MEDICAL EDUCATION RESOURCE

# Clinical Anatomy of Carpal Bones

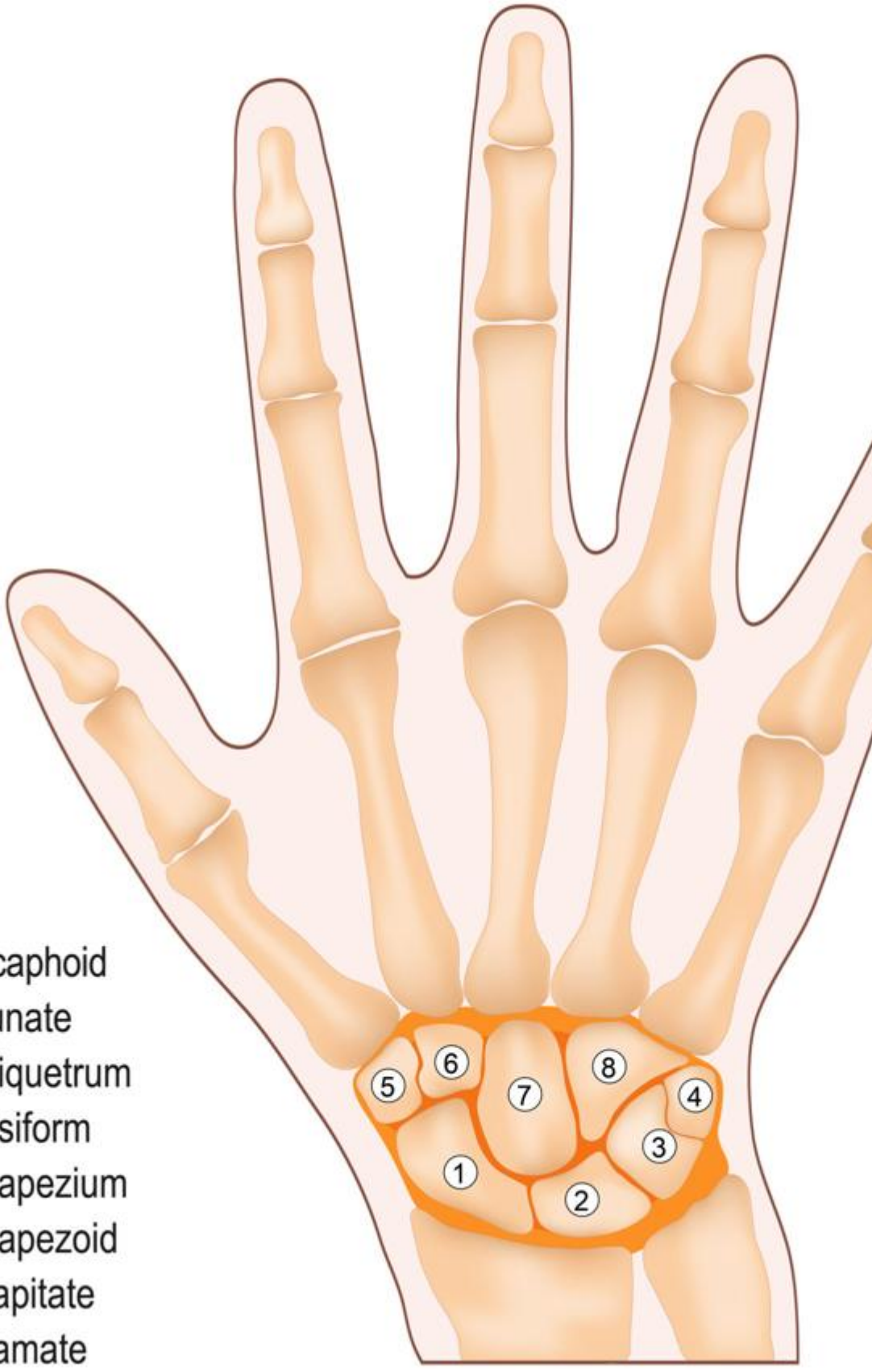
# CLINICAL ANATOMY AND OSSIFICATION OF CARPAL BONES

