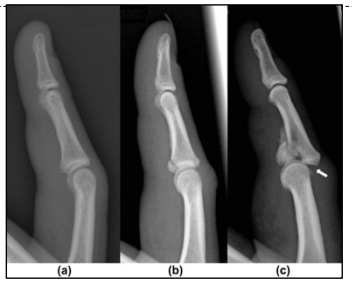

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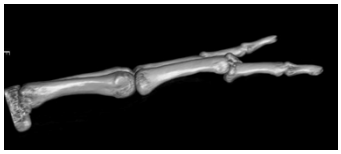
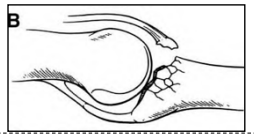
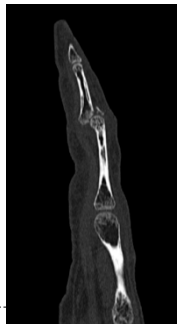
Volar Fracture Dislocation







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Pilon Fractures

- Articular impaction that splays the dorsal/palmar and radial/ulnar margins of the bone
- Unstable
- Skeletal traction device

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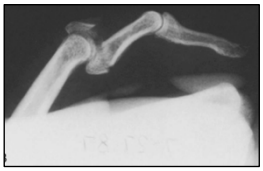
Pilon Fractures



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Surgical Repair Techniques for Fractures

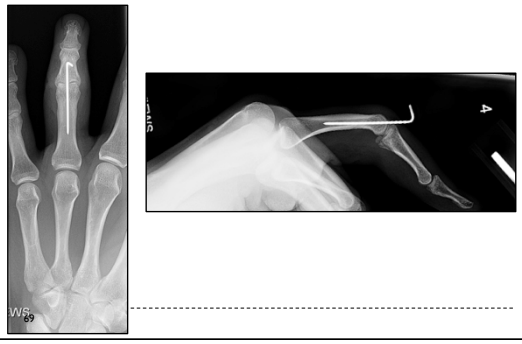
- ORIF: single, large fragment
- Extension block pinning
- Ex-fix/traction
- Hemihamate Autograft
- Volar Plate Arthroplasty
- Cerclage Wire

67

ORIF

68

Extension Block Pinning



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Pinning in Extension

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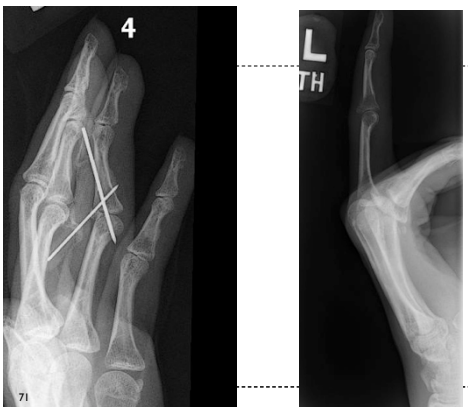

71

Dynamic Skeletal Traction

- Use of ligamentotaxis to achieve joint and fracture reduction
  - Pilon injuries
  - Unstable injuries with several small fragments constituting 30-50% of joint surface
  - Can be combined with pin fixation
  - Joint is not opened

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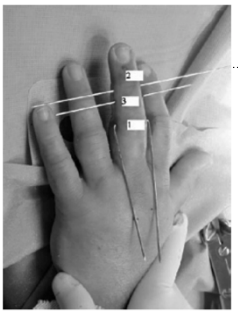

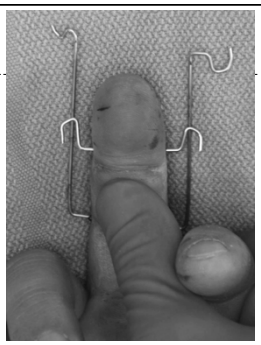

Ruland RT, Hogan CJ, Cannon DL, Slade JF. Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. J Hand Surg. 2008;33A:19-25.

