Pediatric Upper limb fractures:

Radial Neck and head

Lateral Condyle

Distal Radius

Shalin Shah
M.S. Ortho, DNB Ortho

Radial neck fractures in children:

Introduction

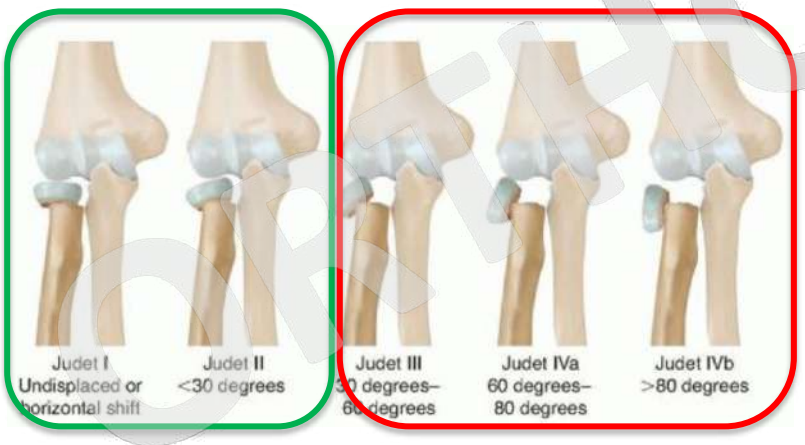
- Rare

- 5% of elbow fractures in children

What is acceptable?

Need for reduction

- Displacement and translation



- Angulation > 30*
  - COR of radial head eccentric
  - CAM impingement
  - Incongruent PRUJ
- Age

Reduction methods ?

Closed reduction

Minimally invasive techniques

Open reduction

Closed reduction methods

Methods of closed reduction

- PATTERSON
- KAUFMAN
- JEFFERY
- MONSELL
- NEHER TORCH
- ESMARCH BANDAGE
- Orthokids

Patterson method

- ELBOW EXTENSION
- FOREARM SUPINATION
- VARUS
- PUSH RADIAL HEAD WITH THUMB

Patterson, JBJS 1934

Jeffery's method

- **Rotate forearm will radial head is seen if true AP profile**

Jeffery, JBJS (Br) 1950

Neher Torch method

- **Assistant pushes distal fragment laterally**

Neher and Torch, JPO 2003

Kaufman method

- Elbow 90 degrees flexion
- Forearm supination
- Thumb pressure on radial head
- Forearm pronated

Kaufman et al, JBJS (Br) 1989

Monson method

- Elbow 90 degrees flexion
- Forearm pronation
- Angulation apex anterior
- Push radius shaft posteriorly

Monson et al, JPO 2009

Orthokids method

Closed Reduction Technique for Severely Displaced Radial Neck Fractures in Children

Maulin Shah, MBBS, MS(Ortho), DNB(Ortho), Gaurav Gupta, MS(Ortho), Qaisur Rabbi, D(Ortho), Vikas Bohra, MS(Ortho), Kemble Wang, FRACS, FAOrthA, Akash Makadia, MS(Ortho), Shalin Shah, MS(Ortho), DNB(Ortho), Chinmay Sangole, MS(Ortho)

JBJS Essential Surgical Techniques 2023

- **Orthokids technique**

Esmarch bandage method

FIGURE 33-95 Reduction of a radial neck fracture has been reported after exsanguination of the extremity with an Esmarch bandage and the elbow in extension.

Esmarch bandage method

FIGURE 33-95 Reduction of a radial neck fracture has been reported after exsanguination of the extremity with an Esmarch bandage and the elbow in extension.