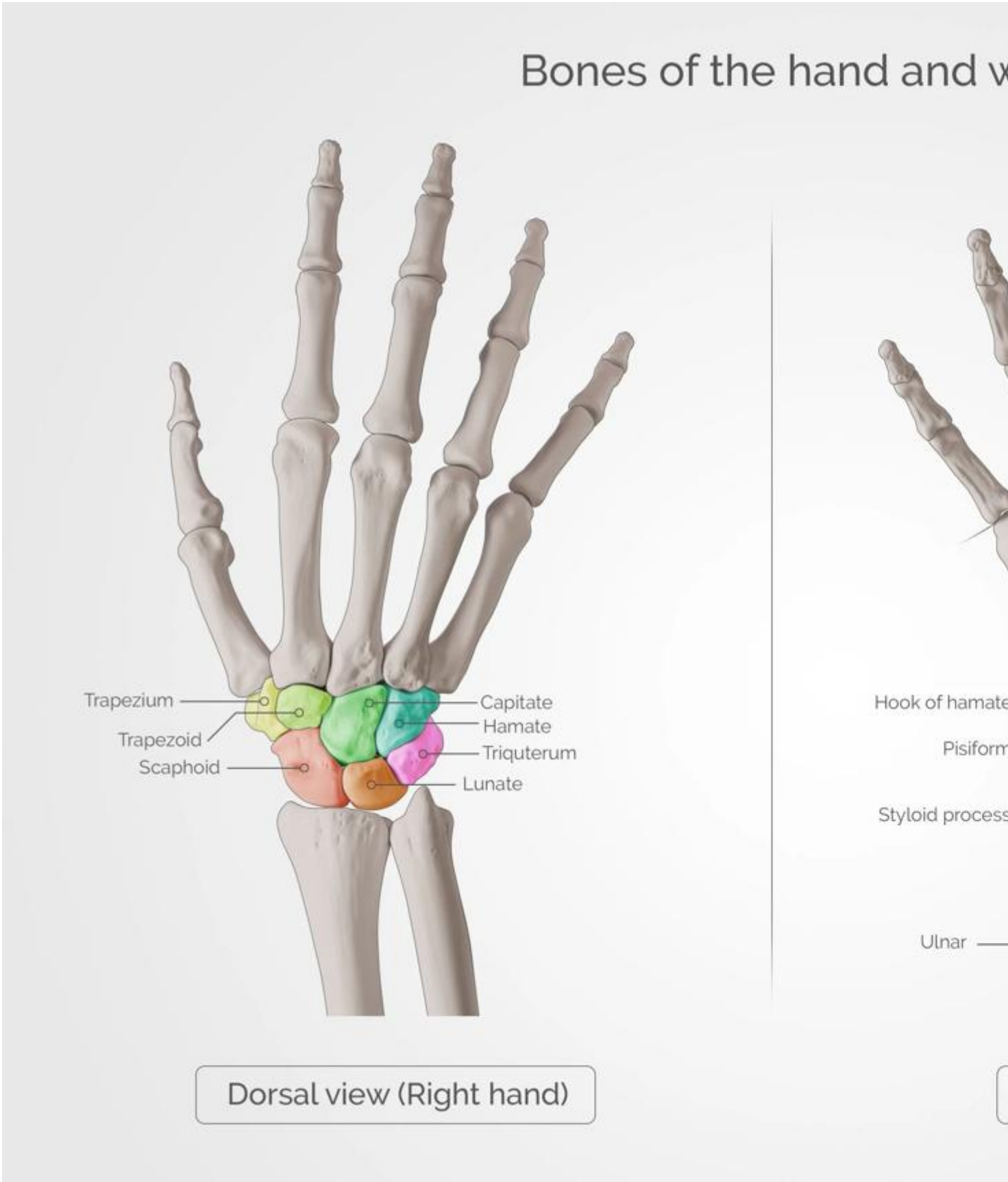
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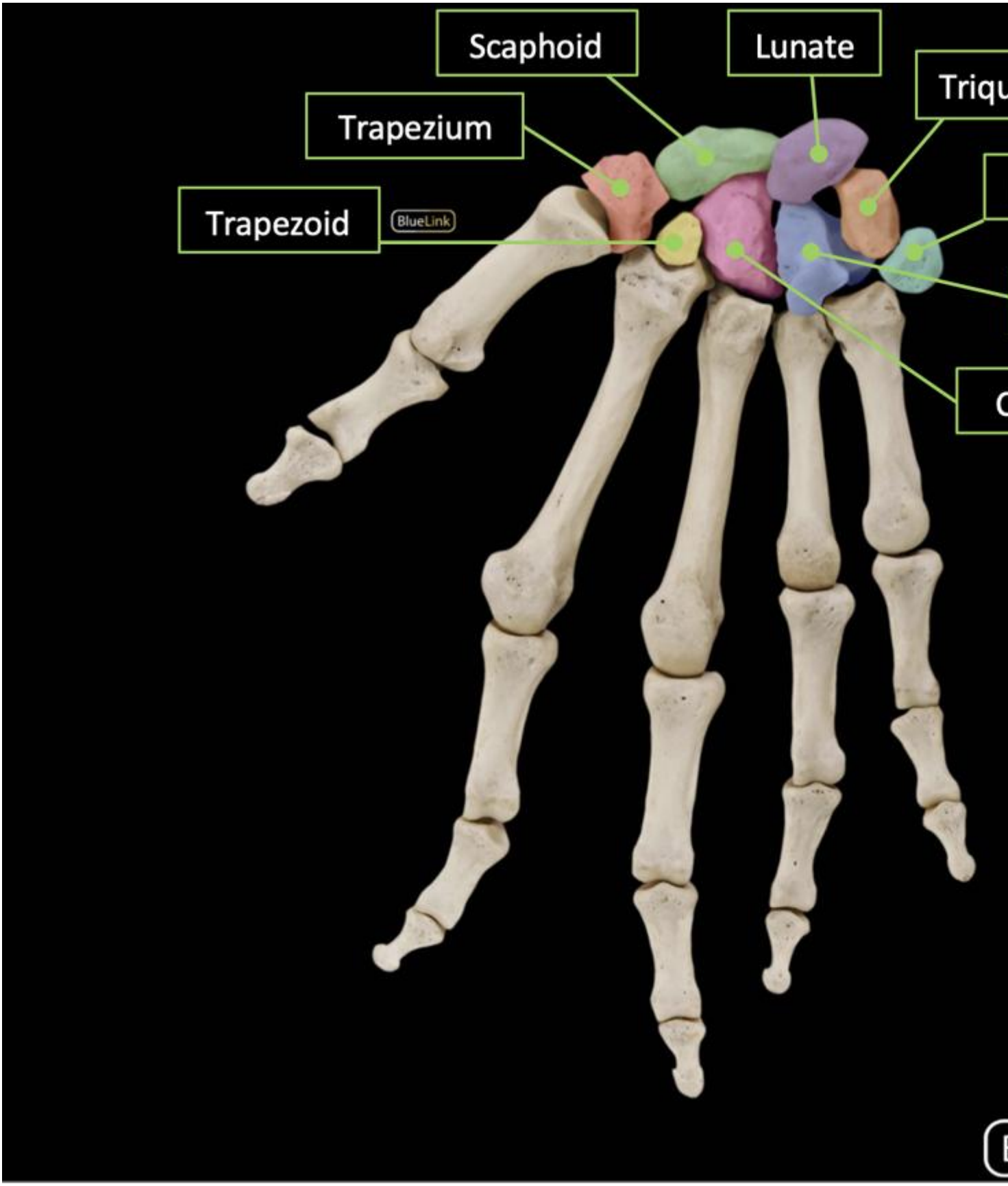
## 1. General Features