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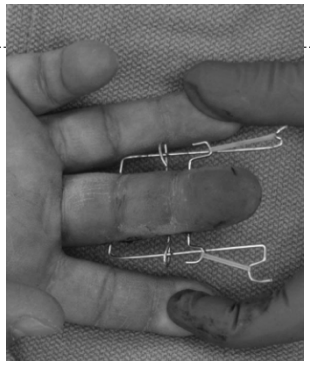

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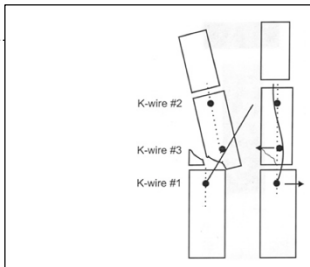

FIGURE 3: Drawing illustrating the lever-assisted reduction of a fracture-dislocation.

Ruland RT, Hogan CJ, Cannon DL, Slade JF. Use of dynamic distraction external fixation for unstable fracture-dislocations of the proximal interphalangeal joint. J Hand Surg. 2008;33A:19-25.

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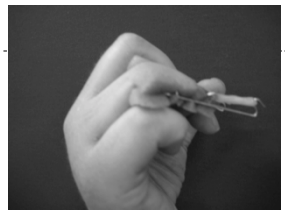

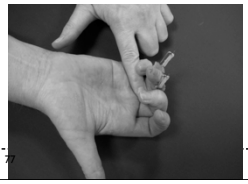

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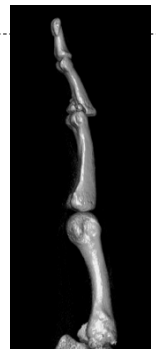

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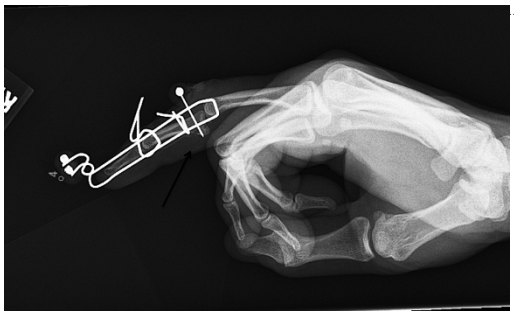

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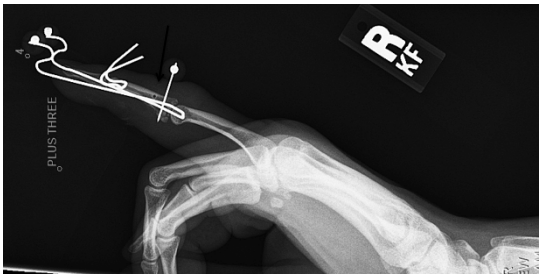

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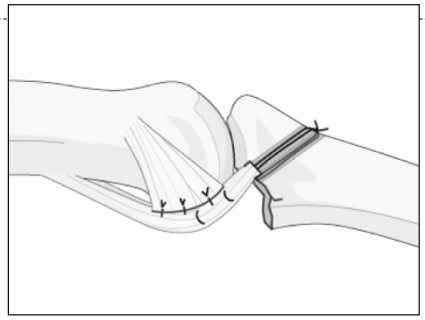
Volar Plate Arthroplasty

- Soft tissue biological arthroplasty
- Advance volar plate into the defect
- Reconstruct volar buttress
- For dorsal fracture dislocations <50%
- Volar incision
- Kwire for 2-3 weeks, DBS
- Dynamic extension splint at 6-8 weeks

82



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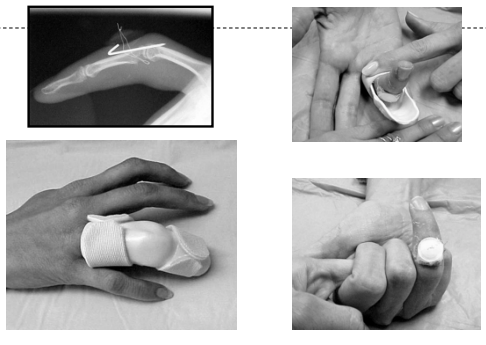


