

TRAUMATIC ELBOW INSTABILITY & TERRIBLE TRIAD INJURIES

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ACKNOWLEDGEMENTS: ADDITIONAL RADIOGRAPHS - ABRAHAM APPLETON, MD



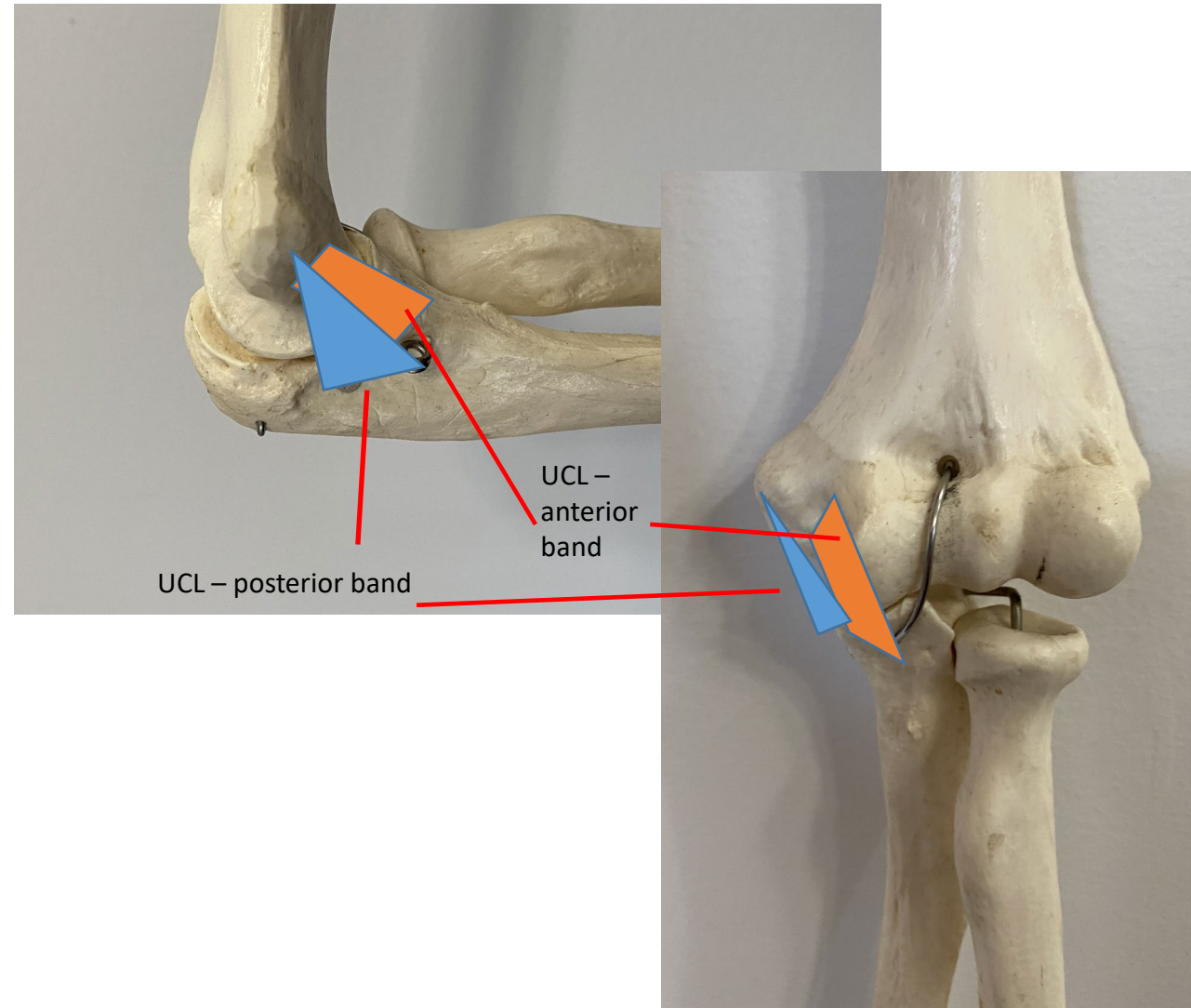
OVERVIEW

- Anatomy
- Classification
- Simple Dislocations
- Complex Dislocations
 - Fracture Dislocations
 - Terrible Triad
- Complications & Sequelae
 - Chronic dislocation
 - Stiffness and Chronic Instability



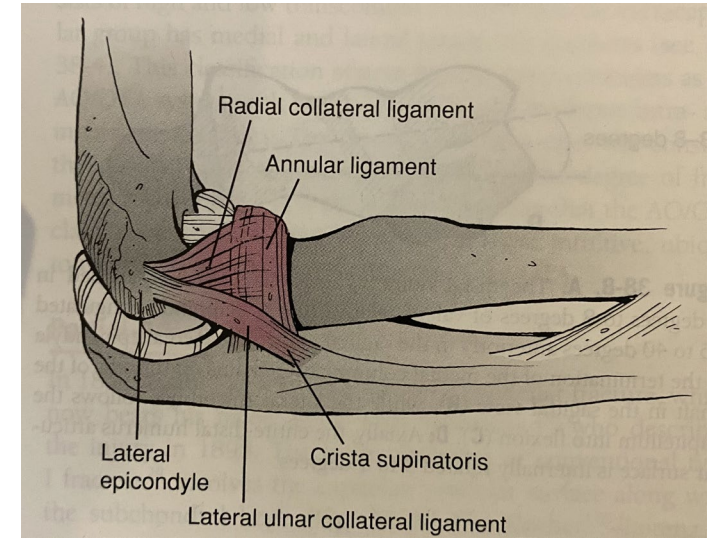
ANATOMY OF ELBOW STABILITY

- Primary Static Constraints
- Secondary Constraints
- Dynamic constraints

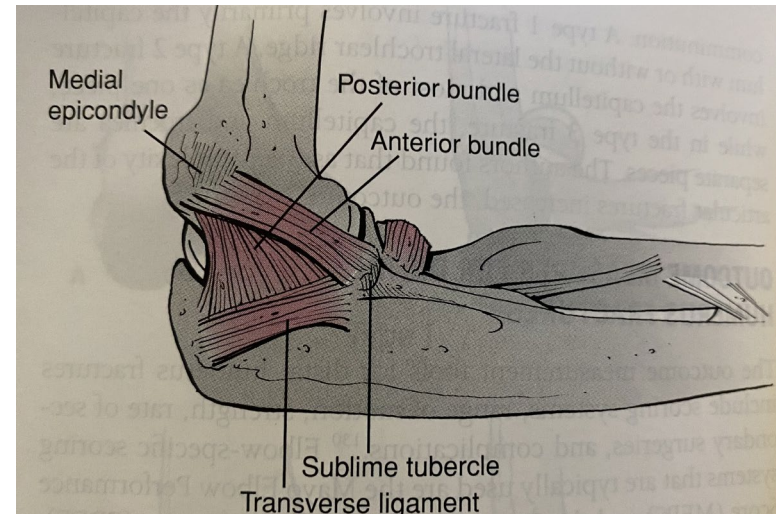


PRIMARY STATIC CONSTRAINTS

- Ulnohumeral Articulation
 - Coronoid in Flexion
 - Olecranon in extension
- Anterior bundle of the medial collateral ligament (MCL)
 - Anteroinferior medial epicondyle to sublime tubercle
- Lateral collateral ligament - 4 components
 - Lateral ulnar collateral ligament
 - Radial collateral ligament
 - Accessory collateral ligament
 - Annular ligament



Athwal GS, Raniga S. Chapter 38. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e*. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019. (Fig 38-9 and 38-10)



SECONDARY STATIC CONSTRAINTS

- Joint Capsule
- Radiocapitellar articulation
 - Contact area of the radiocapitellar joint increases in flexion
- Common flexor and extensor origins

DYNAMIC CONSTRAINTS

- Muscle units that cross the elbow joint
 - Anconeus
 - Triceps
 - Brachialis
- Provide compression forces across joint and proprioception

TRAUMATIC ELBOW INSTABILITY

Mechanism of injury

- Primary mechanism is posterolateral
 - Other mechanisms postulated - controversial
 - Valgus-external rotation
 - Valgus-hyperextension
 - Sequence of injury progression also debated
- Medial dislocations

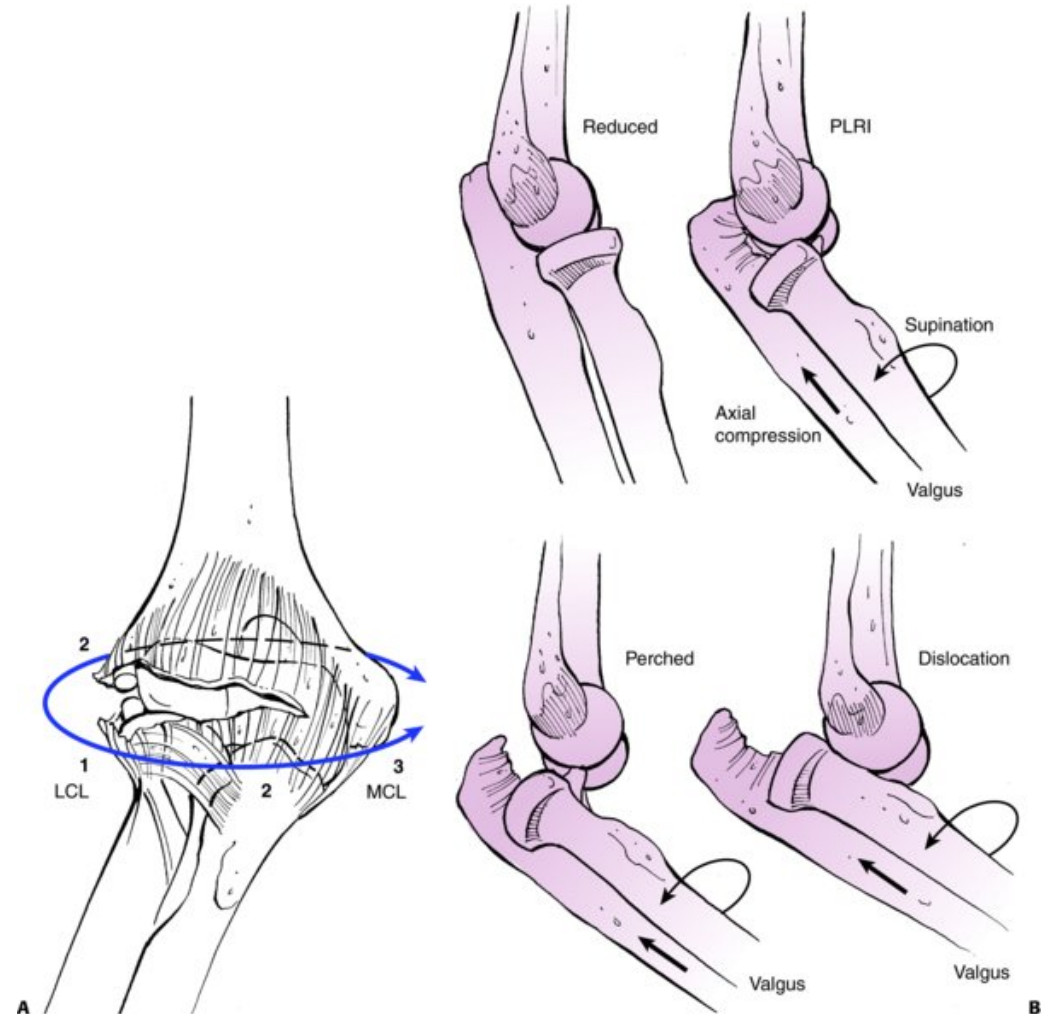
Robinson, PM et al. Simple elbow dislocation. *Shoulder Elbow*. 2017 Jul; 9(3): 195–204.

Jockel CR et al. Simple medial elbow dislocations: a rare injury at risk for early instability. *J Hand Surg Am*. 2013 Sep;38(9):1768-73.

Posterolateral Mechanism - injury progression

- Elbow dislocations are thought to occur with a progression from lateral to medial. Complete dislocation is usually associated with disruption of the medial and lateral collateral ligaments and anterior capsule

- King G, Beingessener D, Pollock J. Chapter 39. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e*. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019. (Fig 39-1)



EVALUATION

- History and physical exam typically diagnostic
- Remove any field splints/dressings – examine skin
- Careful neurovascular exam – pre and post reduction
- AP and lateral radiographs
 - Verify presence and direction of dislocation
 - Associated fractures
- Advanced imaging
 - Complex dislocations
 - Recurrent Instability
 - Performed after reduction if necessary



TRAUMATIC ELBOW INSTABILITY

- Simple Dislocations
- Complex Dislocations – Fracture-dislocations
 - Coronoid fractures
 - Radial Head Fractures
 - Monteggia Fractures
 - Trans-olecranon dislocations
- Terrible Triad
- Chronic Dislocations



ANATOMY



ULNOHUMERAL joint integrity

SIMPLE DISLOCATIONS

- No Fracture
- Mechanism
- Progression of Injury – pathoanatomy
- Treatment

SIMPLE DISLOCATIONS

- Posterior and posterolateral most common – all directions and divergent dislocations can occur
 - Beware patterns other than posterior/posterolateral – can be more unstable after reduction
- Mechanism of Injury
 - Partially flexed elbow
 - Axial load, supination, and valgus
 - Varus mechanisms also described
- Progression of Injury – Controversy over where injury occurs first and is more severe
 - O’Driscoll et al
 - Stage 1 – LUCL tear
 - Stage 2 – disruption of remaining lateral ligaments and capsule
 - Stage 3 – MCL tear – subtypes exist



Medial ligamentous injuries in most cases

SIMPLE DISLOCATIONS: TREATMENT

- Closed reduction –
 - ER vs OR – usually based on practical/workflow considerations – such as adequate sedation
 - Should be expeditious
 - Most are stable after reduction
- Splinted in Flexion
- ROM within stable range after short course of immobilization
 - Sling only and early mobilization after 2-3 days also an option
- Follow up XRs
 - Beware subtle subluxation/ non-concentric reduction
 - Repeat XR after initiating ROM

Simple Dislocation

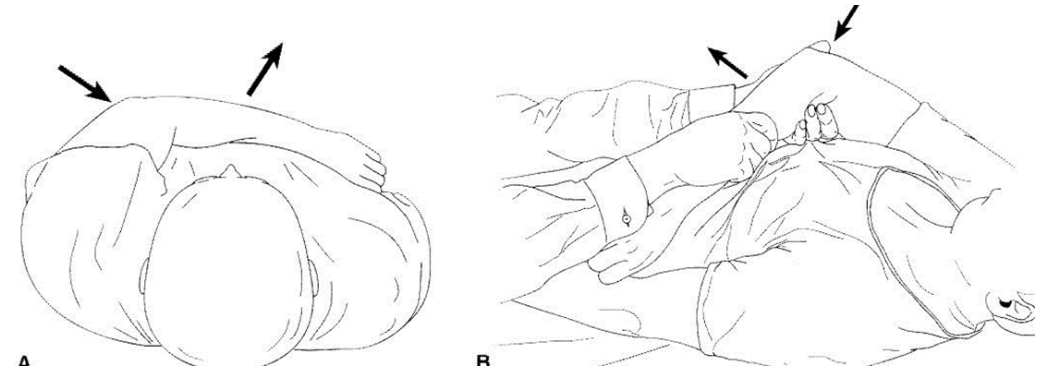


Treat ligaments

Non-op Early motion after reduction

Operative repair/reconstruction (recurrent instability)

REDUCTION MANEUVER



- Adequate sedation/muscle relaxation
 - Minimize articular damage to trochlea during reduction
- Axial traction to partially flexed elbow
- Supination and flexion
 - Supination to position the coronoid under trochlea
- Thumb /finger pressure anteriorly on the olecranon process
- Gently flex elbow once reduced
- Verify reduction and stability on fluoroscopy post reduction

Kumar, A. Ahmed, M.
Closed Reduction of Posterior
Dislocation of the Elbow: A Simple
Technique. *J Ortho Trauma*. Jan 1999;
(1): 58-59

