The thumb and fingers... everything that you probably forgot

Norman J Arbelo Cruz
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  – Mama Pathria
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  – Uncle Tudor
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  – Eddie “The hitman” ...... “one love”
  – The Sampaths
  – Christine “AI” Chung.... Power3d by Watson
Disclosures

• None

• * some of the slides are busy with lots of wording. This is intended to avoid a gazillion slides and enable to make self review easier.
Objectives

• Lesser digits flexor system
  – anatomy injuries
  – pulley system and injuries
  – volar plates
  – collateral ligaments

• Thumb
  – Anatomy
  – injuries

• Lesser digits extensor system
  – anatomy
  – sagittal band
  – extensor hood and retinacular system
  – injuries
Digit flexor tendons
Digit Flexor tendons anatomy

Flexor digitorum superficialis (FDS)

- superficial to FDP, bifurcating at the level of mid proximal phalanx
- At level PIP the slips divide again into 2 smaller slips crossing at midline and reuniting into the opposite slip forming Camper’s chiasm
- Finally inserting on the middle phalanx

Flexor digitorum profundus (FDP)

- Courses deep to the FDS, until the FDS splits at the level of mid proximal phalanx, at which point is located superficial
- Continues its course until inserting on the volar aspect of the distal phalanx

  - Distally it contains a median longitudinal groove or furrow volarly that can resemble a split tendon

1Gupta, P. AJR 2014
FDS and FDP

- Camper’s chiasm (arrow)
- FDS with longitudinal groove (arrow heads)

Gupta, P. AJR 2014
FDS and FDP

Courtesy Dr. Smitaman and Dr. Ortiz
Finger flexion clinical examination

**FDS**
- To test hold MCPJ, PIPJ, and DIPJ of other fingers extended
- Ask patient to flex PIPJ
  - Repeat with other fingers
  - Congenital absence of the FDS is present unilaterally in 6.8%

**FDP**
- To test place hand supine, press middle phalanx into table and ask patient to flex DIPJ
- Quadriga effect
  - Tendon shortened due to surgery or injury
  - Since FDP tendons share a common muscle belly, this leads to a flexor lag
  - Examined by asking patient to make a fist
    - Fingers adjacent to injured digit will not fully flex
Flexor tendon injuries

- Injuries are not as common as the extensor tendons
  - Divided into 5 zones
    - Zone 1 – FDP insertion to distal insertion of FDS
    - Zone 2 (no man’s land) – FDS insertion to distal palmar fold
      - Problematic repair owing complexity of this region. Carry worst prognosis
      - Historically, zone 2 injuries were considered surgically irreparable.
    - Zone 2-5
      - Injuries may involve both FDS and FDP resulting in loss of active flexion
- Most common injuries are lacerations and avulsion injuries
  - FDP is more commonly avulsed than the FDS
  - FDP avulsion can be osseous or soft tissue
    - Jersey finger

Newton AW. Orthopaedics and Trauma 2018
Flexor tendon injuries

- 33yo male with small finger pain.

Jersey finger if tear of FDP at insertion

Rupture of FDS and injury to A2 pulley.
Courtesy Dr. Brady Huang
Flexor tendon injuries

Complete tear and retraction of the FDS.
Courtesy Dr. Brady Huang
Pulley system

• Retinacular structures that maintain the flexor tendon relationship to the joint axes
  – Ensure optimal muscle effort and tendon excursion while flexing finger
  – Prevent buckling or bowstringing
  – Allow efficient conversion of translational force of the muscle to a rotational movement of the fingers
  • Without a pulley, a larger excursion and effort of the tendon would be required to generate same degree of motion.