- The carpus consists of eight short bones, arranged in two rows of four each.
- These bones form the skeletal framework of the wrist and proximal palm.
- They are arranged in an arch, with the concavity facing anteriorly (palmarly).
- The carpal arch is converted into the carpal tunnel by the flexor retinaculum.
- The bones are connected by strong ligaments that provide stability while permitting coordinated wrist movements.
- Most carpal bones are short bones; the pisiform is a sesamoid bone.

# CARPAL BONES




Bones of the hand and w
Trapezium
Trapezoid
Scaphoid
Capitate
Hamate
Triquterum
Lunate
Hook of hamate
Pisiform
Styloid process
Ulnar
Dorsal view (Right hand)


Scaphoid
Lunate
Trapezium
Trapezoid
BlueLink

## 2. Arrangement of Carpal Bones

The eight carpal bones are arranged from lateral (thumb side) to medial (little-finger side) in the anatomical position.

| PROXIMAL ROW | DISTAL ROW |
|---|---|
| Scaphoid | Trapezium |
| Lunate | Trapezoid |
| Triquetrum | Capitate |
| Pisiform | Hamate |

### Important anatomical relationships

- Scaphoid and lunate: Primarily articulate with the distal radius.
- Triquetrum: Articulates with the articular disc of the triangular fibrocartilage complex during certain wrist positions.
- Pisiform: Lies on the palmar surface of the triquetrum.
- Trapezium: Articulates with the first metacarpal, forming the thumb carpometacarpal joint.
- Capitate: Largest carpal bone, centrally located.
- Hamate: Has a hook-shaped projection called the hamulus.

### Mnemonics

“Some Lovers Try Positions That They Can't Handle.”

S – Scaphoid, L – Lunate, T – Triquetrum, P – Pisiform, T – Trapezium, T – Trapezoid, C – Capitate, H – Hamate.