REHAB PROTOCOL – SIMPLE DISLOCATIONS

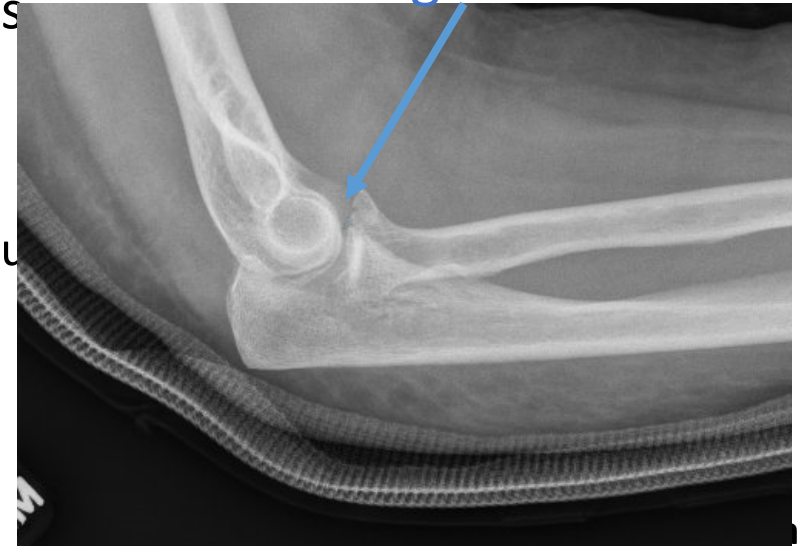
- Short term immobilization and early motion if stable
- Motion within stable range
- Hinged brace use usually not necessary
 - Can be counter-productive if hinge not well positioned
- Allow return to:
 - Light duty at 2 weeks
 - Full activities at 10-12 weeks

IMMOBILIZATION VS EARLY MOTION

- Early motion only appropriate if stable through ROM after reduction
- Three weeks immobilization vs early motion (after 2-3 days)
 - Iordens GI et al. Early results of the FuncSiE trial. *Br J Sports Med* 2015
 - Early motion: better motion at 6 weeks, equivalent thereafter
- Bottom line: short term immobilization and early motion is appropriate
- Is it really stable?
 - Must monitor closely with radiographs to ensure concentric reduction as you initiate early ROM
 - Be vigilant for subtle residual subluxation



Radiocapitellar joint not congruent



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POSTEROLATERAL ELBOW DISLOCATION

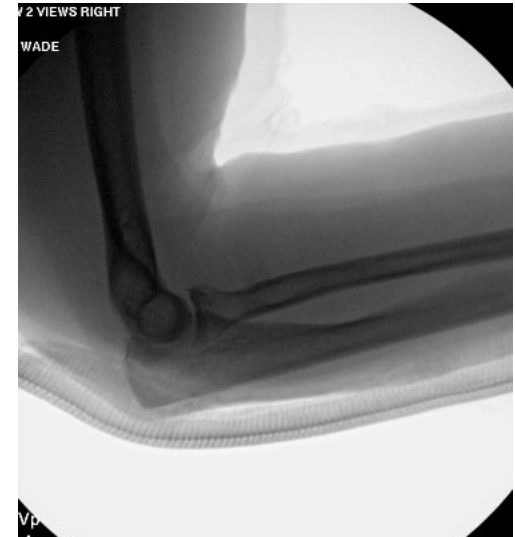


POST-REDUCTION



UNSTABLE AFTER REDUCTION

- Uncommon in simple dislocations
- May require soft tissue reconstruction
- Do what needs to be done to hold a concentric reduction
 - Splint in more flexion
 - External fixator – static vs hinged
 - Elbow cross pinning
 - Internal fixator



EXTERNAL FIXATOR PLACEMENT - PERSISTENT INSTABILITY AFTER REDUCTION

- Two pins in humeral shaft – 5mm pins - laterally - under direct visualization through open incision
- Two pins in ulnar shaft – 4mm pins - posterolaterally - safe to place percutaneously
- Static usually sufficient – 2-3 weeks duration

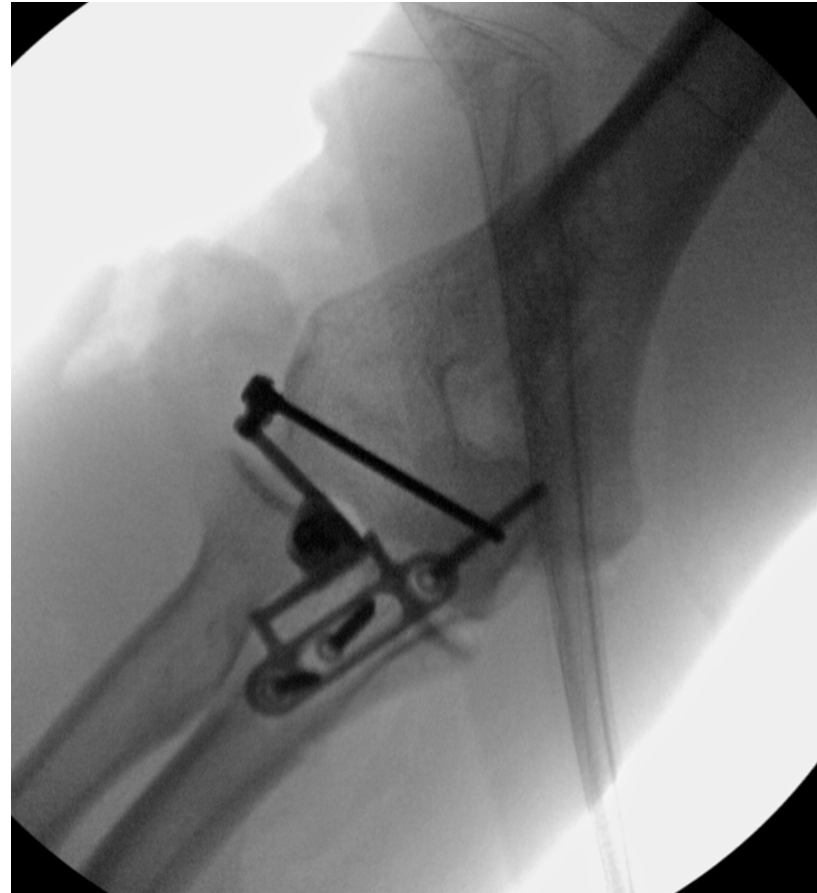


EXTERNAL FIXATOR PLACEMENT - PERSISTENT INSTABILITY AFTER REDUCTION

- Hinged external fixators as definitive management
 - If unstable after reduction
 - Maintain motion while maintaining reduction as soft tissue envelope heals
 - Must ensure concentric reduction through range of motion – verify on fluoroscopy
- Novel “virtual hinge” internal fixators also commercially available



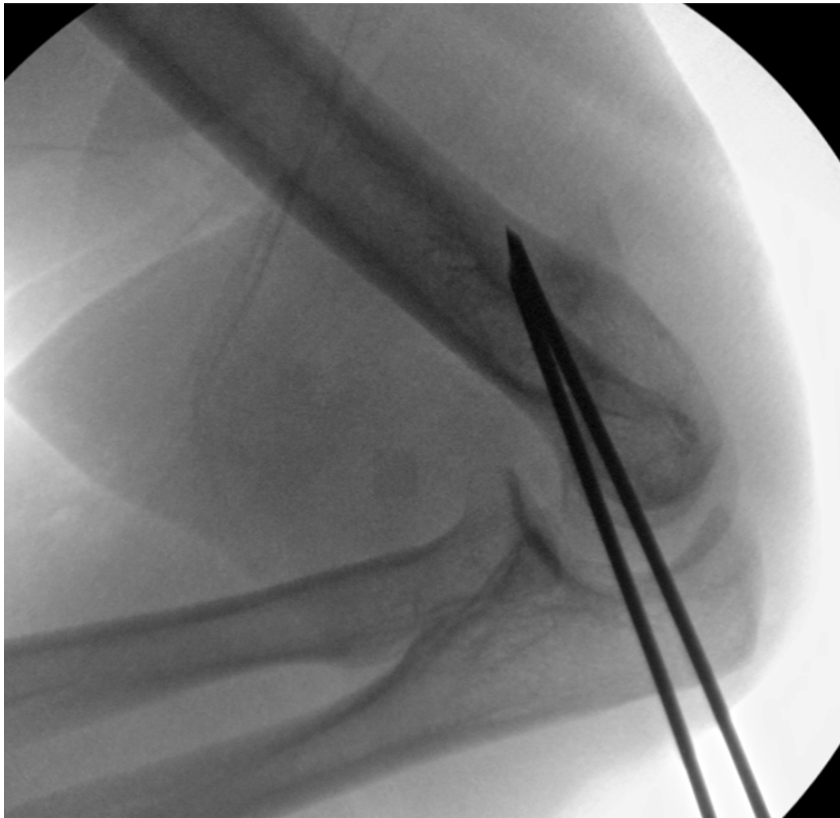
INTERNAL FIXATOR



CROSS PINNING

- Useful when unable to otherwise maintain concentric reduction
- Retrograde placement of 2.8-3.2 mm pins depending on patient size
- Verify reduction – including radiocapitellar joint
- May add antegrade pinning of radiocapitellar joint if necessary
- Pin removal – around 3 weeks and assess maintenance of reduction

CROSS PINNING




SIMPLE DISLOCATIONS - UNSTABLE AFTER REDUCTION

- Uncommon
- High energy injuries
 - Extensive soft tissue injury
- Older women from low energy mechanism
- Advanced imaging
- Often require late soft tissue reconstruction

COMPLEX ELBOW DISLOCATIONS

- Associated with a fracture
- Sub-Types
 - Coronoid Fracture
 - Monteggia Fracture
 - Radial Head Fracture
 - Epicondyle fractures - adolescents
 - Trans-Olecranon fracture-Dislocations
- Terrible Triad

DISLOCATIONS WITH RADIAL HEAD FRACTURE

- Important to recognize the radial head Fr 
 - Sometimes difficult to assess on initial XRs
 - Often suboptimal views with pain and deformity
- Must reconstruct or replace the radial head
 - Important stabilizer to valgus force
- Treat radial head fracture as you would in absence of dislocation

Mason Classification of Radial Head Fractures	
Type	Description
• I	• Nondisplaced fracture
• II	• Displaced partial head fracture
• III	• Displaced entire head fracture
• IV ^a	• Fracture with elbow dislocation

^aJohnston modification of original classification.

Broberg and Morrey Classification of Radial Head Fractures	
Type	Description
• I	• <2 mm of displacement
• II	• >2 mm of displacement and >30% articular surface involvement
• III	• Comminuted fracture

Ganta A, Tejwani NC. Chapter 40. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e*. Philadelphia, PA. Wolters



DISLOCATIONS WITH RADIAL HEAD FRACTURE

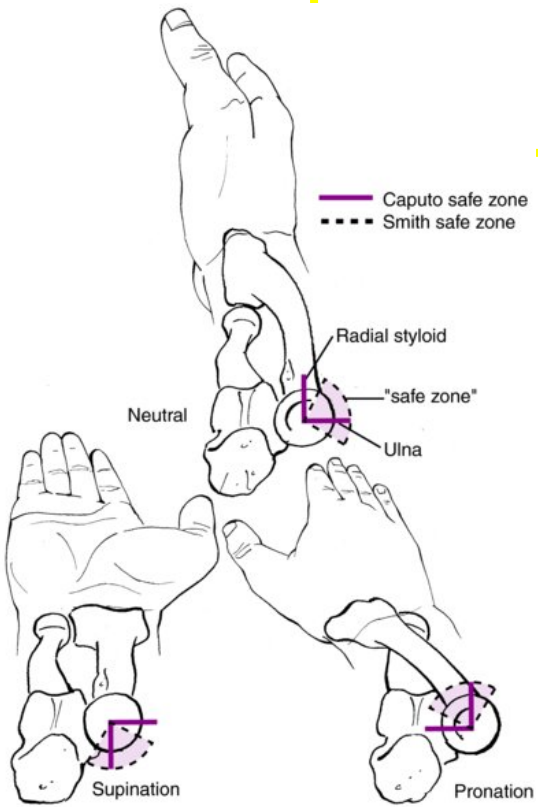
- Important to recognize the radial head Fx
 - Sometimes difficult to assess on initial XRs
 - Often suboptimal views with pain and deformity
- Must reconstruct or replace the radial head
 - Important stabilizer to valgus force
- Treat radial head fracture as you would in absence of dislocation





ORIF RADIAL HEAD

Safe Zones



King G, Beingessener D, Pollock J. Chapter 39. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e*. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019. (9-6)



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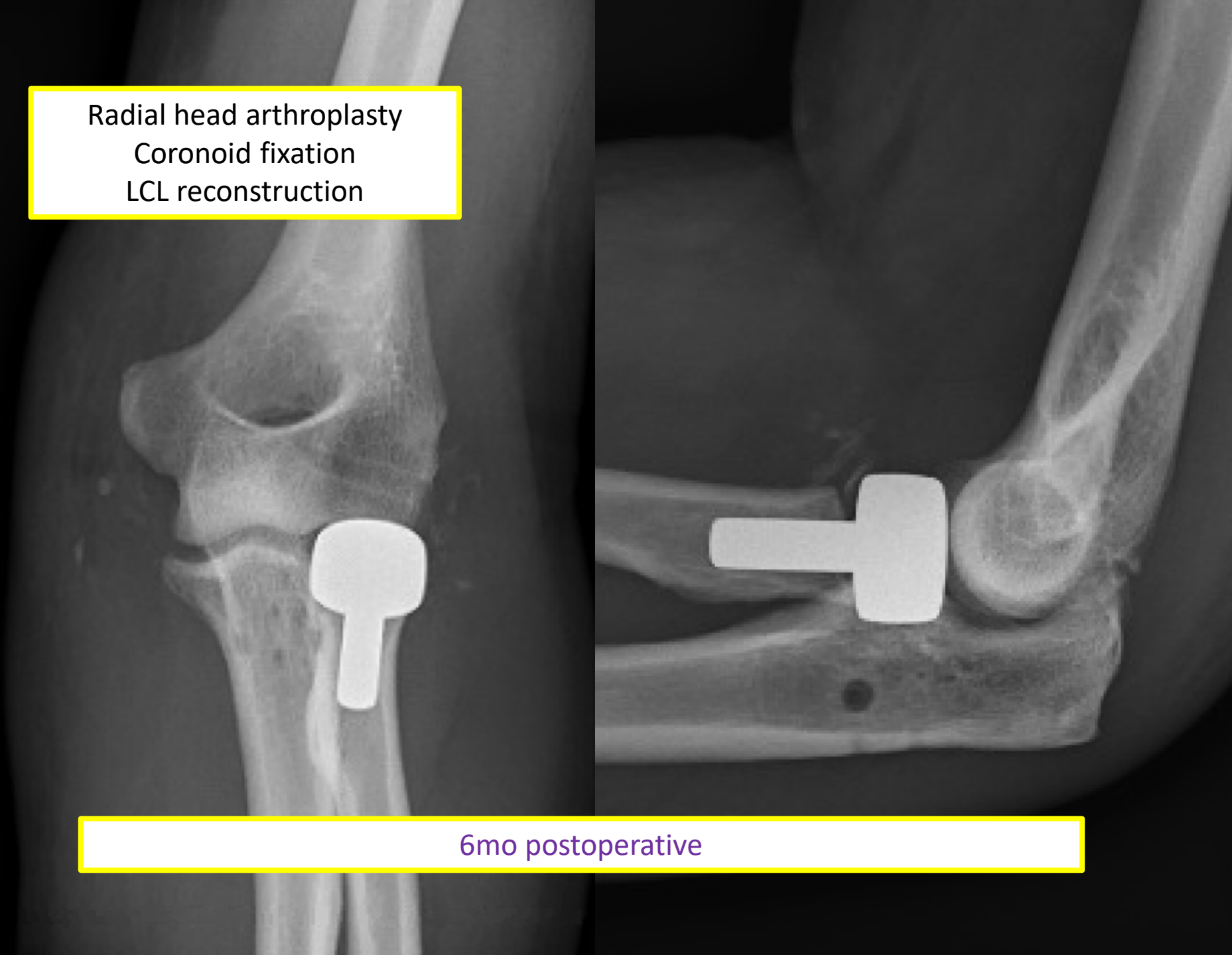
04/2018