• Composed of the transverse carpal ligament, palmar aponeurosis and digital flexor pulley\(^1\)
  – Digital flexor pulley composed of
    • Synovial component – tendon sheath
    • Pulley (retinacular) – fibrous reflections

\(^1\)Doyle JR. Clinical orthopaedics and related research 2001
Pulley system

• Consist of localized thickening of the digital tendon sheath
  • 5 annular
  • 3 cruciate

  – A1, A3, A5
    • Located at level of the joint and attach to volar plate
      – MCP, PIP, and DIP respectively

  – A2 and A4
    • Located mid portion of proximal and middle phalanx

  – C1, C2, and C3
    • Located distal to A2, A3 and A4
    • Allow some degree of bowstringing

**Thumb pulleys will be discussed in thumb section**
Pulley system

- Bowstringing is characterized by a gap between the flexor tendon and the volar surface of the bone.

- Optimal visualization of these injuries is performed while flexing finger. Dynamic imaging, such as ultrasound provide advantage.
I JUST WISH I COULD UNDERSTAND...
WHY I SHOULD CARE!
# Pulleys

## TABLE 4. Moment Arm and Motion at the Metacarpophalangeal, Proximal Interphalangeal, and Distal Interphalangeal Joints

<table>
<thead>
<tr>
<th>Joints</th>
<th>Moment Arm (millimeters)</th>
<th>Lost Joint Motion (degrees)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacarpophalangeal</td>
<td>2 mm increase (10 to 12)</td>
<td>85 to 68</td>
</tr>
<tr>
<td>Proximal interphalangeal</td>
<td>1.5 mm increase (7.5 to 9)</td>
<td>110 to 88</td>
</tr>
<tr>
<td>Distal interphalangeal</td>
<td>1 mm increase (5 to 6)</td>
<td>65 to 52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>260 to 208* (total)</td>
</tr>
</tbody>
</table>

*Finger tip fails palm: 2.5 +/- cm (1 inch).
A comparatively slight increase in the moment arm results in a significant loss of finger flexion.

## TABLE 5. Joint Range of Motion, Moment Arm, and Tendon Excursion

<table>
<thead>
<tr>
<th>Joint (ROM)</th>
<th>Moment Arm (millimeters)</th>
<th>Excursion (millimeters)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metacarpophalangeal (85)</td>
<td>10*</td>
<td>14.8*</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>17.8</td>
</tr>
<tr>
<td>Proximal Interphalangeal (110)</td>
<td>7.5*</td>
<td>14.4*</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>17.3</td>
</tr>
<tr>
<td>Distal Interphalangeal (65)</td>
<td>5*</td>
<td>5.7*</td>
</tr>
</tbody>
</table>

*Normal Values

\[Joint \text{ ROM} \times \text{ MA} = \text{ Excursion}\]

57.29°

The relationship between required range of motion, normal and increased moment arm, and the resultant excursion. Joint range of motion divided by one radian multiplied by the moment arm yields excursion (see text.) MA = moment arm.

Doyle JR. Clinical orthopaedics and related research 2001
### Pulleys

**TABLE 6. Flexor Tendon Biomechanics After Pulley excision with the Skin Intact**

<table>
<thead>
<tr>
<th>Pulley(s) Excised</th>
<th>Intact</th>
<th>Percent difference</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tendon Excursion</td>
<td>Work of Flexion</td>
</tr>
<tr>
<td>A1</td>
<td>A2, A4</td>
<td>$-0.64 \pm 2.04$</td>
<td>10.00 ± 8.16</td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>A1, A4</td>
<td>$8.50 \pm 1.62$</td>
<td>44.10 ± 7.15</td>
<td></td>
</tr>
<tr>
<td>A4</td>
<td>A1, A2</td>
<td>$9.93 \pm 3.40$</td>
<td>19.95 ± 10.21</td>
<td></td>
</tr>
<tr>
<td>A1, A2</td>
<td>A4</td>
<td>$20.56 \pm 3.67$</td>
<td>62.36 ± 13.91</td>
<td></td>
</tr>
<tr>
<td>A2, A4</td>
<td>A1</td>
<td>$33.66 \pm 4.60$</td>
<td>107.04 ± 22.77</td>
<td></td>
</tr>
<tr>
<td>A1, A4</td>
<td>A2</td>
<td>$9.69 \pm 1.91$</td>
<td>39.83 ± 8.70</td>
<td></td>
</tr>
<tr>
<td>A1, A2, A4</td>
<td>none</td>
<td>$65.09 \pm 6.21$</td>
<td>172.35 ± 15.30</td>
<td></td>
</tr>
</tbody>
</table>

A = annular pulleys.