84

Hemihamate Autograft

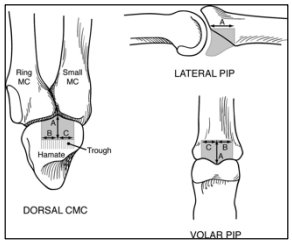
- Autograft is harvested form the dorsal distal aspect of the hamate and used to recreate the volar lip of the proximal end of the middle phalanx.
- >50% articular involvement
- Chronic

85

86

Hemi-Hamate Autograft

- Harvest portion of hamate and use as volar lip of proximal end of middle phalanx



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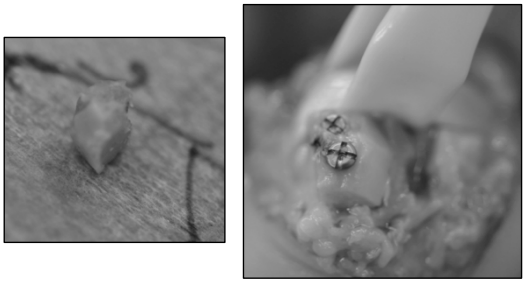
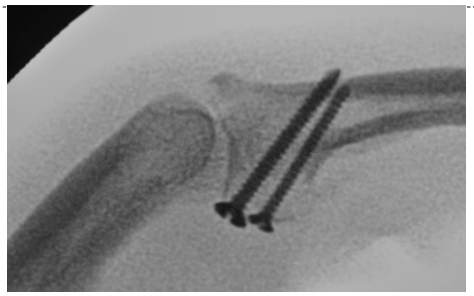


Courtesy of Scott W. Wolfe, MD

88



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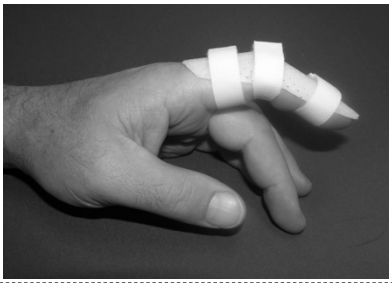
Post-op Splint
Dorsal Blocking Splint



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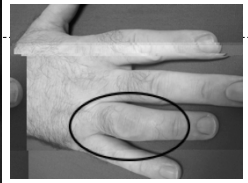
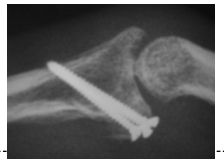



91

Cerclage Wiring

- For pilon or comminuted fractures with fragments too small for individual screw fixation
- Shotgun the joint (hyperextend after detachment of the volar plate and collateral ligaments)
- Elevation and grafting of depressed fragments
- Place cerclage wire to prevent widening of the articular surface

92

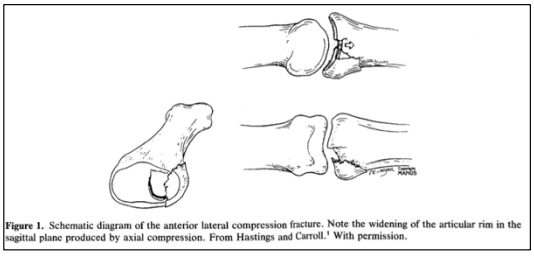


Figure 1. Schematic diagram of the anterior lateral compression fracture. Note the widening of the articular rim in the sagittal plane produced by axial compression. From Hastings and Carroll.[1] With permission.