LT

FALL OFF 10ft LADDER

Radial head arthroplasty
Coronoid fixation
LCL reconstruction



6mo postoperative

7/9:22:04

86026

VIEW 3 OR MORE VIEWS

M

ELBOW VIEWS

DOB 8/3/19

061



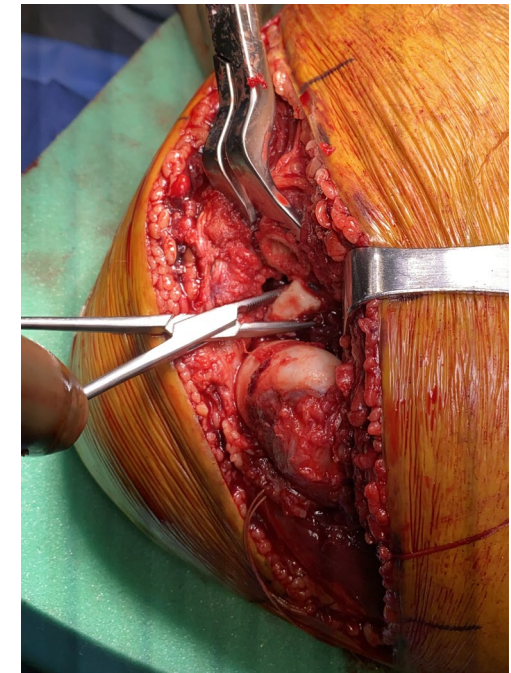
2 YEARS
Mild degenerative changes

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EI: 1

Radial Head Replacement

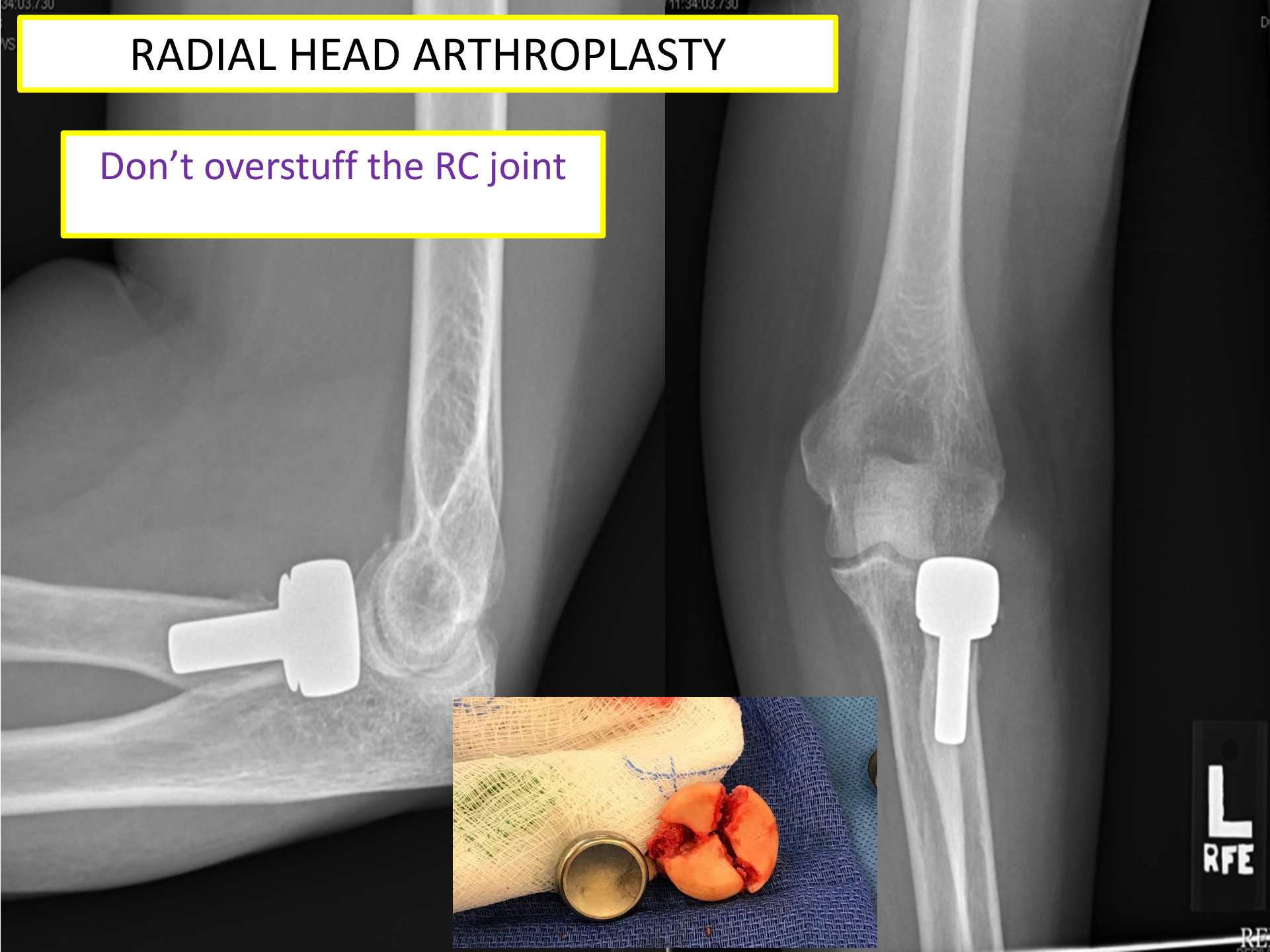
- Don't overstuff the joint.
 - Diameter of implant
 - Radial neck length
- Approximate size of elliptical portion of the native radial head
 - Usually several mm's smaller than outer diameter of radial head
 - Reassemble head on back table – beware fragment spread
- Length –
 - Overlengthening causes pain, stiffness and capitellar wear
 - Only severe overlengthening will be visible on XR
 - Direct intraoperative visualization of a gap in the lateral ulnohumeral joint
 - Most reliable indicator of overlengthening following the insertion of a radial head prosthesis.
- Ensure congruent tracking on full ROM
- Elbow flexion/extension and pronation/supination

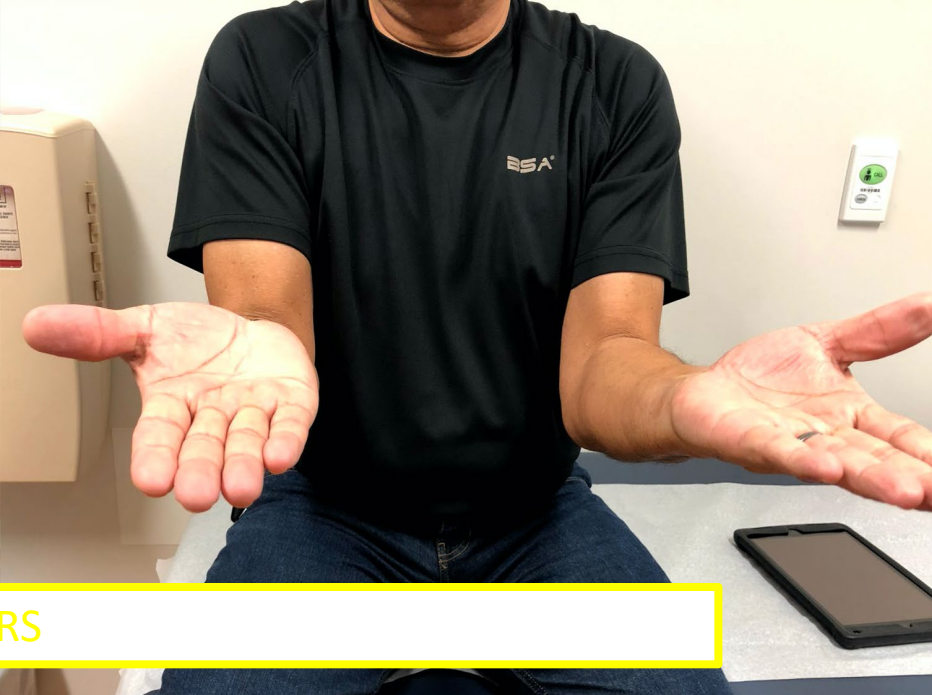
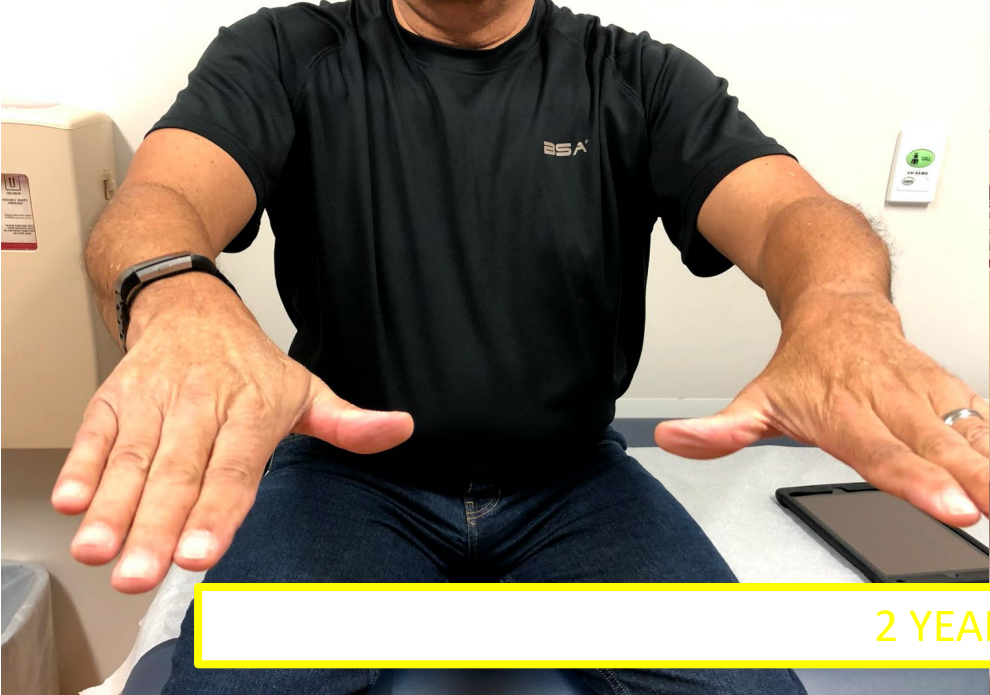
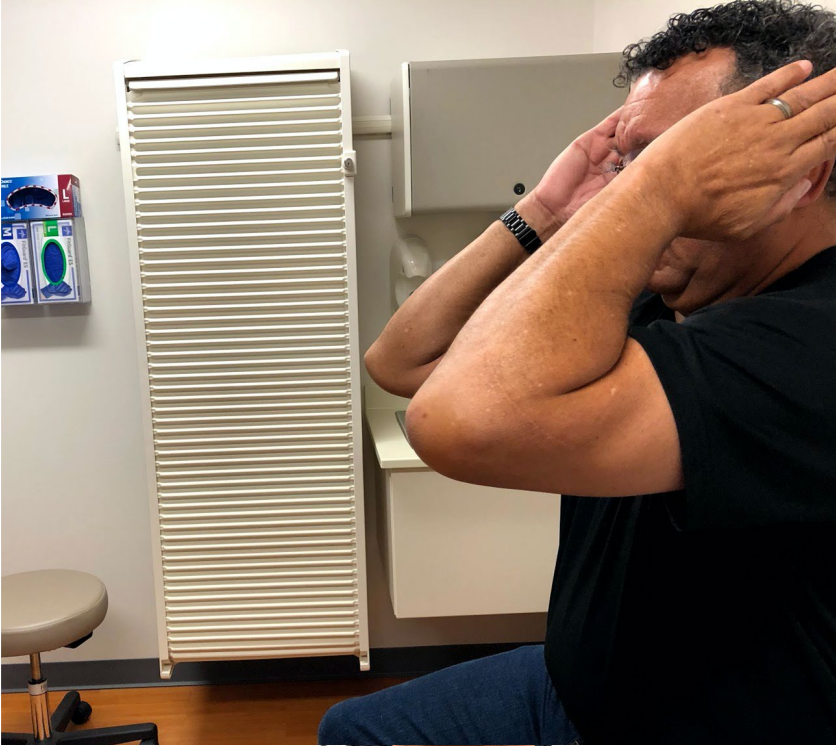


Frank SG et al. Determination of correct implant size in radial head arthroplasty to avoid overlengthening. *JBJS*; - Vol 91 (7): 1738-1746

RADIAL HEAD ARTHROPLASTY

Don't overstuff the RC joint

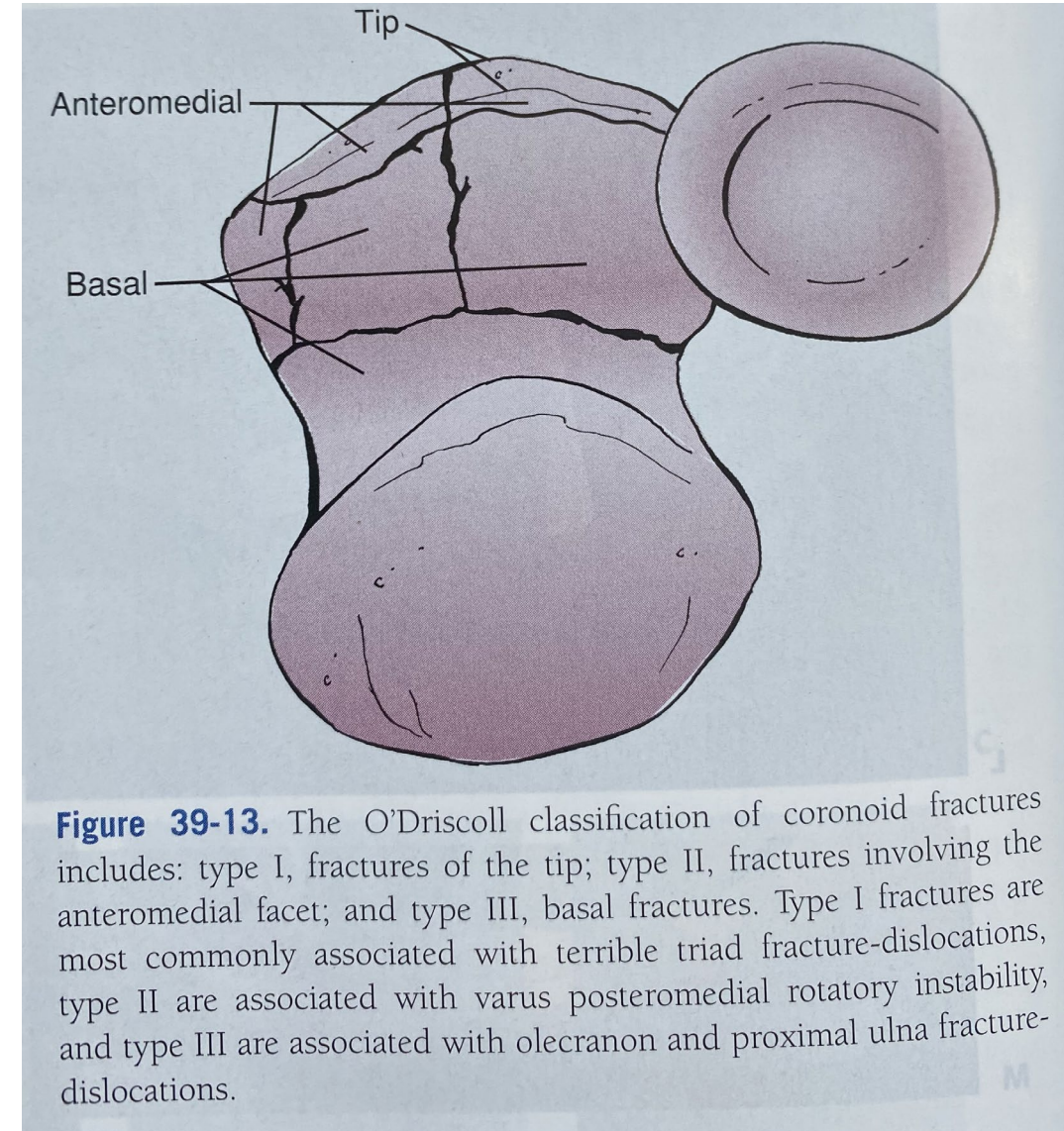




2 YEARS

DISLOCATION WITH CORONOID FRACTURE

- Even small coronoid fractures are important and impact stability



King G, Beingsener D, Pollock J. Chapter 39. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e*. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019. (Fig 39-1)