Pulley injury

- Injuries: A2 > A3 > A4 > A1
- Gap between flexor tendon and phalanx should be <1-2 mm
- Partial tear → conservative tx
- Complete tear → surgery

Clavero JA. RadioGraphics 2002
Pulleys

• If surgery needs to be performed
  – Preservation or reconstruction of all components of the pulley system is a worthy goal, but not always possible
  – Most important pulleys to preserve or reconstruct are the A2 and A4 pulleys¹

¹Gupta, P. AJR 2014
Volar plates

- Dense fibrocartilaginous structure located volar to the joint capsule and helps prevent hyperextension of the joints.
  - 3 volar plates in digits
  - 2 volar plates in thumb

- Collateral ligaments also contribute to stability

- PIPJ volar plate has different arrangement proximally
  - Plate extends into two appendages known as check-rein ligaments
  - The space between the check-rein ligaments allow passage for digital vessels under the flexor sheath and vincular arteries.

**Thumb has both dorsal and volar plates**
Volar plates

- Multiple classifications for volar plate injuries
  - Most used are\(^1\)
    - Eaton’s
    - Keifhaber-Stern
  - Stable injury usually involves <40% of the articular arch
  - Unstable injuries involve >40%, with volar plate and collateral ligaments attached to the fracture fragment

\(^1\)Pattni, A. Eplasty 2016
Volar plates

- Need to place special attention to location of avulsed volar plate.
- Displacement of the plate between fracture fragments or located in joint space may affect healing and reduction attempts.

Clavero, JA. Radiographics 2002
Collateral ligaments

- Main stabilizers of the MCP and IP joints
  - Injury can lead to instability
  - Thumb UCL most commonly affected
- Accessory collateral ligament are contiguous with the volar plate

Newton et al. Orthopedics and trauma 33:1
Collateral ligaments

- Right hand pain for several weeks, caught in a sliding door sometime in August. Radiographs from 9/22/2017 were negative. Pain not improving. No history of rheumatologic disease noted in epic.
Dupuytren Contracture (palmar fibromatosis)

- Most common superficial fibromatosis
  - Affects 1-2% of population
  - Seen almost exclusive in Caucasian
    - Usually >65yo
    - Men most affected
  - Etiology not well understood
    - Trauma, microvascular injury, immune mediated, genetic factors
  - Presents painless subcutaneous nodule
    - May progress into fibrous cords that attach and cause traction to the flexor tendons

Murphy, MD Radiographics 2009
Stenosing tenosynovitis (tenovaginitis)

- Inflammation, thickening, and mechanical mass effect upon a tendon
  - De Quervain tenosynovitis
  - Trigger finger
  - Trigger thumb

- It’s common for diagnosis not to be apparent prior to imaging
  - Thus important for radiologist to be aware of this entity

Vuillemin, V. J Ultrasound 2012
Stenosing tenosynovitis (tenovaginitis)

• Represents one of the most common conditions seen in practice of hand surgeons
  – Thumb and ring finger most commonly affected

– Common risk factors
  • DM
  • obesity
  • female
  • certain occupations with high activity levels

Chang, EY. Skeletal Radiol 2015
Stenosing tenosynovitis

• Can be a result of a multitude of factors
  – Mechanical
  – Inflammatory process
  – Tumors
  – Hormonal

• Non-operative management provides satisfactory results
  – Failures treated with A1 pulley release