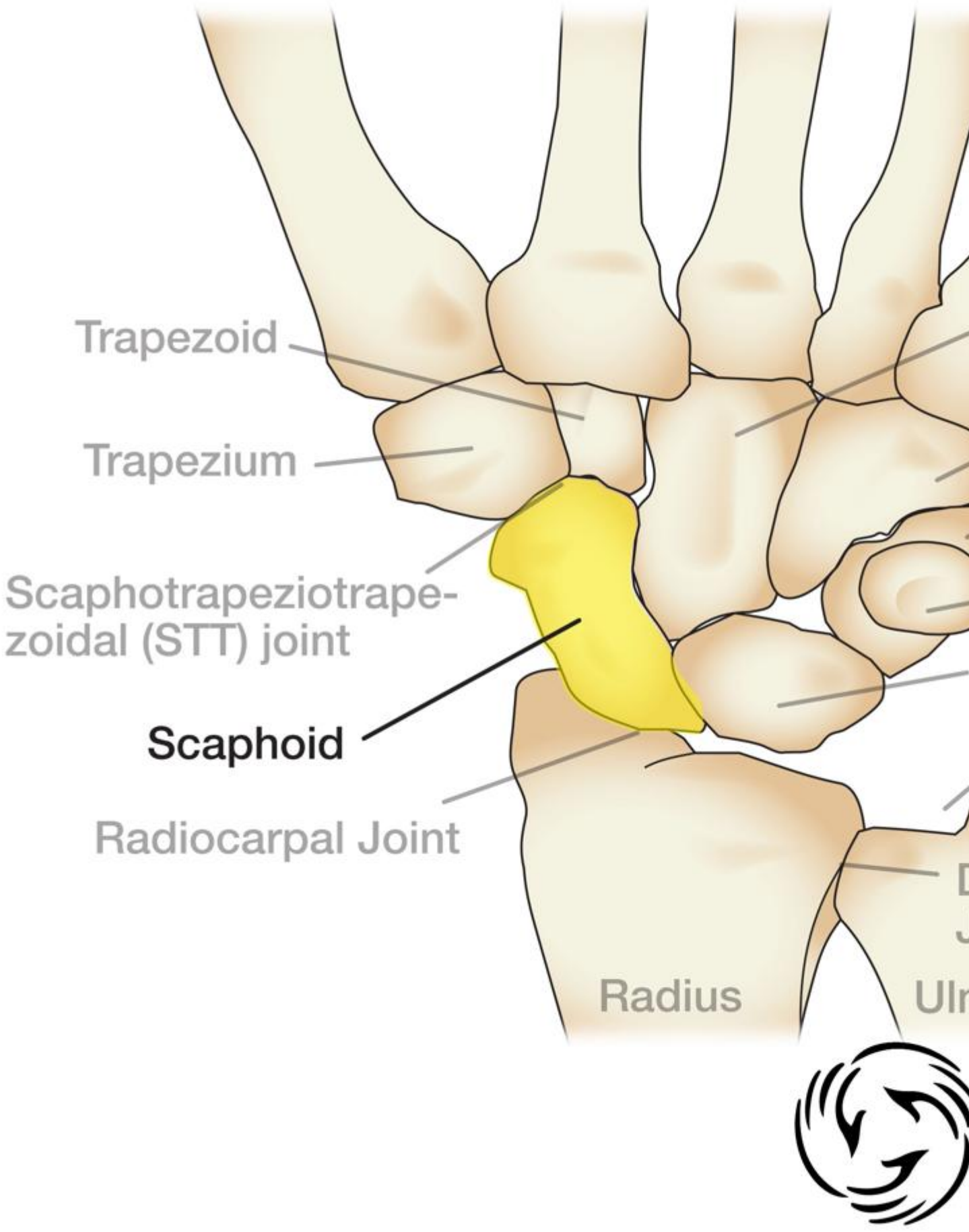
Alternative mnemonic: “She Looks Too Pretty; Try To Catch Her.”

For rapid recall:

- Proximal row: SLTP
- Distal row: TTCH

## 3. Clinical Anatomy of Individual Carpal Bones

### A. Scaphoid


Trapezoid
Trapezium
Scaphotrapeziotrape-
zoidal (STT) joint
Scaphoid
Radiocarpal Joint
Radius

- The most commonly fractured carpal bone.
- Situated on the lateral side of the proximal carpal row.
- Bridges the proximal and distal carpal rows.
- Has three main regions: proximal pole, waist and distal pole.
- Forms part of the floor of the anatomical snuffbox.

Scaphoid fracture

- Commonly occurs following a fall on an outstretched hand (FOOSH).
- The waist is the most common fracture site.
- Clinical findings include:
    - Tenderness in the anatomical snuffbox.
    - Tenderness over the scaphoid tubercle.
    - Pain on thumb movement or axial compression.
- Fractures may be difficult to identify on initial radiographs.
- Important complications include nonunion and avascular necrosis (AVN).

Anatomical basis of avascular necrosis

- The main blood supply arises from branches of the radial artery.
- Most vessels enter through the distal and dorsal portions of the scaphoid.
- Blood flows predominantly in a retrograde direction towards the proximal pole.
- Fracture through the waist may interrupt blood supply to the proximal fragment.