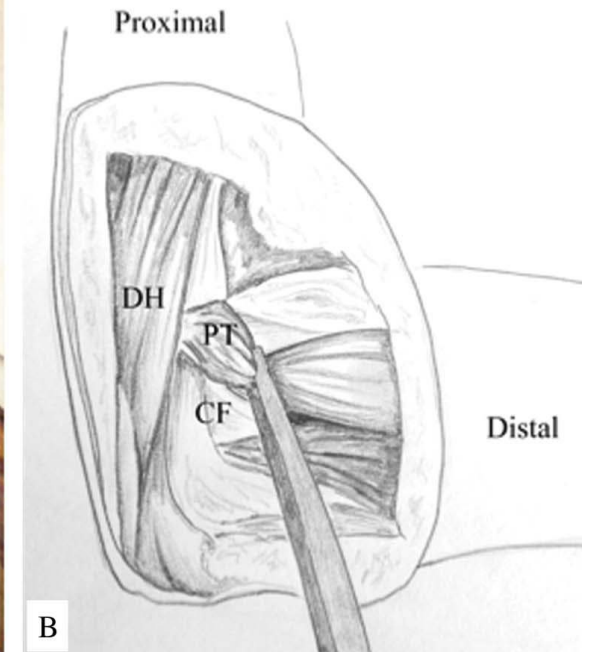
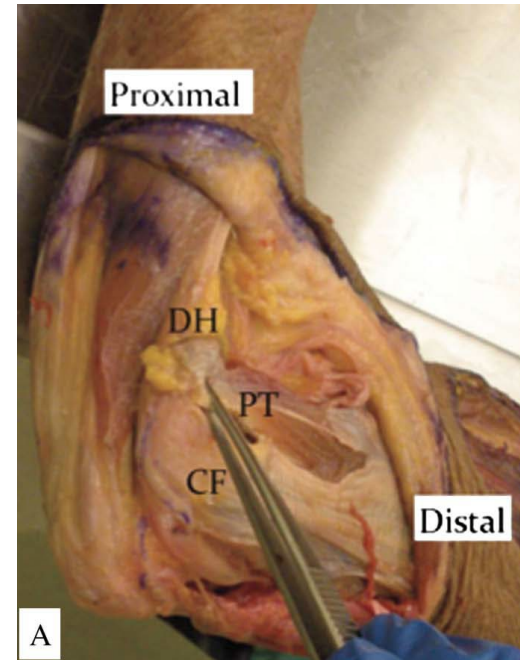
MANAGEMENT OF CORONOID FRACTURES

- Surgical approaches
 - Medial: Over-The-Top (Hotchkiss)
 - Medial: FCU split
 - Direct Anterior
- ORIF fragments large enough
- Suture lasso or soft tissue reconstruction of capsule for small fragments
 - Tip: can use ACL guide and drill with large kirschner wire large enough to allow suture passage



Medial Over-the-Top Approach

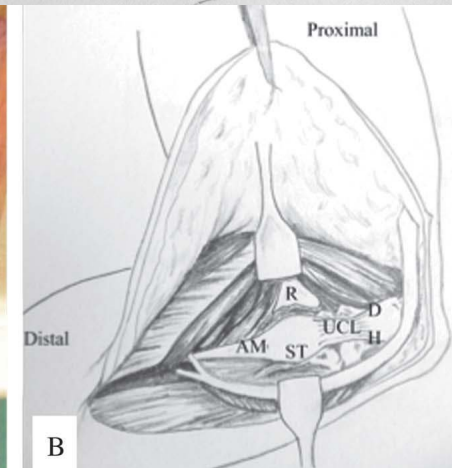
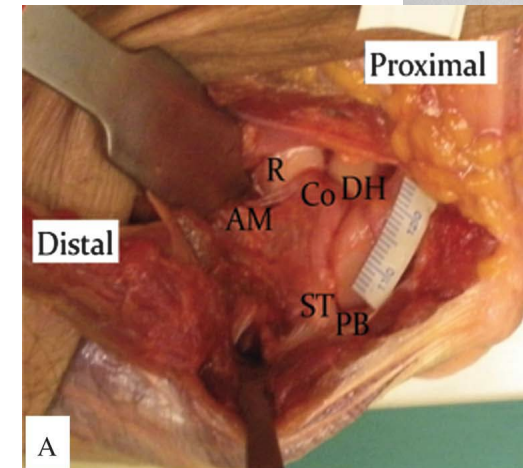
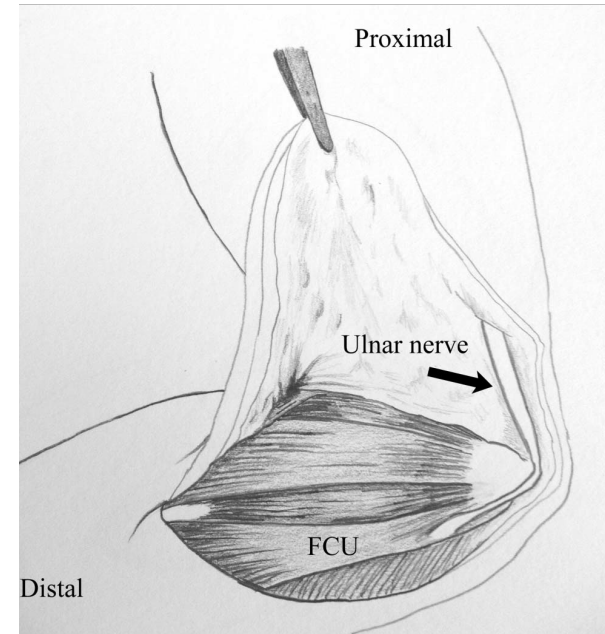
- Interval between pronator teres and common flexor origin
- PT elevated off epicondyle and reflected anteriorly



Huh J et al. Medial elbow exposure for coronoid fractures: FCU-split versus over-the-top. *J Orthop Trauma*. 2013 Dec;27(12):730-4.

Medial: FCU-Split Approach

- Provides more extensive exposure of the anteromedial than the Over-the-Top approach
- Interval between humeral and ulnar heads of the FCU
 - Track ulnar nerve to the interval
 - May extend split distally to first motor branches of ulnar nerve



Huh J et al. Medial elbow exposure for coronoid fractures: FCU-split versus over-the-top. *J Orthop Trauma*. 2013 Dec;27(12):730-4.

Anterior Approach

- Used in addition to lateral approach addressing radial head and lateral ligaments
 - Useful for small fragments and capsular reconstruction
- Technique
 - Biceps aponeurosis incised
 - Interval is between radial artery and median nerve
 - Brachialis divided to expose coronoid

Reichel LM et al. Anterior approach for operative fixation of coronoid fractures in complex elbow instability. *Tech Hand Up Extrem Surg.* 2012 Jun;16(2):98-104.



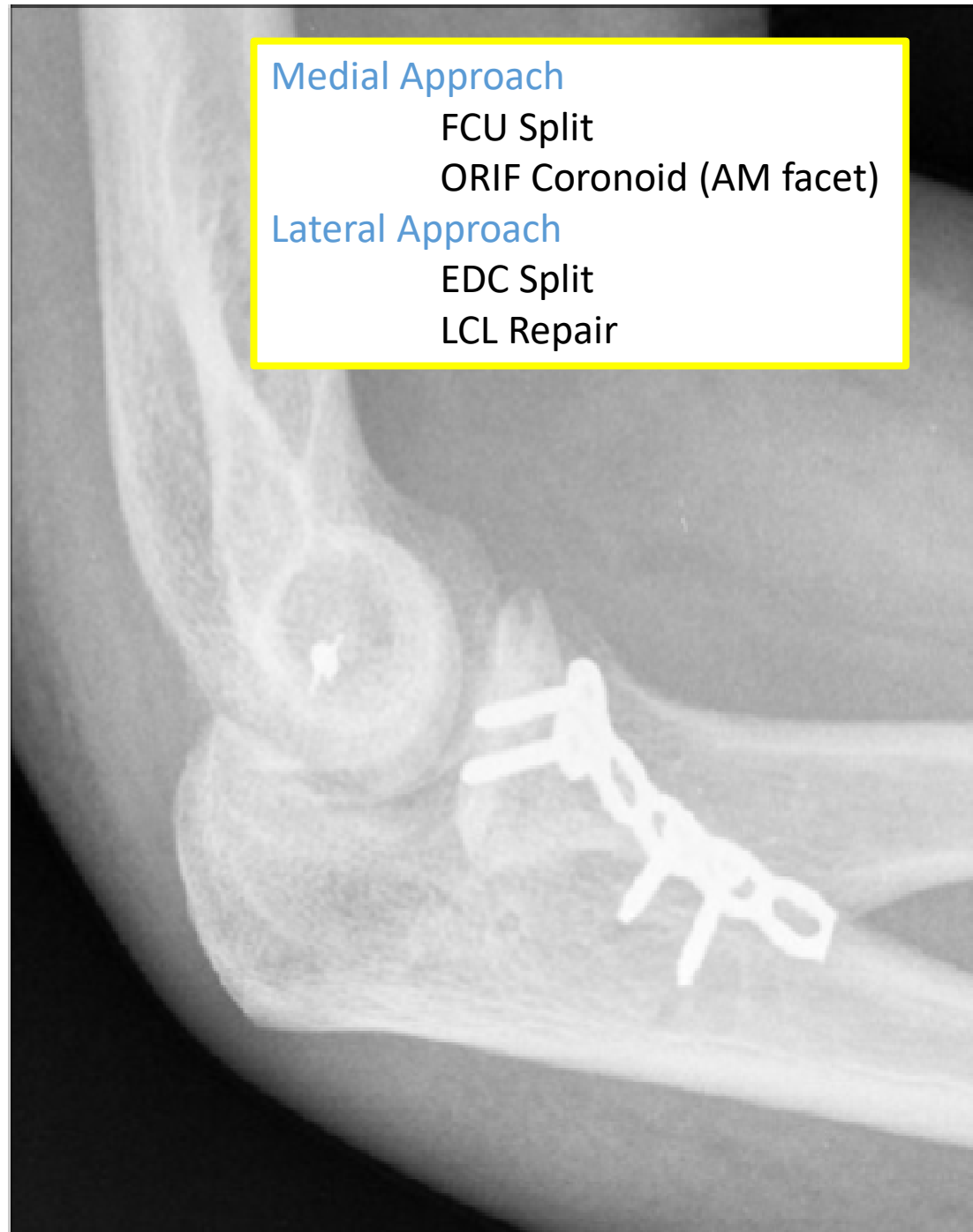
MANAGEMENT OF CORONOID FRACTURES

- Surgical approach
 - Medially – Protect and transpose ulnar nerve & reflect flexor pronator mass distal from origin
 - Through fracture of olecranon posteriorly or radial head laterally
- ORIF fragments large enough





Fall off back off a truck



Medial Approach
FCU Split
ORIF Coronoid (AM facet)

Lateral Approach
EDC Split
LCL Repair

MECHANISM - AXIAL LOAD

- “Direct blow”
- “Pilon of the elbow”
- Radius and ulna displace in the same direction

Trans-olecranon fracture/dislocation

Ring et al.
Transolecranon
fracture-
dislocation of the
elbow. *J Orthop
Trauma*. 1997
Nov;11(8):545-
50.

TRANSOLECRANON DISLOCATIONS

- Most commonly radius and ulna shaft dislocate anteriorly
- The radiocapitellar joint is dislocated but the
- Proximal radio-ulnar joint remains intact
 - Distinct from a Monteggia fracture
- Treatment
 - ORIF of olecranon fracture including coronoid fragment
 - Assess stability – must ensure concentric reduction of radiocapitellar joint
 - Malreduction of olecranon can make concentric reduction impossible

Haller JM et al. Patient Outcomes After Transolecranon Fracture-Dislocation. *J Am Acad Orthop Surg.* 2021 Feb 1;29(3):109-115.



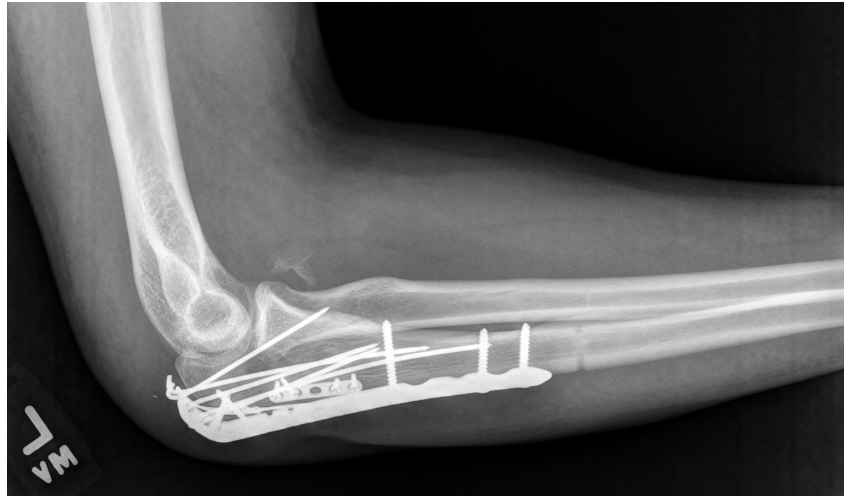
RIGHT TRANS-OLECRANON ELBOW FRACTURE DISLOCATION



RIGHT TRANS-OLECRANON ELBOW FRACTURE DISLOCATION



ORIF OF ULNA WITH REDUCTION OF RC JOINT POST-OP



OFTEN REQUIRE HARDWARE REMOVAL



DISLOCATIONS WITH EPICONDYLE FRACTURE

- **Adolescents** – epicondyle fractures through physis
- Ligaments intact
- Need to manage differently than isolated epicondyle fractures
 - ORIF imparts stability and should be performed