Vuillemin, V. J. ultrasound 2012
Don’t worry

• We covered already half of the stuff and most of the technical factor
Anatomy of the thumb
The volar thumb

- **Carpometacarpal**
  - Adductor pollicis
    - Transverse head
    - Oblique head

- **Thenar muscles**
  - Abductor pollicis brevis
  - Flexor pollicis brevis
  - Opponens pollicis

- **Forearm**
  - Abductor pollicis longus
  - Flexor pollicis longus
The volar thumb

- **Quick facts**
  - **Adductor pollicis**
    - Inserts at
      - ulnar base 1st proximal phalanx
      - 1st MTP joint volar plate
      - Contributes fibers to extensor hood (forms adductor aponeurosis)
  - **Abductor pollicis brevis**
    - Shares insertion with the flexor pollicis brevis tendon at lateral base 1st proximal phalanx
    - Also contributes fibers to the extensor hood
  - **Flexor pollicis brevis (FPB)**
    - Consists of superficial and deep components
    - Common tendon insertion with the abductor pollicis brevis tendon.
    - Also innervation by branches of the deep-ulnar nerve
  - **Opponens pollicis**
    - Abducts, flexes, and rotates 1st metacarpal
    - Draws thumb across palm
The dorsal thumb

- Extensor pollicis brevis (EPB)
- Extensor pollicis longus (EPL)
- Extensor carpi radialis brevis and longus

- Note location of the 2 intersection sites
Pulleys of the thumb

• 4 pulleys described
  – A1 and A2
  – Oblique
  – Av (3 types)
    • Present in up to 93% specimens
      – Type I – transverse with a small gap between A1
      – Type II – no gap
      – Type III – triangular converging to radial side

Chang, EY. Skeletal Radiol 2015
Thumb MCPJ

- Similar to MCPJ of the lesser digits with some major exceptions
  - Complex range of motion
  - Accessory collateral ligaments attach to sesamoids
  - Flexor tendon don’t exhibit splitting, instead the FPB attaches to radial sesamoid and proximal phalanx radial base
  - Presence of a dorsal plate that’s blends with the EPB with no definite osseous attachment

Rawat, U. Radiographics 2016
Thumb UCL tear

- Violent hyperabduction of the thumb
  - Tear of the ulnar collateral ligament
    - Type I - tear at osseous attachment
    - Type II – tear midsubstance ligament
    - Type III - osseous avulsion
  - Stener lesion – torn ligament displaces superficial to adductor aponeurosis
Thumb UCL Tears

- UCL Tear, no retraction
- UCL Tear, Stener lesion

Courtesy Dr. Brady Huang
Digit Extensor tendons
Digit extensor tendon anatomy

- Extensor tendons
  - Extrinsic
    - Extensor digitorum comunis (Ec)
    - Extensor indexes propius (Ei)
    - Extensor digiti minimi quinti (Ed5)
  - Intrinsic
    - Interosseous
      - Palmar (3)
        » Flexion MCP and adductor
      - Dorsal (4)
        » Flexion MCP and abductor
    - Lumbricals
      - Located palmar to deep transverse palmar ligament
      - Flexor MCP
      - Only tendon originates in tendon and inserts in tendon

***No tendinous insertion of the EDC to the base of proximal phalanx has been demonstrated***
Digit extensor tendon anatomy

- Retinacular system
  - Extensor hood
    • Sagittal band
    • Aponeurotic expansion of the interossei lateral band at each side of digit to base of proximal phalanx between and central slip
  - Retinacular ligaments
    • Secure conjoint tendon to flexor sheath preventing dorsal subluxation\(^1\)
  - Triangular ligament
    Attach the conjoint tendon to dorsum of middle phalanx to prevent palmar subluxation\(^1\)

\(^{1}\)Gupta, P. AJR 2014
Digit extensor tendon anatomy
Digit extensor tendon anatomy
Sagittal band (SB)