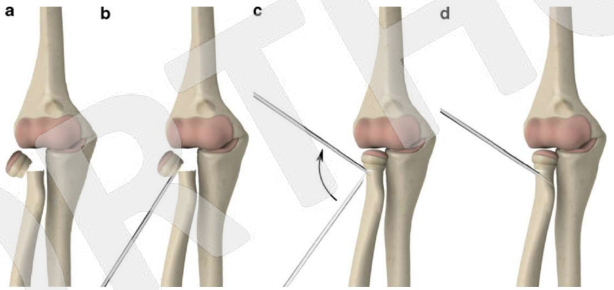
Minimally invasive techniques

Reduction

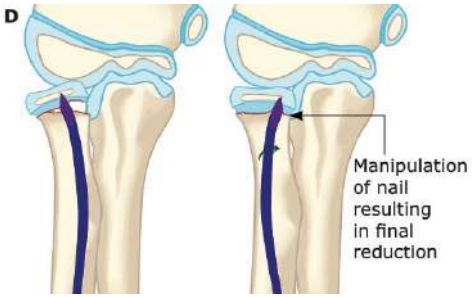
Closed reduction

Minimally invasive techniques

Open reduction

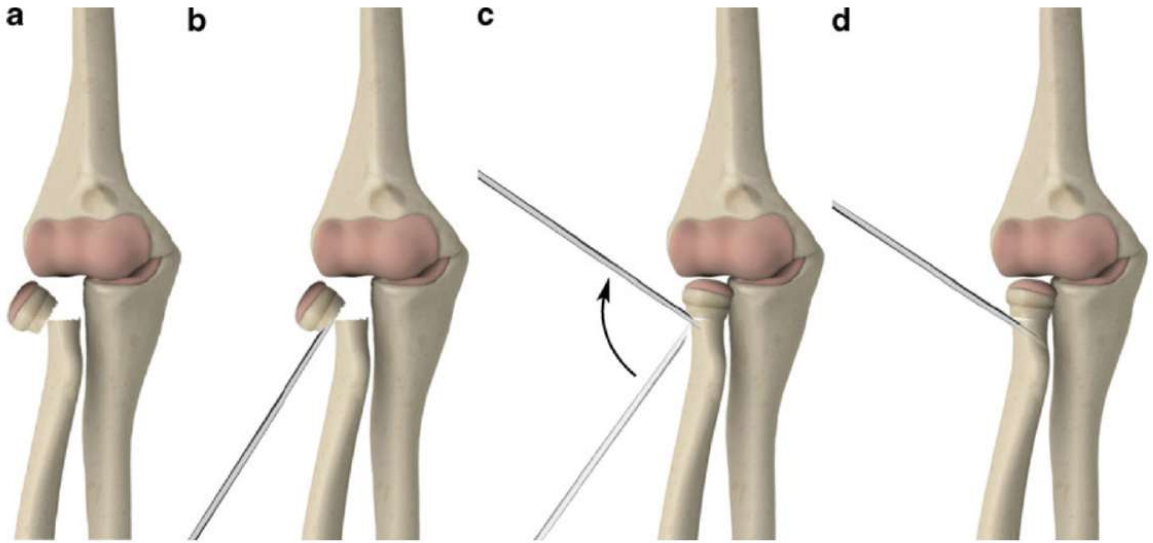


Percutaneous K-wire leverage



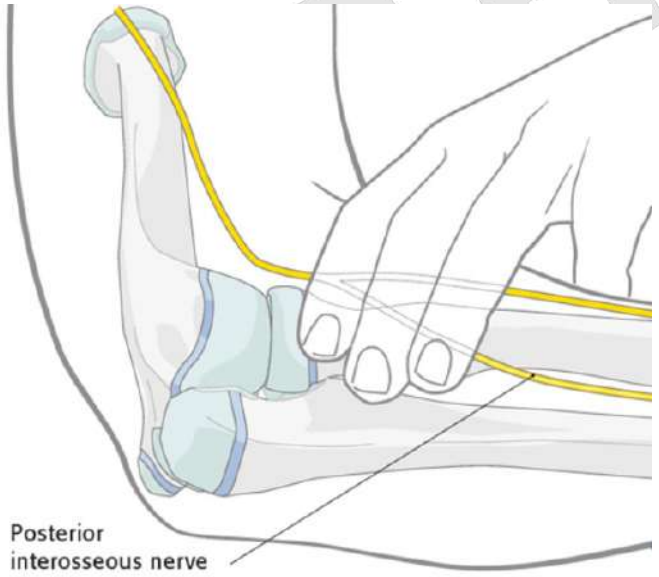
Metaizeau technique