ELBOW DISLOCATION IN ADOLESCENT



Post Reduction



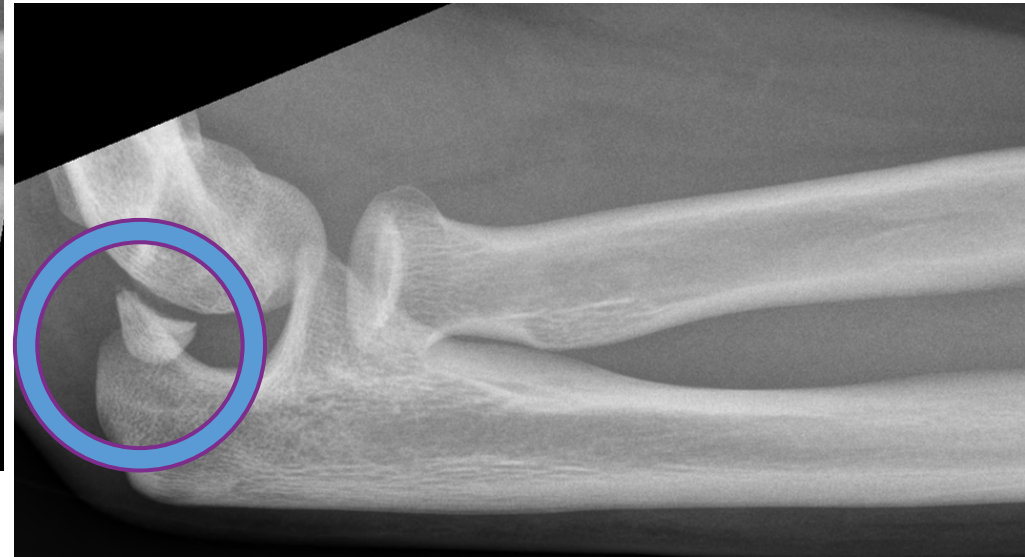


14 YEAR OLD FEMALE GYMNAST

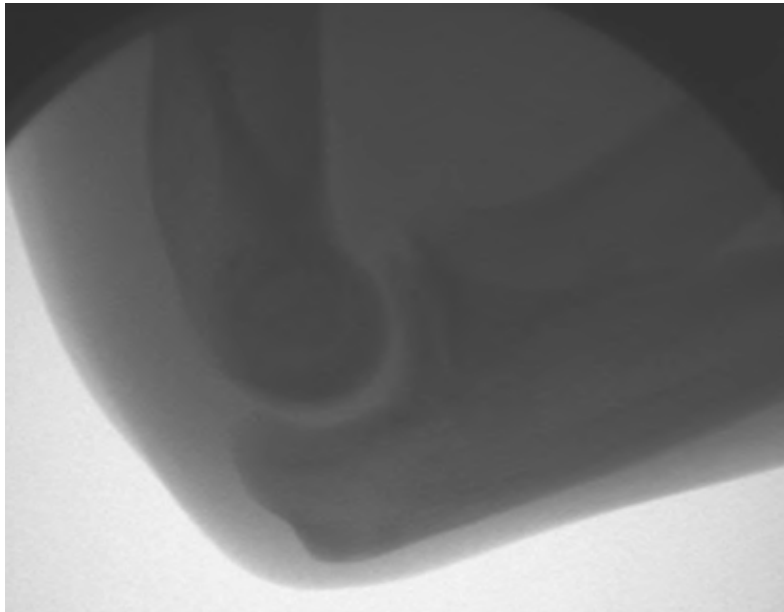
VALGUS INJURY

LATERAL DISLOCATION

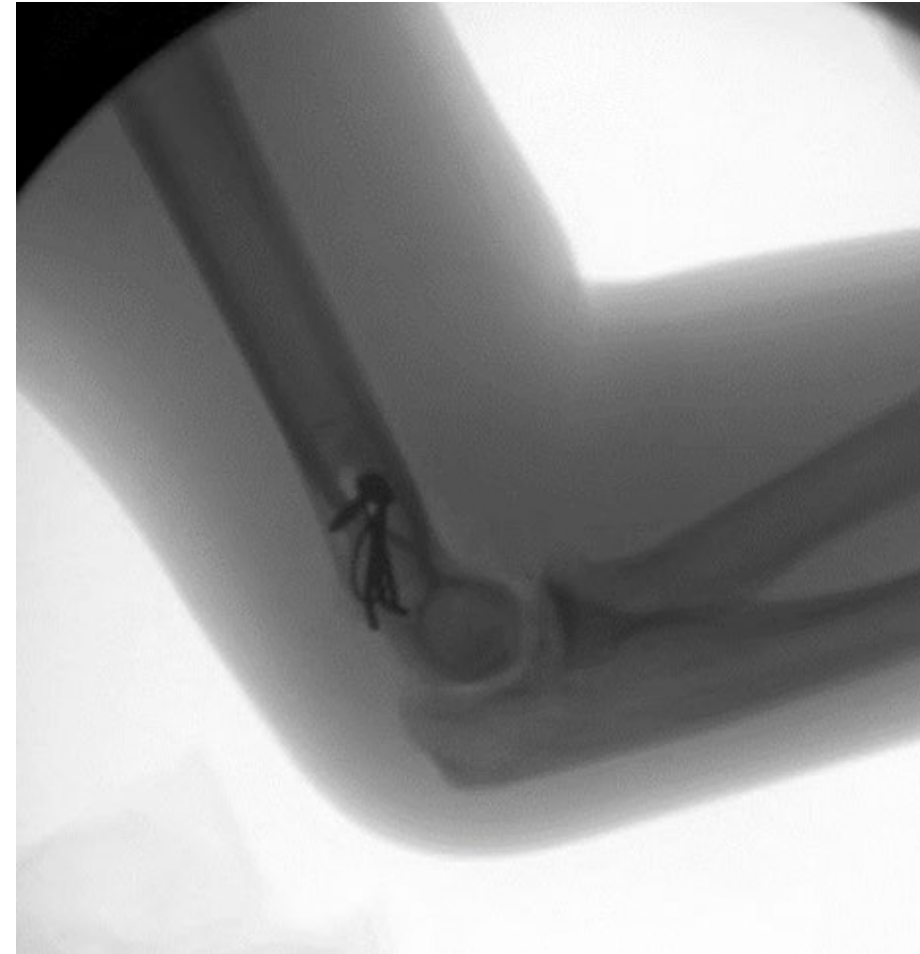
WITH MEDIAL EPICONDYLE AVULSION FRACTURE



POST-REDUCTION – STRESS VIEWS DEMONSTRATE **INSTABILITY TO VALGUS**



ORIF RESULTS IN RESTORATION OF STABILITY TO VALGUS

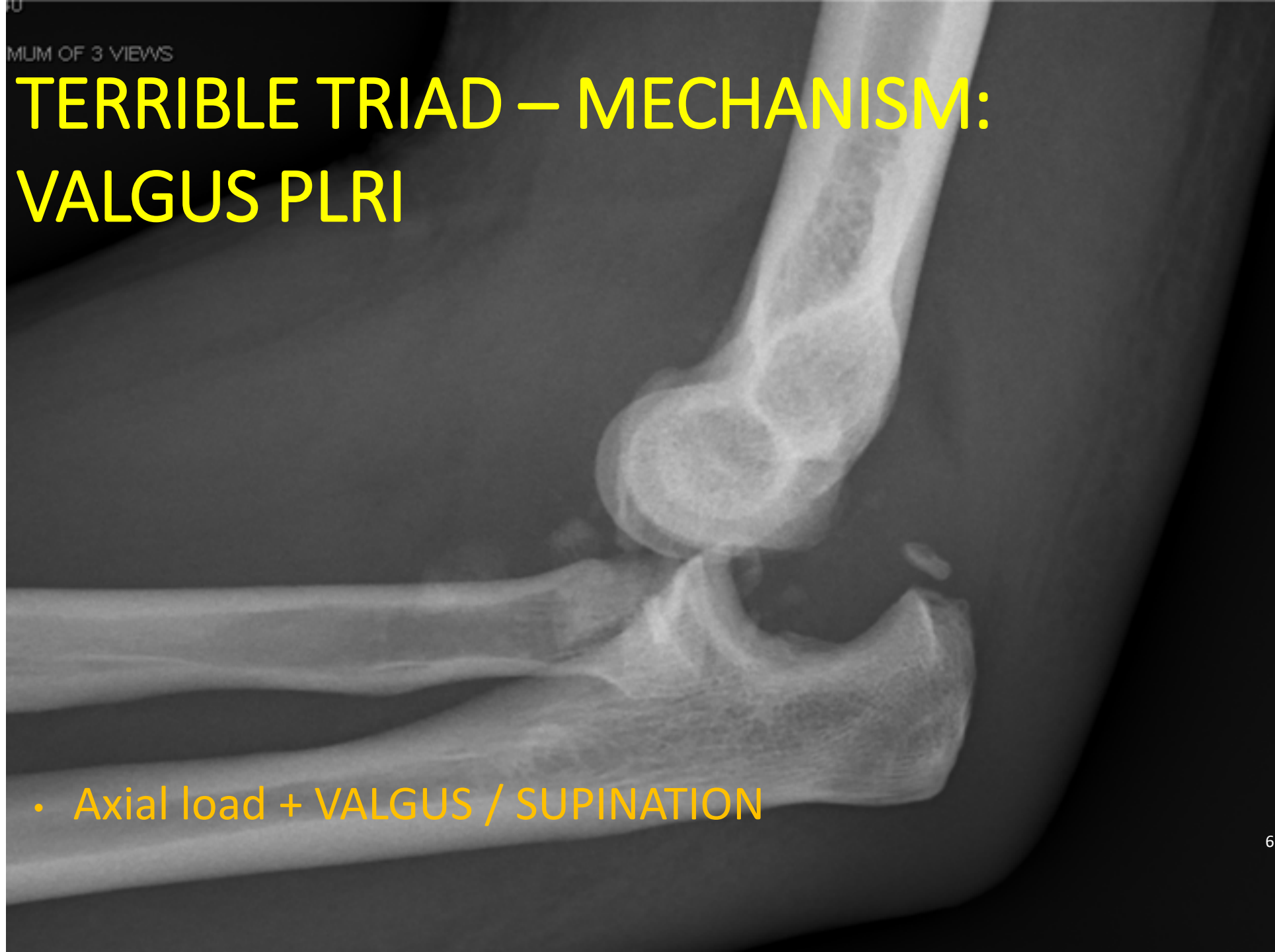


TERRIBLE TRIAD

- Fall on extended elbow, valgus and posterolateral rotatory stress
- Constellation of injuries
 - Posterior dislocation
 - Radial Head Fracture
 - Coronoid Fracture
- Nonsurgical management in select, low-demand patients if concentric reduction achieved
- Surgical Management is necessary in most cases

NUM OF 3 VIEWS

TERRIBLE TRIAD – MECHANISM: VALGUS PLRI



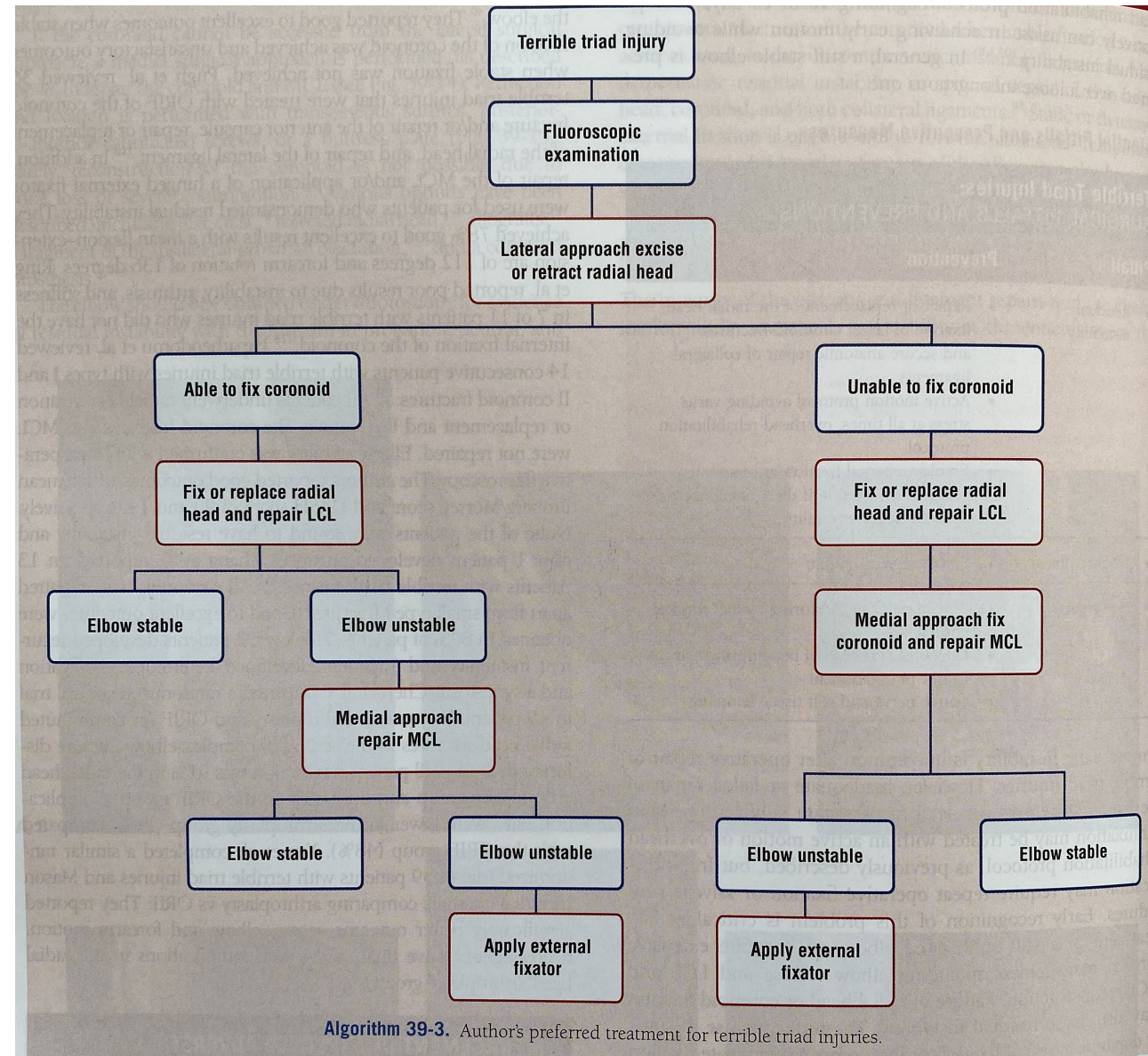
- Axial load + VALGUS / SUPINATION

TERRIBLE TRIAD TREATMENT ALGORITHM

- Nonoperative Treatment can be appropriate in select lower-demand patients
- Requires very close clinical and radiographic follow-up

Chan K et al. Can we treat select terrible triad injuries nonoperatively. *Clin Orthop Related Res.* 2014, July; 472(7): 2092-9.

King G, Beingessener D, Pollock J. Chapter 39. In: Tornetta P, Ricci WM, eds. *Rockwood and Green's Fractures in Adults, 9e.* Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

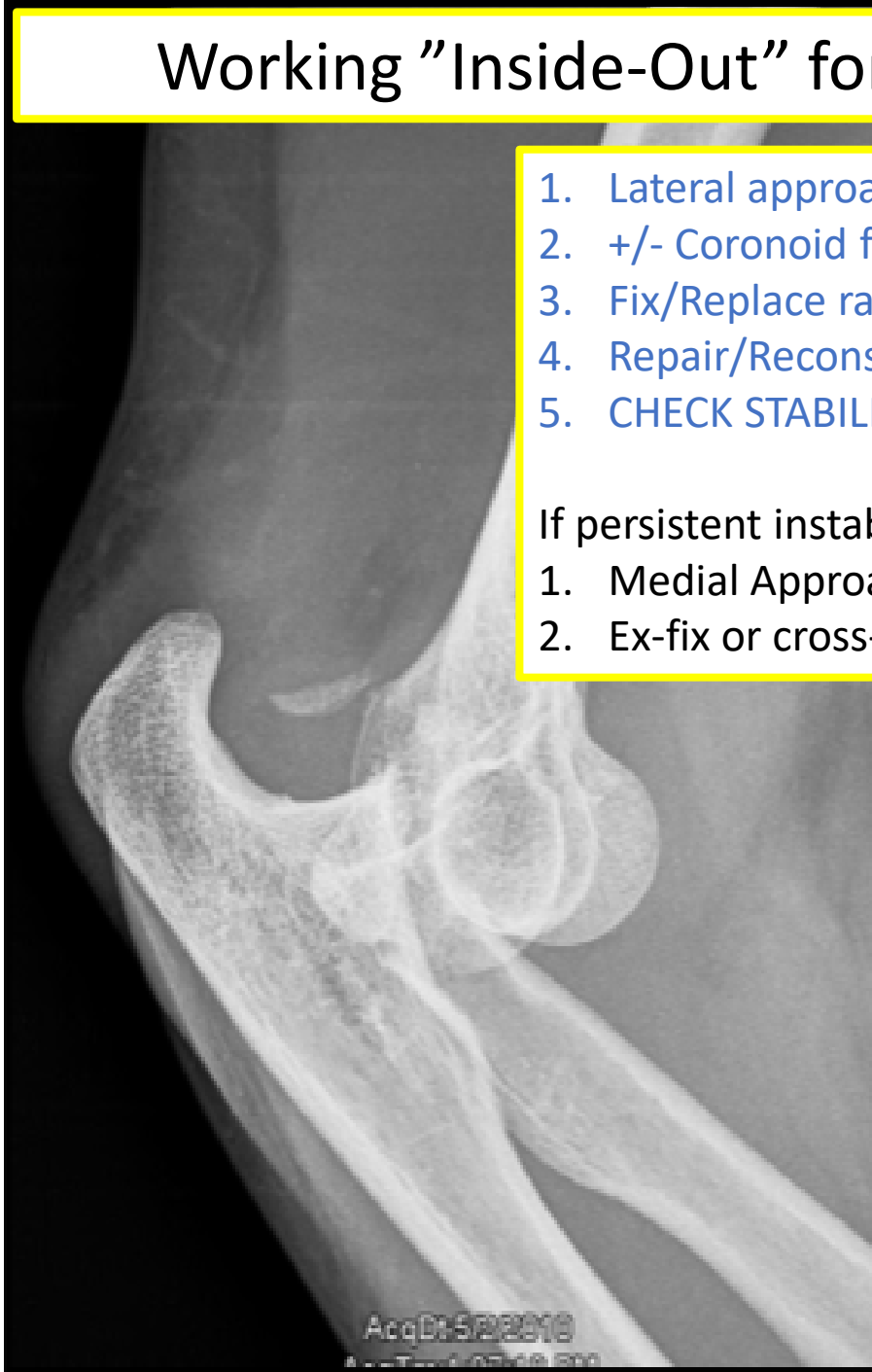


Working "Inside-Out" for the Terrible Triad

1. Lateral approach
2. +/- Coronoid fixation
3. Fix/Replace radial head
4. Repair/Reconstruct LCL
5. CHECK STABILITY

If persistent instability, consider...