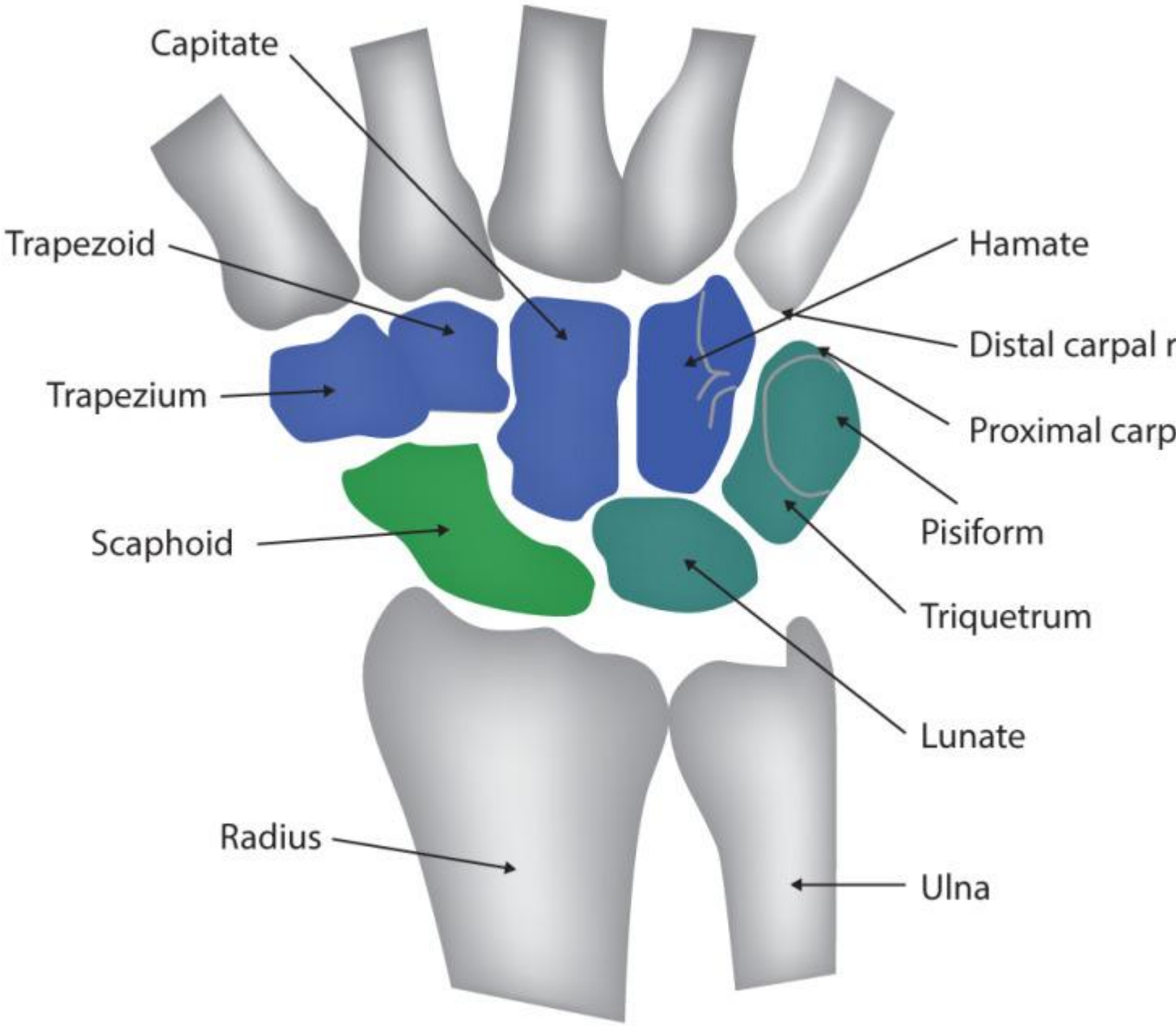
- Consequently, the proximal pole has an increased risk of AVN.



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NEET PG pearl: Scaphoid is the most commonly fractured carpal bone; the proximal pole is particularly vulnerable to avascular necrosis.

### B. Lunate




- Crescent-shaped bone in the proximal carpal row.
- Situated between the scaphoid and triquetrum.
- Articulates proximally with the radius and distally with the capitate.
- Classically described as the most commonly dislocated carpal bone.

Lunate dislocation

- Usually occurs following high-energy wrist hyperextension injuries.
- The lunate may displace towards the palmar aspect.
- A displaced lunate may compress the median nerve in the carpal tunnel.
- This may cause paraesthesia, numbness and weakness in the median nerve distribution.

Kienböck disease

- Refers to avascular necrosis of the lunate.
- Presents with chronic wrist pain, stiffness and reduced grip strength.
- May progress to lunate collapse and secondary wrist arthritis.

Must know: Scaphoid — common fracture; lunate — classic dislocation and Kienböck disease.

### C. Triquetrum

- Pyramidal-shaped bone on the medial side of the proximal carpal row.
- Lies between the lunate and pisiform.
- Articulates with the hamate distally.
- One of the more commonly fractured carpal bones, after the scaphoid.