93

94

RA PIP Joint

- Extrinsic factors affecting PIP function
  - MCP joint involvement
    - Subluxation of EDC tendon, sagittal band rupture
    - Underopposed flexion of MCP joint
    - Volar subluxation of the MCP joint
    - Intrinsic shortening
  - Stretching or rupture of the terminal extensor tendon at DIP joint
    - Too much extension force delivered to PIP joint→swan neck
    - Swan neck at PIPJ
  - Flexor tenosynovitis or flexor tendon rupture
    - Underopposed extensor force→swan neck
- PIP joint synovitis→attenuation of central slip

95

RA PIP Joint

- Boutonniere deformity
  - Dorsal synovitis and capsular distension at the PIP joint
    - Lengthening of the central slip
    - Palmar displacement of the lateral bands of the long extensor
    - Shortening of transverse retinacular ligament
    - Volar plate contracture
    - ORL shortening
    - DIP hyperextension
- Swan neck deformity
  - Extrinsic factors impacting PIPJ (previous slide)
    - Excessive extension force at PIPJ
    - Attenuated transverse retinacular ligament
    - Attenuated volar plate
    - Dorsal displacement of lateral bands
    - Intrinsic muscle shortening
    - DIP flexion posture

96

97

98

Soft Tissue Reconstructions-RA

- Boutonniere
  - Attempts to rebalance
  - Arthrodesis
  - Arthroplasty
- Swan-neck
  - Superficialis tenodesis
  - Intrinsic release
  - Arthroplasty

99

Soft Tissue Reconstruction

- Proximal Fowler Tenotomy
  - Treatment for mallet finger
    - Mature terminal tendon that has healed with slight elongation resulting in a persistent extension lag
  - Central slip tenotomy
  - Extensor mechanism slides proximally
  - Tethering effect of the central slip is removed
  - Boutonniere does not result because triangular ligament is intact and release is done from underneath the extensor mechanism

100

Soft Tissue Reconstruction

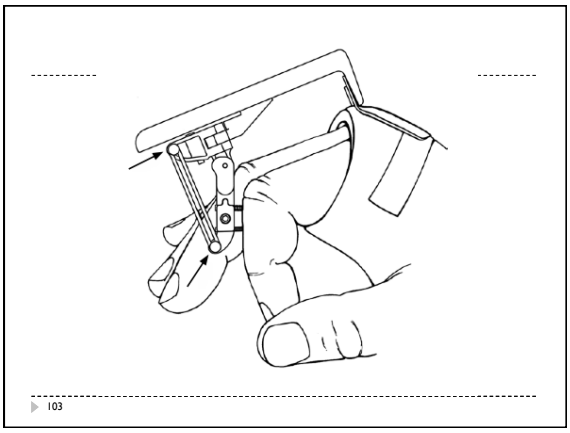
- Distal Fowler
  - Treatment of chronic, supple boutonniere
  - Intentional sectioning of the terminal tendon
  - Does not result in a mallet finger!

101

Digit Widget

- www.handbiolab.com
- Treatment of PIP flexion contractures
- Extension torque, transmitted to the joint by bone pins in the middle phalanx, "grows" all contracted palmar tissues back towards normal length
- Avoids skin pressure limitations of conventional splints and casts
- The ultimate dynamic PIP extension splint!