1. Medial Approach for MCL
2. Ex-fix or cross-pinning



TERRIBLE TRIAD - SURGERY

- Surgical approach – lateral is the workhorse
 - **Posterior** – extensile with better medial exposure, but create large skin flaps
 - **Lateral** – can work through radial head if replacing
 - May need to add medial approach if MCL requires reconstruction
- Fix coronoid and repair or replace radial head
- Assess stability – repair or reconstruct MCL/LCL as needed

- Challenging cases requiring **medial and lateral ligament reconstruction**
- Finkbone PR, O’Driscoll SW. Box-loop ligament reconstruction of the elbow for medial and lateral instability. *J Shoulder Elbow Surg.* 2015 Apr;24(4):647-54.
 - Reconstruct both the medial and lateral collateral ligaments with 1 graft.
 - "Box-loop" design: tendon graft passed through the humerus and ulna and
 - Tied back to itself, making a box-loop.

Outcomes – Terrible Triad

- Zaidenberg EE et al. [Terrible triad injuries at a mean follow-up of nine years.](#) *J Shoulder Elbow.* 2019 Dec;11(6):450-458.
 - 12 patients – mean follow up 9.2 years
 - Coronoid repair, radial head repair/replacement and lateral ligament reconstruction
 - Average ROM: 6-145; sup/pron: 82.5/80
 - 75% had XR evidence of DJD
 - **No difference** between radial head replacement and reconstruction
- Chen et al. [Replacement or repair of terrible triad of the elbow: A systematic review and meta-analysis.](#) *Medicine (Baltimore).* 2019 Feb; 98(6): e13054
 - 115 patients with Mason 2-3 injuries
 - **Better ROM and fewer complications with radial head replacement**

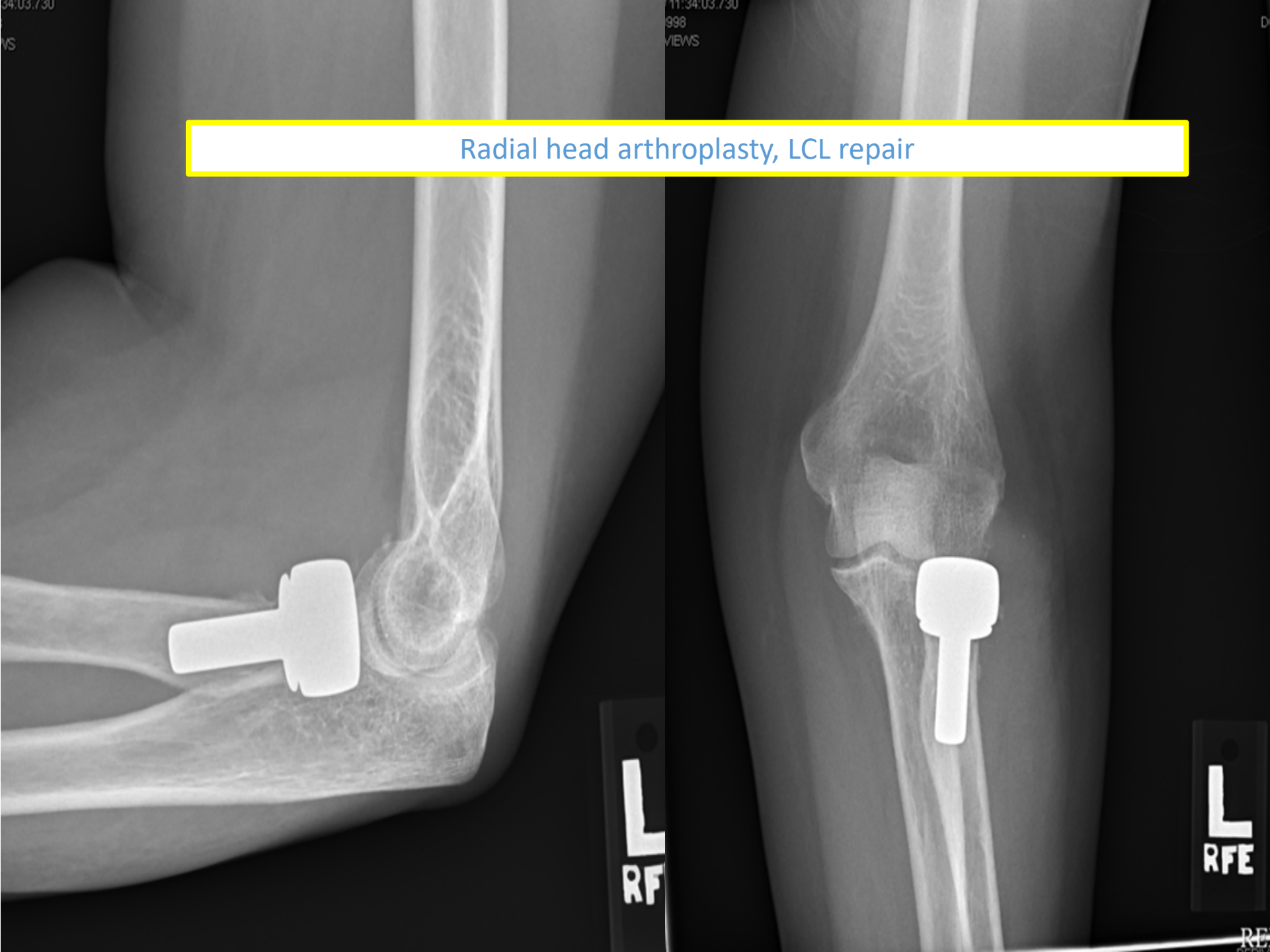
Complications – Terrible Triad

- Chen et al. [Replacement or repair of terrible triad of the elbow: A systematic review and meta-analysis.](#) *Medicine (Baltimore)*. 2019 Feb; 98(6): e13054
 - Total Complications: 47.4% ORIF vs 20% Arthroplasty
 - Instability: 33% vs 0%
 - Stiffness: 21% vs 5%
 - Heterotopic ossification: 10% vs 5%
 - Reoperation: 44% vs 23%

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12/11/2017 12:03:56.770
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ELBOW, COMPLETE MINIMUM OF 3 VIEWS
Image #11

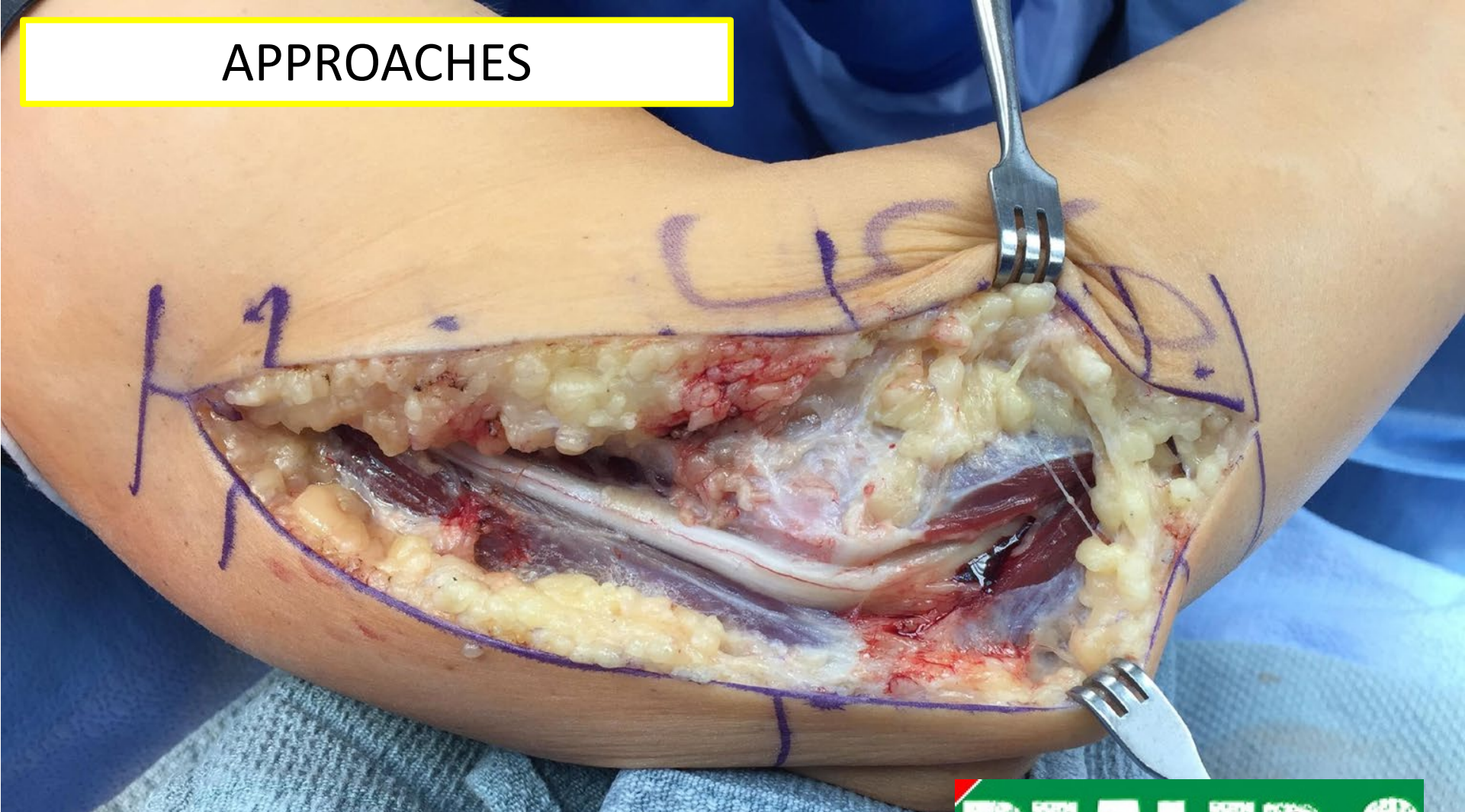


Ground level fall
Comminuted radial head fracture Type I coronoid, elbow dislocation



Radial head arthroplasty, LCL repair

APPROACHES



Single posterior incision
Vs
Separate medial and lateral approaches



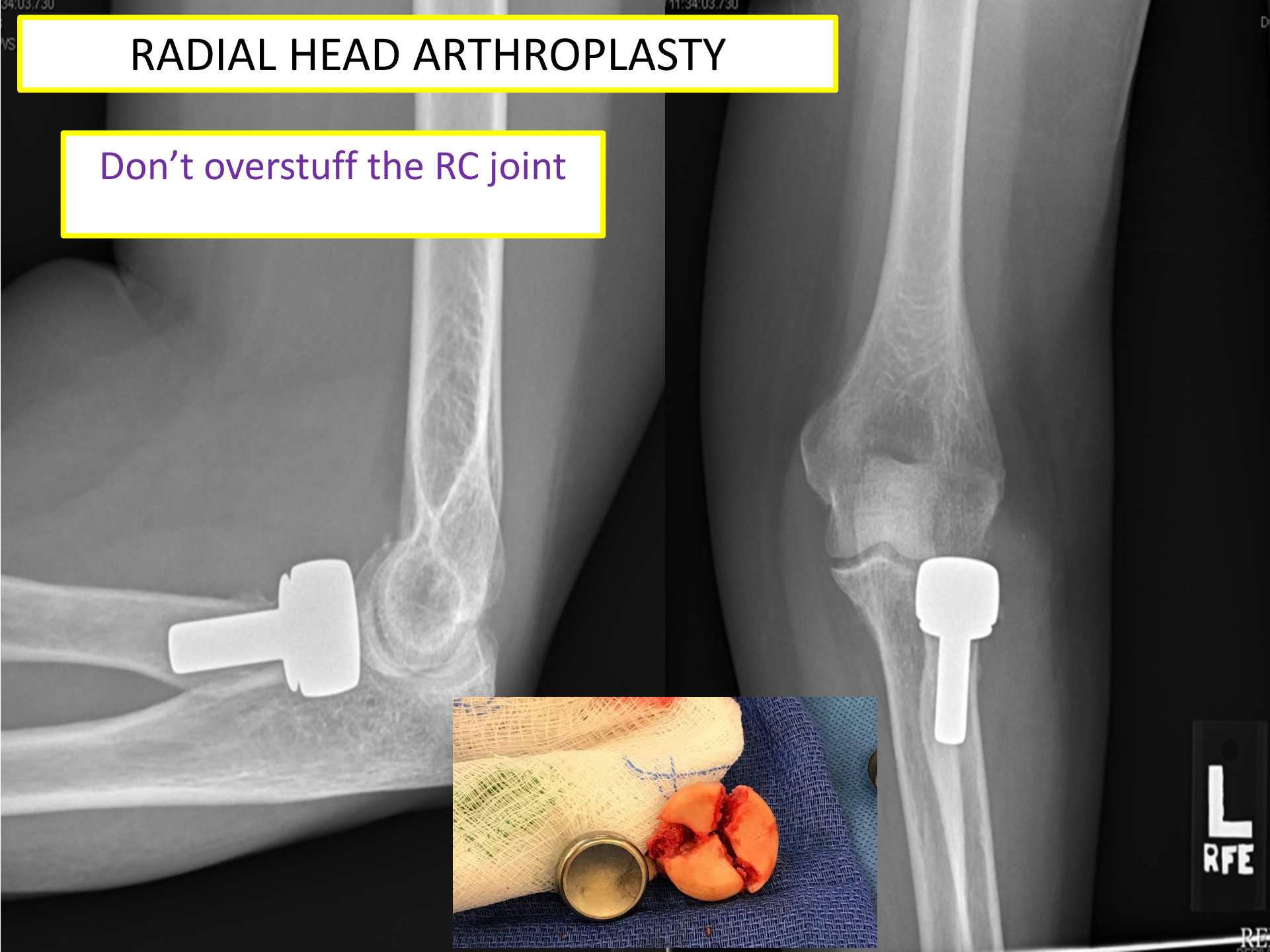
ORIF RADIAL HEAD

Safe Zone of Hotchkiss

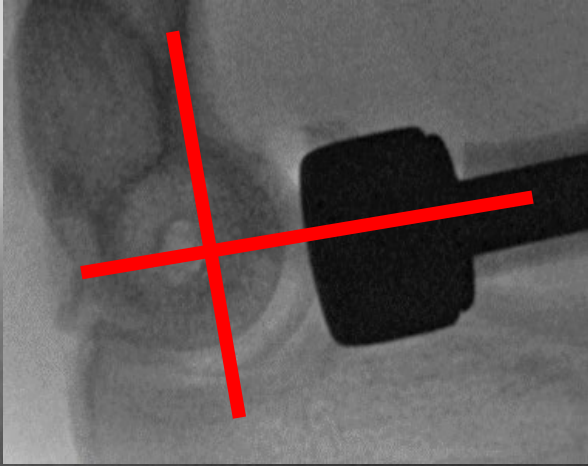


RADIAL HEAD ARTHROPLASTY

Don't overstuff the RC joint



REPAIR or RECONSTRUCT the LCL COMPLEX



Consider Reconstruction:

- High Energy
- Poor Tissue
- Dislocated in splint
- Highly unstable

CHRONIC DISLOCATIONS

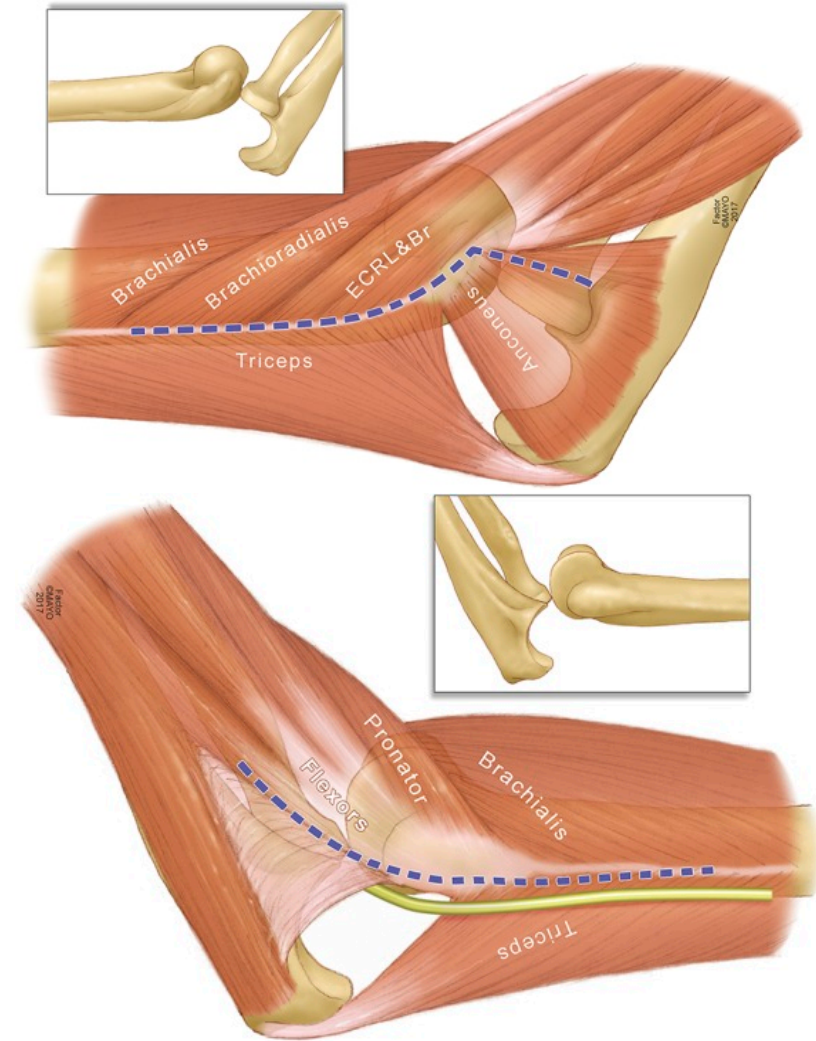
- Uncommon
- Dislocations greater than 2 weeks
- Soft tissue and osseous changes make reduction difficult to achieve
Intra-articular fibrosis
 - Contracture of capsule and collateral ligaments
 - Shortening of muscle-tendon units across joint – especially triceps
- Evaluation – AP, lat radiographs and CT scan to assess for intra-articular fractures
 - MRI of limited benefit

CHRONIC DISLOCATIONS - SURGERY

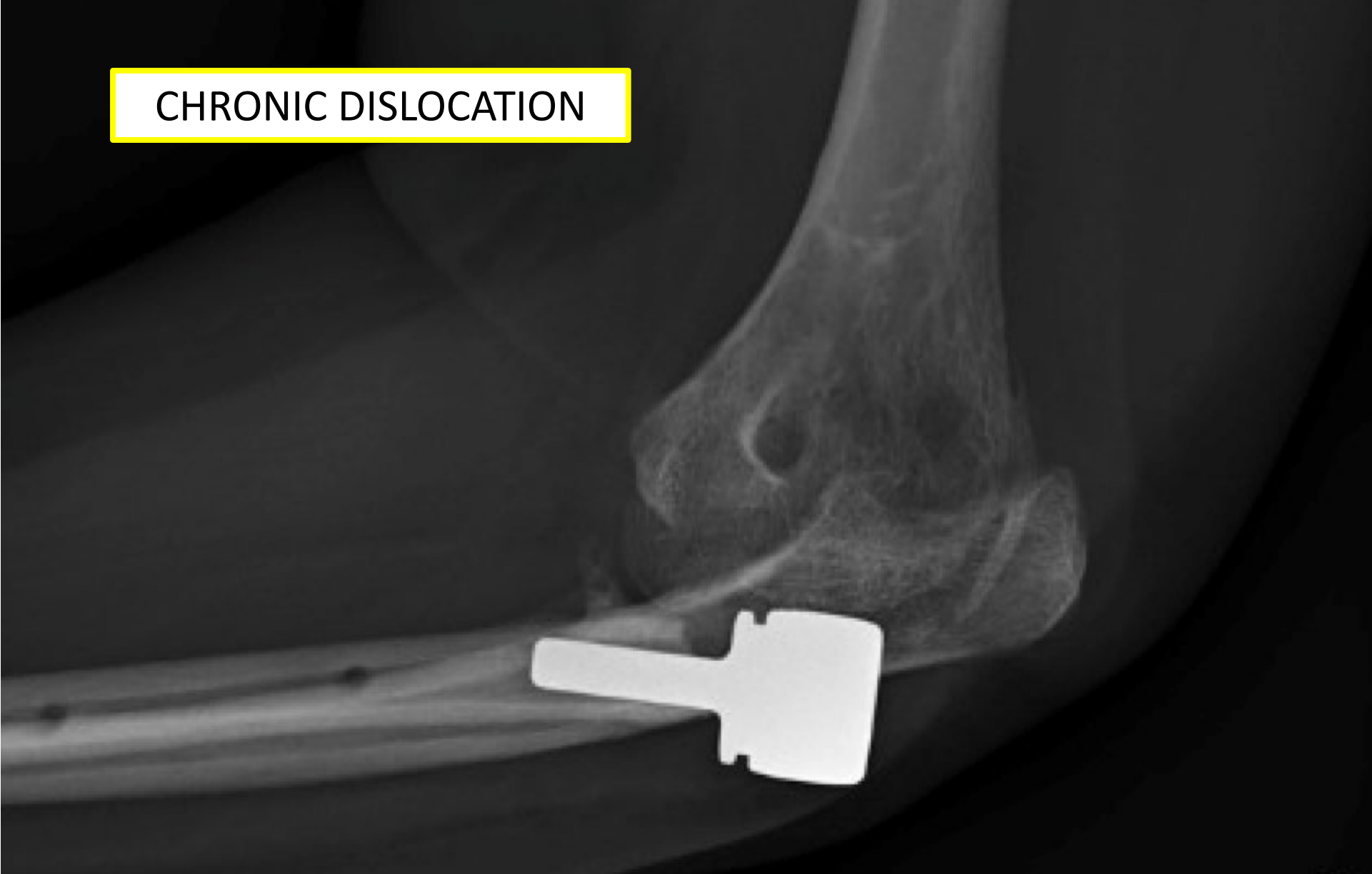
- Open reduction and extensive debridement
 - Triceps reflecting or paratricipital approach
- Debridement of fibrosis and release or recession of posterior capsule and collateral ligaments
- Possible releases of muscle origins: brachialis, brachioradialis, wrist extensors
- Triceps V-Y lengthening
- Ulnar nerve transposition
- Some combination of ligament reconstruction, hinged ex fix, cross pinning for stability

O'Driscoll SW et al. **Surgical Treatment of Chronic Elbow Dislocation Allowing for Early Range of Motion: Operative Technique and Clinical Results.** *J Orthop Trauma.* 2018 Apr; 32(4): 196-203.

- 32 patients – mean dislocation of 6 months duration
- Medial and lateral approaches
- Extensive releases
- Debridement of scar in olecranon/fossa
- ROM
 - Preop – 8 degrees arc of motion
 - Post – mean ROM 31-132
- No cases of recurrent instability



CHRONIC DISLOCATION



Dislocated for 6 weeks s/p Terrible Triad

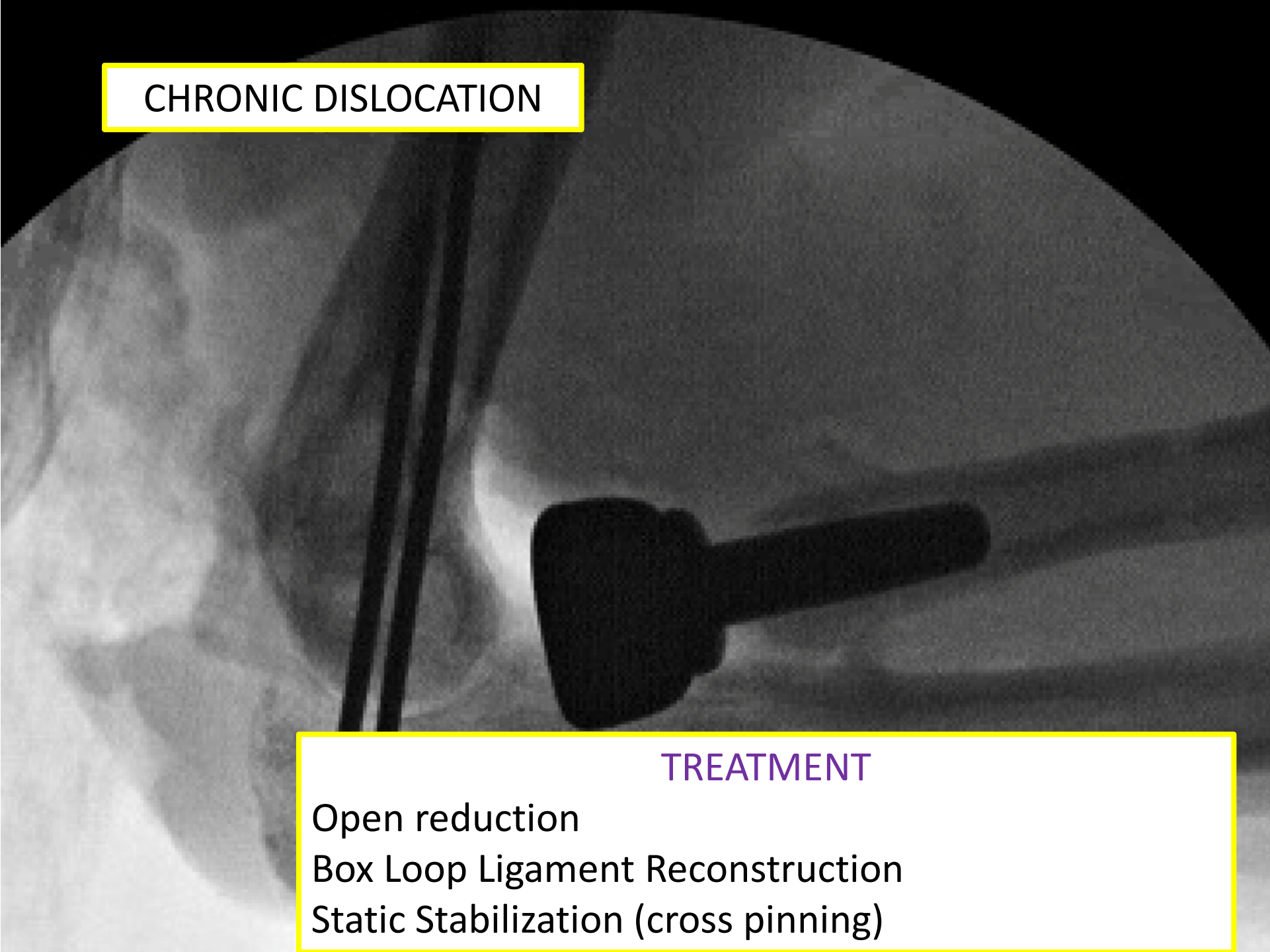
CHRONIC DISLOCATION



TREATMENT CONSIDERATIONS

Open reduction
Stabilization (static vs dynamic)
+/- Ligament Reconstruction

CHRONIC DISLOCATION



TREATMENT

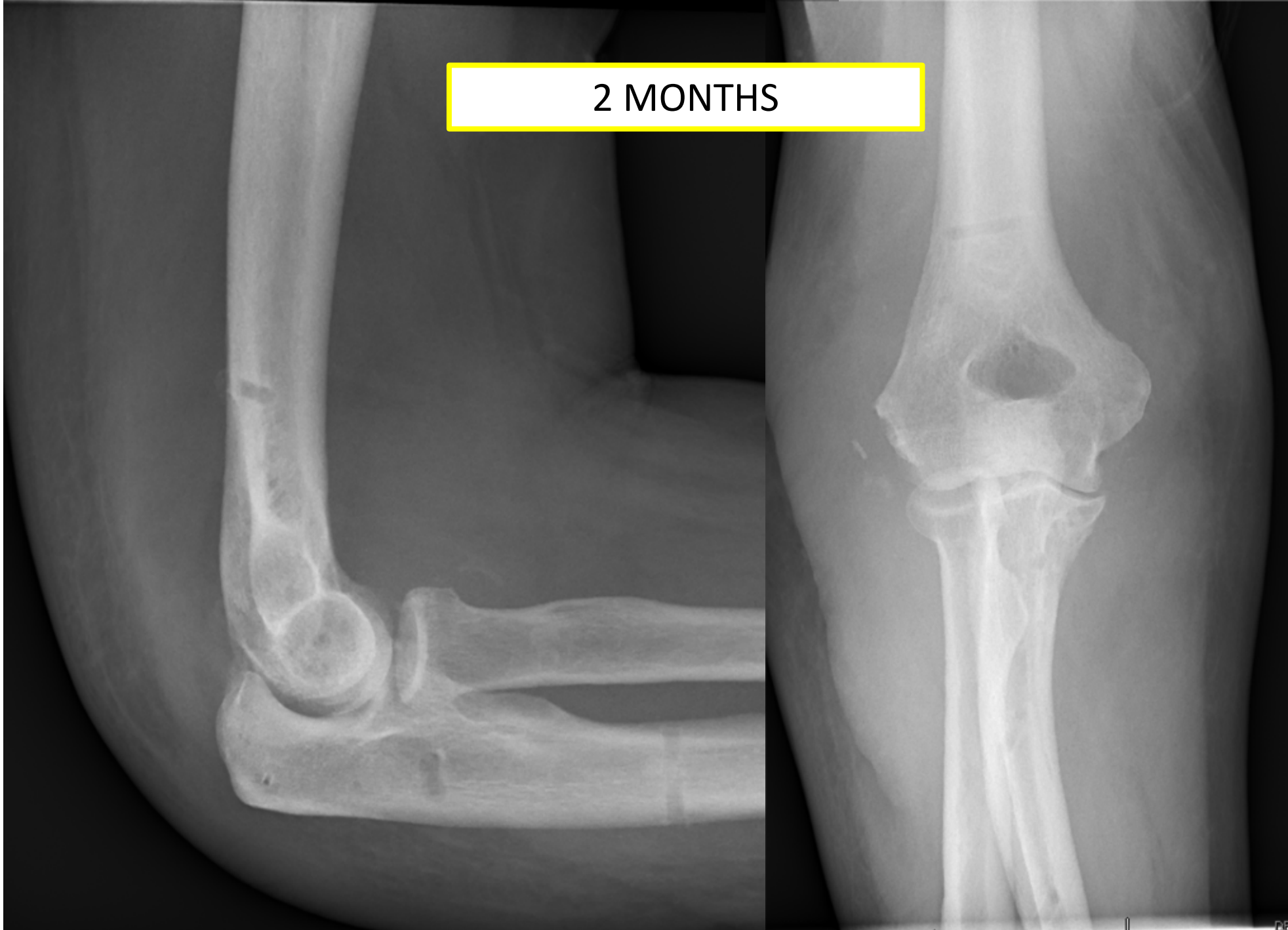
Open reduction
Box Loop Ligament Reconstruction
Static Stabilization (cross pinning)