Clinical importance

- Dorsal cortical chip (avulsion) fracture may occur following a fall on an outstretched hand.
- Typically causes dorsoulnar wrist pain and tenderness.
- Can be missed on standard wrist radiographs.

### D. Pisiform

- Small, pea-shaped bone on the palmar surface of the triquetrum.
- Classified as a sesamoid bone embedded in the tendon of flexor carpi ulnaris.
- Forms one of the medial attachments of the flexor retinaculum.
- An important palpable landmark at the proximal medial palm.

Clinical importance

- Forms part of the medial boundary of Guyon's canal (ulnar tunnel).
- May be involved in pisotriquetral arthritis.
- Fracture or accessory ossicles may create diagnostic confusion on radiographs.

### E. Trapezium

- Most lateral bone of the distal carpal row.
- Articulates with the first metacarpal at the thumb carpometacarpal joint.
- Has a groove for the tendon of flexor carpi radialis.
- Its palmar tubercle provides attachment to the flexor retinaculum.

Clinical importance

- The trapeziometacarpal joint is a common site of osteoarthritis at the base of the thumb.
- The saddle-shaped joint permits opposition, flexion, extension, abduction and adduction of the thumb.

### F. Trapezoid

- Second bone of the distal carpal row.
- Located between trapezium and capitate.

- Articulates distally with the second metacarpal.
- Has a relatively stable, tightly constrained position.

Clinical importance

- Isolated fractures are uncommon.
- Injuries may be associated with other carpal or carpometacarpal trauma.