Percutaneous K-wire leverage



Technical tips: Protect the PIN

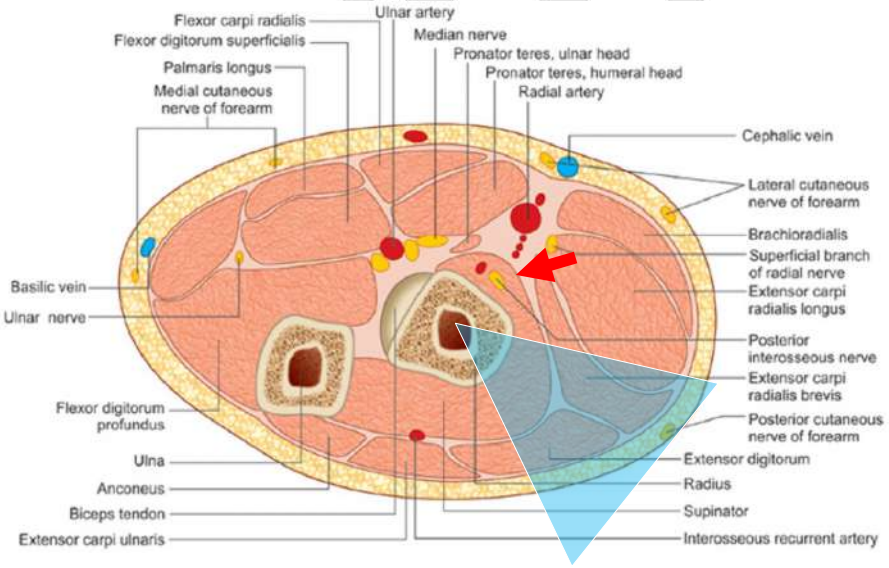
PIN crosses lateral surface of radius 3 finger-breadths distal to radial neck



Technical tips: Protect the PIN

Safe zone for wire insertion:

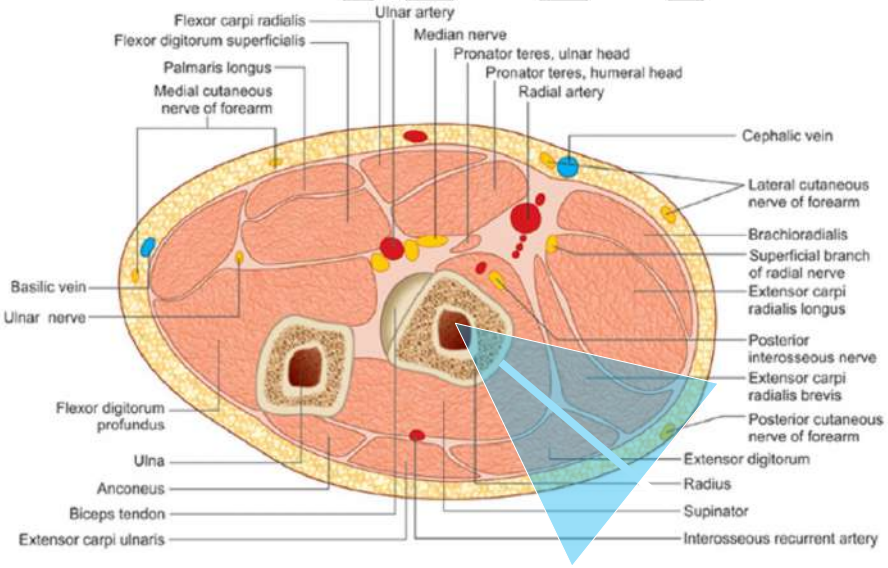
- Postero-lateral aspect
- Pronation increases safe zone