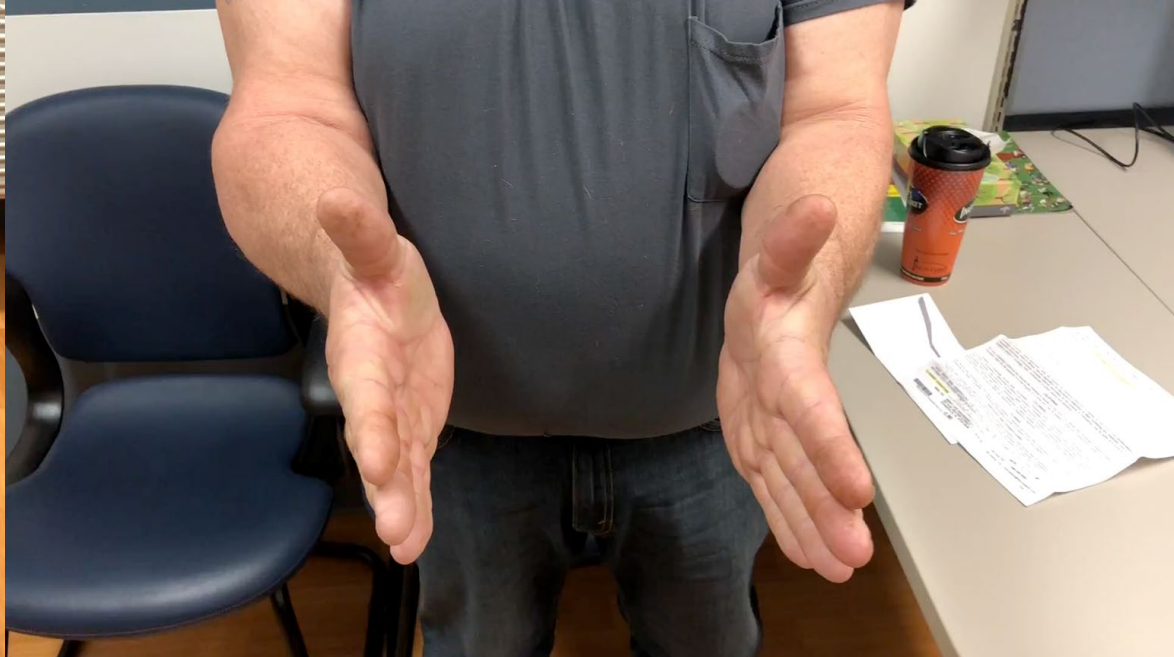
CHRONIC DISLOCATION

HINGED EX-FIX

TREATMENT
Open reduction
Hinged External Fixation

2 MONTHS





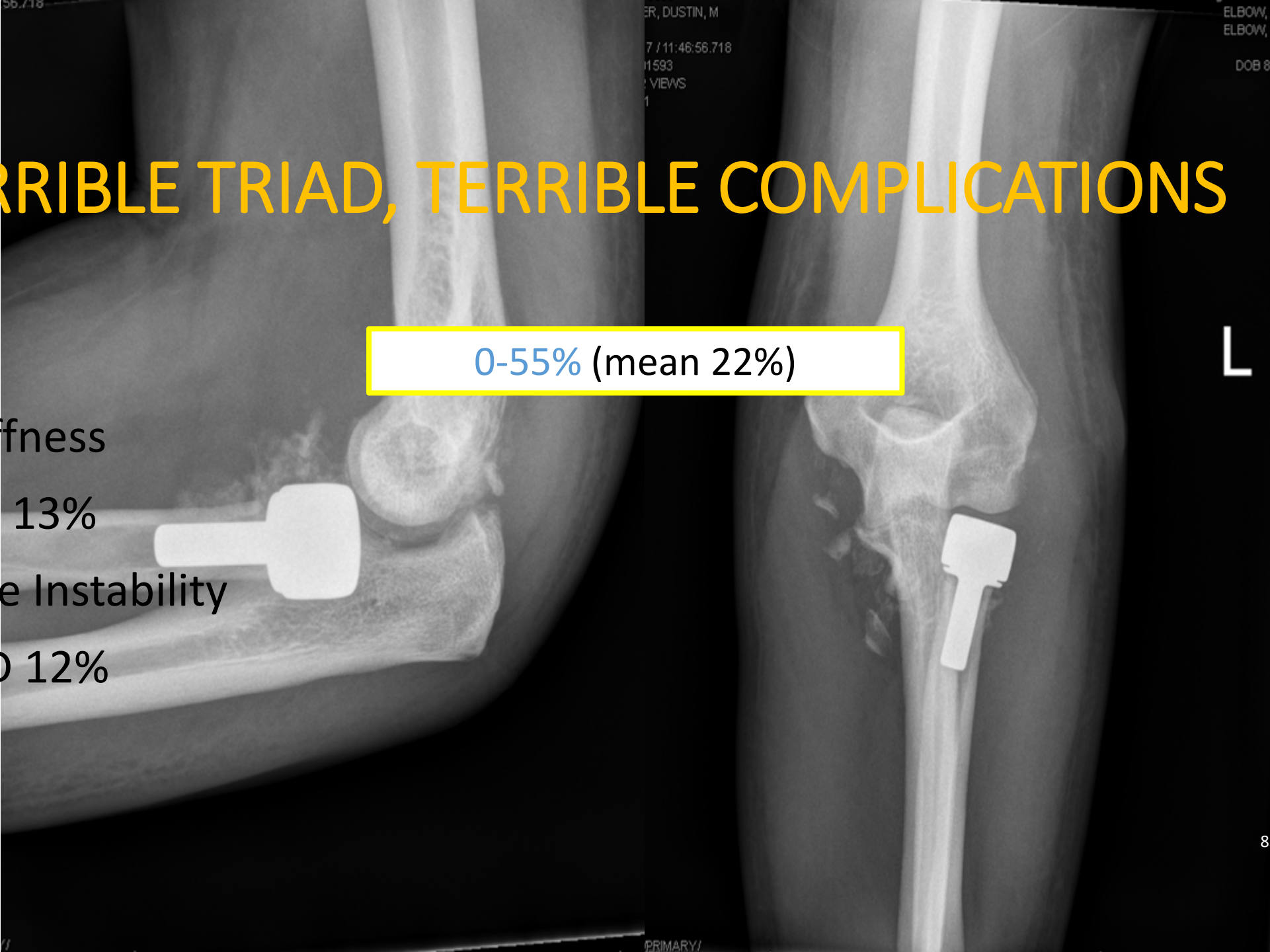
TRAUMATIC ELBOW INSTABILITY: COMPLICATIONS

- Heterotopic ossification
- Synostosis
- Chronic instability – requiring late soft tissue reconstruction
- Stiffness – very common to lose some ROM
 - Severe cases may require arthroscopic or open debridement and releases

TERRIBLE TRIAD, TERRIBLE COMPLICATIONS

0-55% (mean 22%)

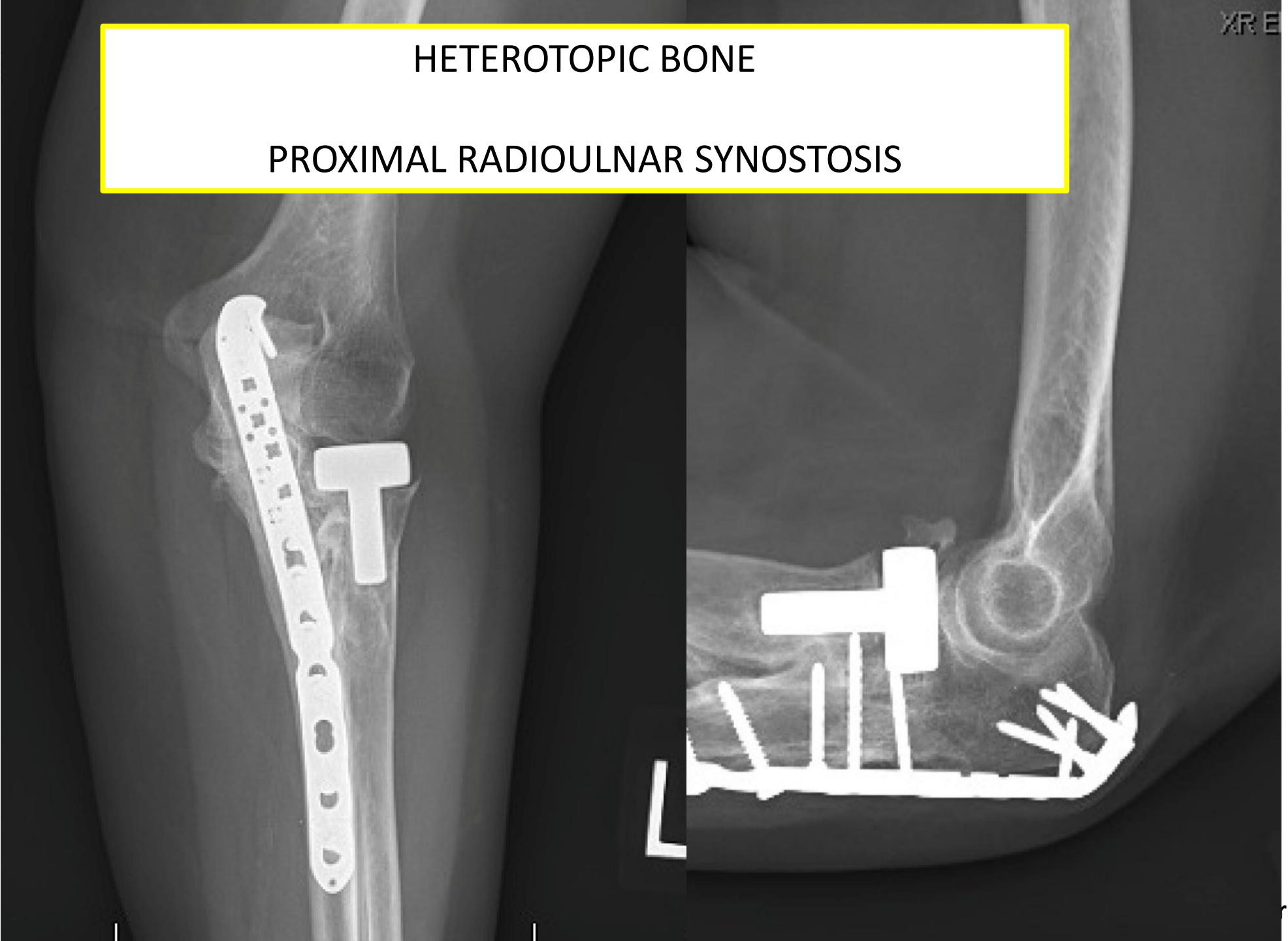
- Stiffness
- HO 13%
- Late Instability
- DJD 12%



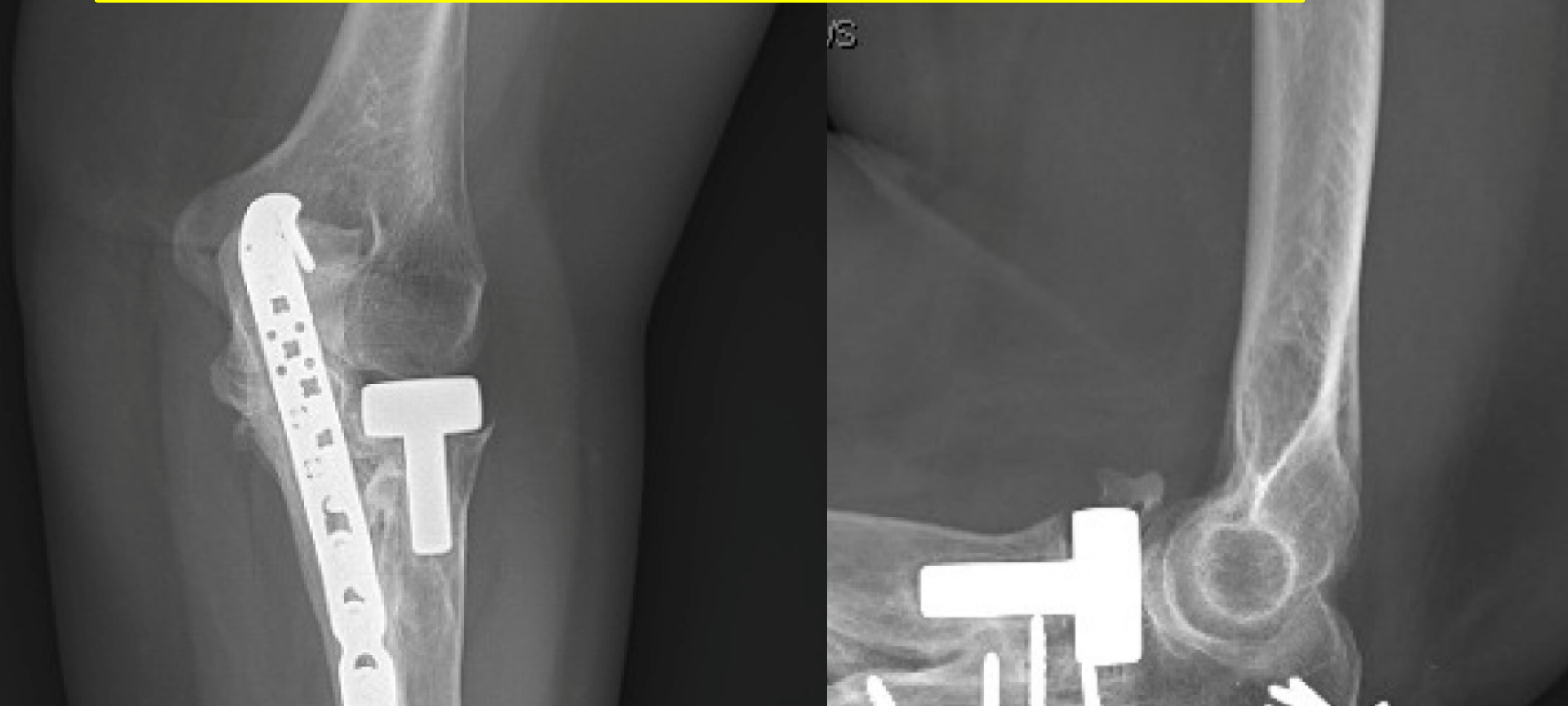
HETEROTOPIC OSSIFICATION/SYNOSTOSIS

- Can require open resection in severe cases that limit ROM
- **SYNOSTOSIS**
 - Increased risk with:
 - Associated head injuries
 - Proximal 1/3 fractures

HETEROTOPIC BONE
PROXIMAL RADIOULNAR SYNOSTOSIS



PROXIMAL RADIOULNAR SYNOSTOSIS



TREATMENT
Excision (anterior vs posterior approaches)
+/- interposition fat grafting

THANK YOU!!!