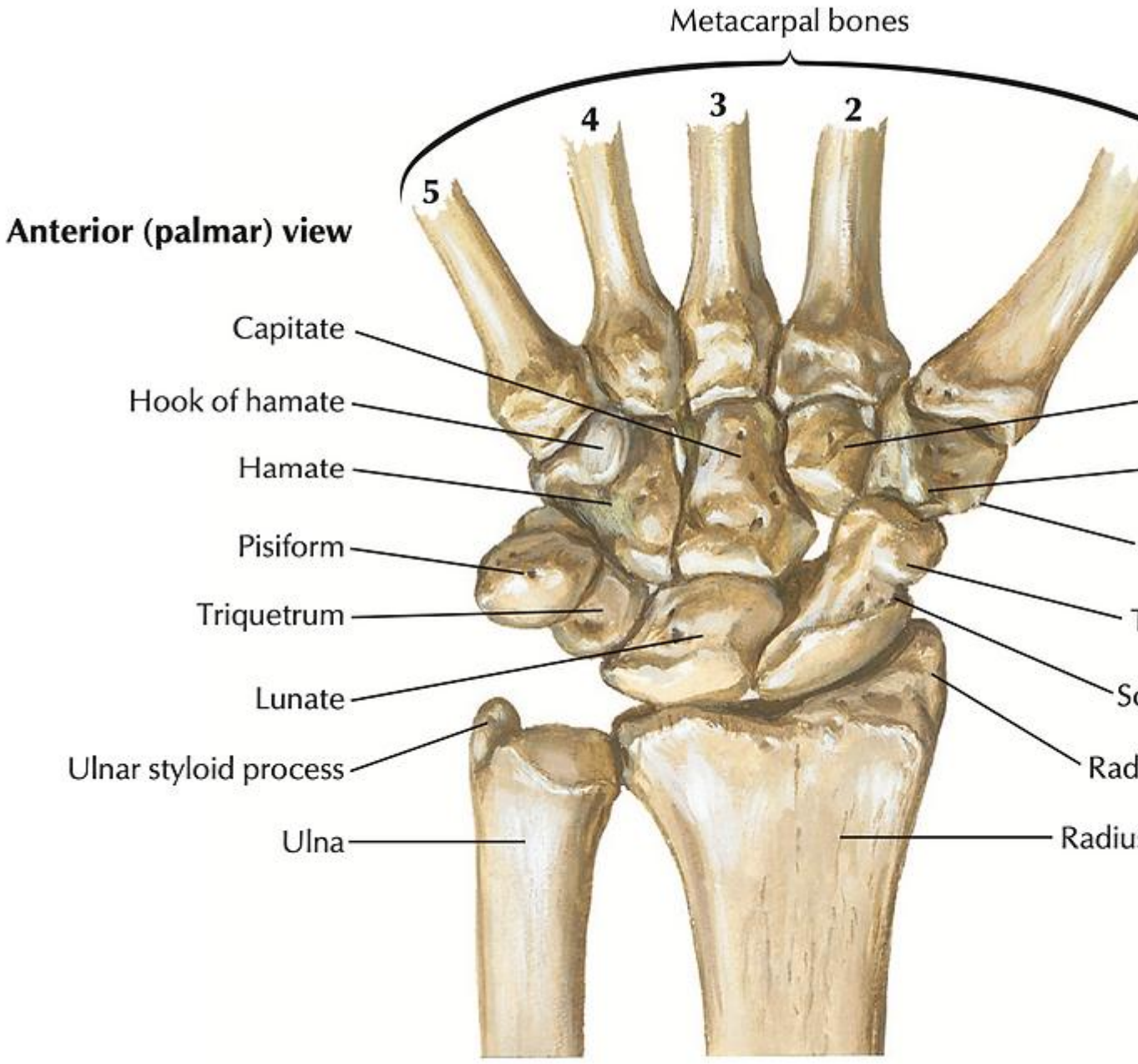
## G. Capitate

- Largest carpal bone.
- Centrally located in the distal carpal row.
- Its rounded head articulates with the scaphoid and lunate proximally.
- Forms an important component of central carpal mechanics.

Clinical importance

- Isolated capitate fractures are relatively uncommon.
- May be involved in scaphocapitate fracture syndrome, sometimes associated with rotation of the proximal capitate fragment.
- The proximal capitate fragment may develop avascular necrosis after severe injury.

## H. Hamate




- Located on the medial side of the distal carpal row.
- Has a hook-shaped palmar projection, the hook of hamate (hamulus).
- Articulates with the fourth and fifth metacarpals.
- The hook contributes to the medial attachment of the flexor retinaculum.

Hook of hamate fracture

- May occur in athletes participating in sports involving bats, racquets or golf clubs.
- Commonly causes pain on the hypothenar side of the wrist.
- The hook lies near Guyon's canal, containing the ulnar nerve and artery.
- Injury may produce ulnar nerve irritation and sensory or motor deficits.
- Fractures may also damage flexor tendons passing nearby.

NEET PG pearl: Hook of hamate fracture may affect the ulnar nerve and artery because of their close anatomical relationship.

## 4. Important Carpal Bone Disorders — Comparison

| CONDITION | BONE / STRUCTURE | KEY CLINICAL POINT |
|---|---|---|
| Scaphoid fracture | Scaphoid | Snuffbox tenderness; AVN risk |
| Lunate dislocation | Lunate | May compress median nerve |
| Kienböck disease | Lunate | Avascular necrosis |
| Dorsal chip fracture | Triquetrum | Dorsoulnar wrist pain |
| Thumb-base osteoarthritis | Trapezium–first metacarpal joint | Painful thumb movement and grip |
| Scaphocapitate syndrome | Scaphoid and capitate | Associated fracture pattern |

| | | |
|---|---|---|
| Hook fracture | Hamate | Ulnar nerve and tendon injury risk |
| Pisotriquetral arthritis | Pisiform–triquetrum joint | Ulnar-sided palmar wrist pain |

## 5. Carpal Instability

Carpal stability depends upon the integrity of the intrinsic and extrinsic wrist ligaments.

### Important ligament injuries

Scapholunate ligament injury

- May occur following wrist hyperextension.
- Causes pain over the dorsoradial wrist.
- Can produce widening of the scapholunate interval on radiographs.
- Chronic disruption may lead to scapholunate advanced collapse (SLAC wrist).

Lunotriquetral ligament injury

- May produce ulnar-sided wrist pain.
- Can cause abnormal movement between the lunate and triquetrum.

Perilunate dislocation

- A high-energy carpal injury in which the capitate and distal carpal row displace relative to the lunate.
- Unlike a true lunate dislocation, the lunate may remain aligned with the radius.
- Requires urgent assessment because of associated ligament injuries and possible median nerve compression.

## 6. Congenital Variations

### Carpal coalition

- Congenital union of two or more carpal bones.
- Most commonly involves the lunate and triquetrum.
- May be fibrous, cartilaginous or osseous.
- Often asymptomatic and detected incidentally.
- Occasionally causes wrist pain or altered wrist mechanics.

### Accessory carpal ossicles

- Additional small ossicles may occur near normal carpal bones.
- Usually represent developmental variants.
- Important to differentiate from acute fracture fragments on radiographs.

# OSSIFICATION OF CARPAL BONES

## 7. General Features of Ossification

- Each of the eight carpal bones usually ossifies from a single ossification centre.
- The carpal bones develop initially as cartilaginous models.
- In standard teaching, the carpal bones are considered unossified at birth on radiographs.
- Ossification begins during infancy and continues throughout childhood.

- The capitate is usually the first carpal bone to show an ossification centre.
- The pisiform is the last to ossify.
- Ossification generally occurs earlier in girls than in boys.

## 8. Sequence of Ossification

| ORDER | CARPAL BONE | APPROXIMATE APPEARANCE |
|---|---|---|
| 1 | Capitate | 1–3 months |
| 2 | Hamate | 2–4 months |
| 3 | Triquetrum | 2–3 years |
| 4 | Lunate | 2–4 years |
| 5 | Scaphoid | 4–6 years |
| 6 | Trapezium | 4–6 years |
| 7 | Trapezoid | 4–6 years |
| 8 | Pisiform | 8–12 years |

The order and timing are approximate, particularly for the scaphoid, trapezium and trapezoid, whose ossification periods overlap.