- Collagenous structure with a palmar origin from a confluence of the volar plate and flexor tendon sheath.
  - A1 pulley, transverse metacarpal ligament
  - Run superficial to the capsule and collateral ligaments
    - Splits to a thin superficial and thick deep layer to envelop the EDC
  - Proximal margins are free
  - Distal margin blends with the aponeurotic expansion of the interossei

Gupta, P. AJR 2014
Extension of MCP joint

• “Extension of the MCP joint is carried out mainly by the common extensor muscle and the appropriate extensor muscles by means of pulling the tendons over the sagittal band”

• Initially tough that extension of the MCP joint was by a lasso or sling effect from the SB

Figure 22. Drawings show the sling mechanism of extension of the MCP joint. (a) In a neutral position, the sagittal band is relaxed. (b) In the hyperextension position, the sagittal band is tensed, restricting the proximal excursion of the extensor tendon (arrows).

Clavero JA Radiographics 2003
Extension of MCP joint

Mechanics of Metacarpophalangeal Joint Extension

Timothy G. Marshall, BMedSc, MBBS,* Brahman Sivakumar, MBBS, MS,* Belinda J. Smith, BAppSc,* Mark S. Hile, BE(Hons), MBBS*

| TABLE 1. Mean (Range) Force in Newtons Before and After Division of EDC or SB, With MCP Joint in Neutral and Flexed Positions |
|---|---|---|---|---|---|
| Position | EDC | SB |
| | Intact | Divided | P Value | Intact | Divided | P Value |
| Force (N) with MCP joint in extension | 1.14 (0.32–1.92) | 0.19 (0.00–0.47) | < .05 | 1.00 (0.42–1.48) | 0.89 (0.14–1.48) | .13 |
| Force (N) with MCP joint in 45° flexion | 1.88 (1.24–2.35) | 1.22 (0.58–2.02) | < .05 | 1.88 (1.49–2.15) | 1.74 (1.08–2.33) | .16 |

Conclusions The sagittal bands do not primarily extend the MCP as a sling or lasso. The extensor tendon continuation to the extensor hood and middle phalanx is the major extension motor. The MCP joint is extended by the torque generated by the extensor tendon passing the joint carrying a force and possessing an extension moment arm.
Sagittal band injury

• Usually closed injuries resulting from resisting finger extension or direct trauma
  – Punch to mouth with laceration
    • 10% become infected

• Boxer’s knuckle most commonly involve radial sagittal band
  – May lead to instability
  – Ulnar subluxation

• Classified into 3 types
  • Type 1 – contusion without tear or instability
  • Type 2 – tears associated with extensor tendon snapping without complete dislocation
  • Type 3 – tendon dislocation into the intermetacarpal groove

Extensor Hood Injury

Extensor injuries

- Most important injuries
  - Mallet finger
    - Zone I
  - Boutonniere deformity
    - Zone III
Extensor injuries

• Mallet finger (zone 1)
  – Forced flexion at DIP while PIP is extended
    • Produces an avulsion injury of terminal tendon
  – Ask patient to extend fingers
    • If DIPJ is flexed, but the other joint are extended
Extensor injuries

- Boutonniere deformity
  - Injury to the central slip
    - Initially PIPJ extension occurs owing to lateral bands
    - But progresses as lateral slips sublux
    - PIPJ extension with DIPJ flexion

Newton AW. Orthopaedics and Trauma 2018
Extensor tendon injury dynamic imaging
Extensor tendon injury dynamic imaging
Extensor tendon injury dynamic imaging
Summary

• Understand concept that both extensor and flexor mechanism of the digits consist both of tendinous and retinacular structures that work as a single unit
  – Failure of the retinaculum (pulley) leads to increased effort and work
    • Place attention to location of flexor tendon on sagittal
  – Failure of the tendon may lead to complete failure of joint
    • Early bouttonniere deformity may be masked
References

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