102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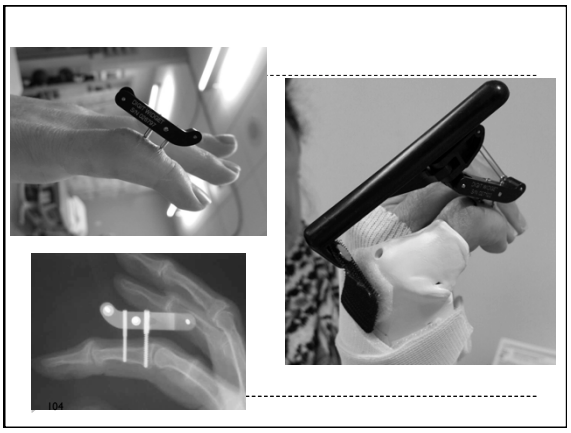
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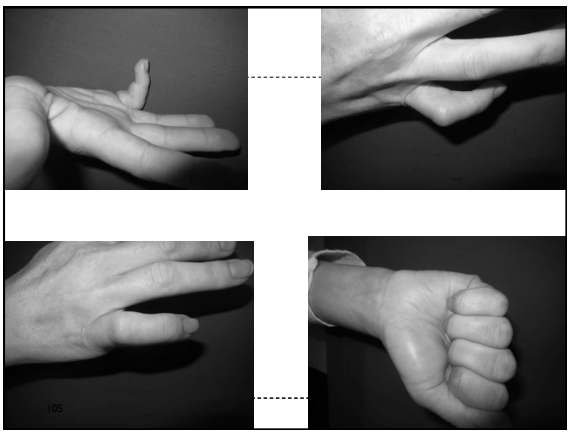
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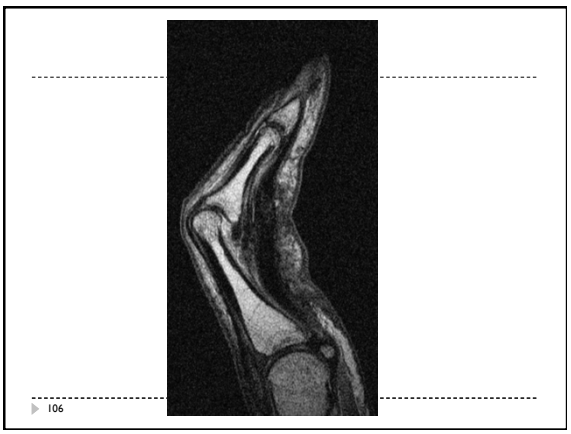
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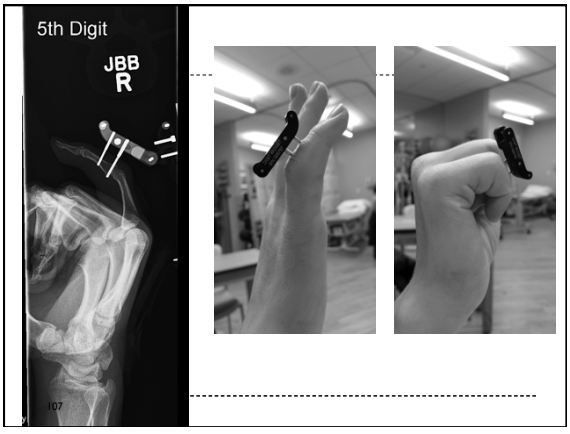
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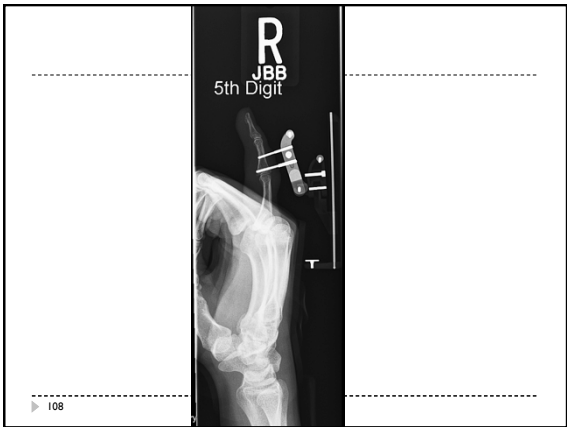
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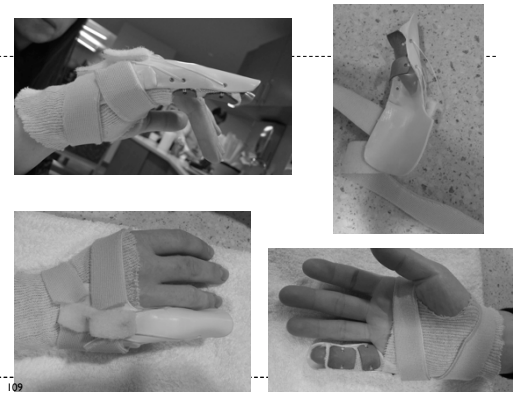

109

Implications for Rehabilitation

- Improved, detailed knowledge of the PIP joint improves
  - Evaluation skills
  - Diagnostic skills
  - Splint design skills
  - Program progression skills
- Knowledge of surgical procedures
  - Improves patient outcomes

110

Thank You

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111