Radiopaedia

+2

### Ossification sequence — visual memory aid

**1**

Capitate

1–3 mo

**2**

Hamate

2–4 mo

**3**

Triquetrum

2–3 yr

**4**

Lunate

2–4 yr

**5**

Scaphoid

4–6 yr

## 6

Trapezium

4–6 yr

## 7

Trapezoid

4–6 yr

## 8

Pisiform

8–12 yr

Conventional sequence of appearance of the eight ossification centres.

### Important ossification facts

- First to ossify: Capitate, closely followed by hamate.
- Last to ossify: Pisiform.
- Number of ossification centres: Eight, usually one for each bone.
- The carpal bones do not have the typical shaft-and-epiphysis arrangement of long bones.
- The ossification centres enlarge until the cartilaginous models are progressively replaced by bone.
- The appearance of the centres varies with sex, nutritional status, endocrine factors and population characteristics.

## 9. Clinical Importance of Carpal Ossification

### A. Skeletal age assessment

- Radiographs of the left hand and wrist are commonly used in skeletal age assessment.
- The appearance and maturation of carpal centres contribute to assessment of bone age in children.
- Common standards include the Greulich–Pyle atlas and Tanner–Whitehouse methods.
- Estimation must account for individual and population variation.

### B. Paediatric wrist radiographs

- Unossified cartilage is not visible as mature bone on ordinary radiographs.
- Normal ossification centres should not be mistaken for fracture fragments.
- Irregular or developing centres may resemble traumatic abnormalities.

### C. Developmental abnormalities

- Delayed ossification may occur in constitutional growth delay, endocrine disorders or chronic systemic disease.
- Skeletal age assessment should be interpreted alongside clinical findings, not as an isolated diagnosis.

## 10. High-Yield Quick Revision

| EXAMINATION POINT | ANSWER |
|---|---|
| Number of carpal bones | 8 |

| | |
|---|---|
| Proximal row | Scaphoid, lunate, triquetrum, pisiform |
| Distal row | Trapezium, trapezoid, capitate, hamate |
| Most commonly fractured carpal bone | Scaphoid |
| Common site of scaphoid fracture | Waist |
| Scaphoid fragment prone to AVN | Proximal pole |
| Classically most commonly dislocated carpal bone | Lunate |
| Avascular necrosis of lunate | Kienböck disease |
| Sesamoid carpal bone | Pisiform |
| Largest carpal bone | Capitate |
| Smallest carpal bone | Pisiform |
| Hook-shaped projection | Hamate |
| Carpal bone associated with thumb CMC osteoarthritis | Trapezium |
| Common congenital carpal coalition | Lunotriquetral |

| | |
|---|---|
| First carpal bone to ossify | Capitate |
| Last carpal bone to ossify | Pisiform |
| Number of ossification centres | 8 |

## 11. Exam Focus

### University long-answer questions

1. Describe the arrangement of carpal bones and discuss their important clinical correlations.
2. Describe the ossification of carpal bones and explain its importance in skeletal age estimation.

### Short-note questions

- Scaphoid fracture and avascular necrosis.
- Lunate dislocation.
- Kienböck disease.
- Hook of hamate fracture.
- Ossification sequence of carpal bones.
- Carpal coalition.
- Scapholunate instability.

### Viva questions

1. Which is the most commonly fractured carpal bone? — Scaphoid.
2. Which part of scaphoid is prone to avascular necrosis? — Proximal pole.
3. Which is the largest carpal bone? — Capitate.
4. Which is the sesamoid carpal bone? — Pisiform.
5. Which carpal bone ossifies first? — Capitate.
6. Which carpal bone ossifies last? — Pisiform.
7. What is Kienböck disease? — Avascular necrosis of the lunate.
8. Which nerve may be compressed in lunate dislocation? — Median nerve.

## NEET PG / INI-CET Clinical Pearls

- Fall on an outstretched hand + anatomical snuffbox tenderness ? Suspect scaphoid fracture, even with normal initial radiographs.
- Scaphoid waist fracture + retrograde blood supply ? Increased risk of proximal pole AVN.
- Volar lunate dislocation + median nerve symptoms ? Acute median nerve compression requiring urgent evaluation.
- Chronic dorsal wrist pain + lunate sclerosis/collapse ? Kienböck disease.
- Hypothenar pain following a racquet or bat injury ? Suspect hook of hamate fracture.
- Carpal coalition involving lunate and triquetrum ? Common congenital fusion pattern.
- First and last carpal ossification centres ? Capitate and pisiform, respectively.

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