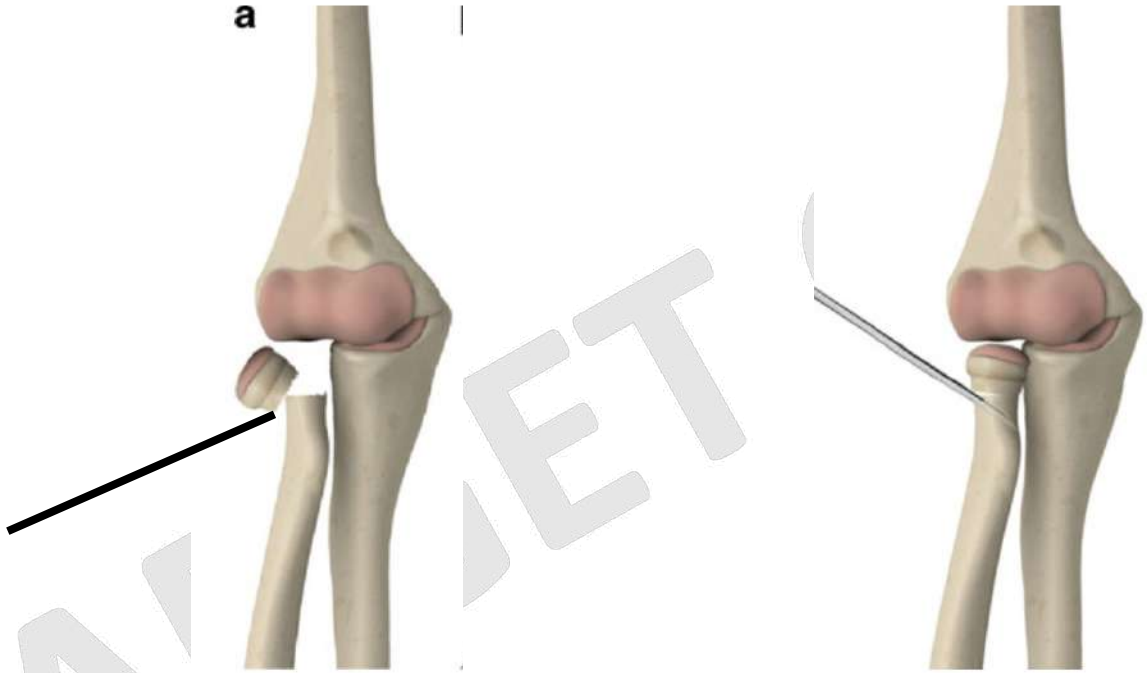
Technical tips: Protect the PIN

Safe zone for wire insertion:

- Postero-lateral aspect
- Pronation increases safe zone
- Insert wire in safe zone
- Maintain contact with bone during manipulation
- Avoid blind withdrawal and reinsertion



Technical tips: wire insertion and manipulation

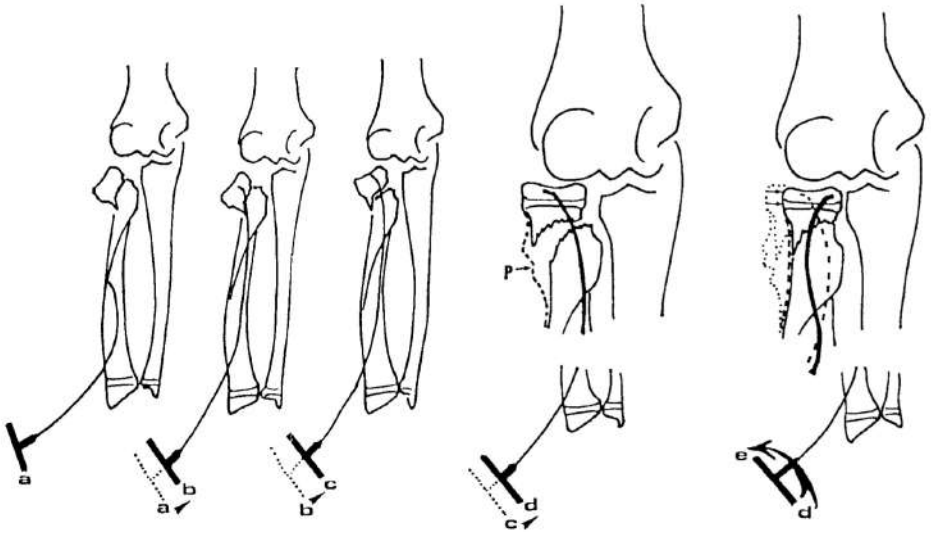


Metaizeau Technique

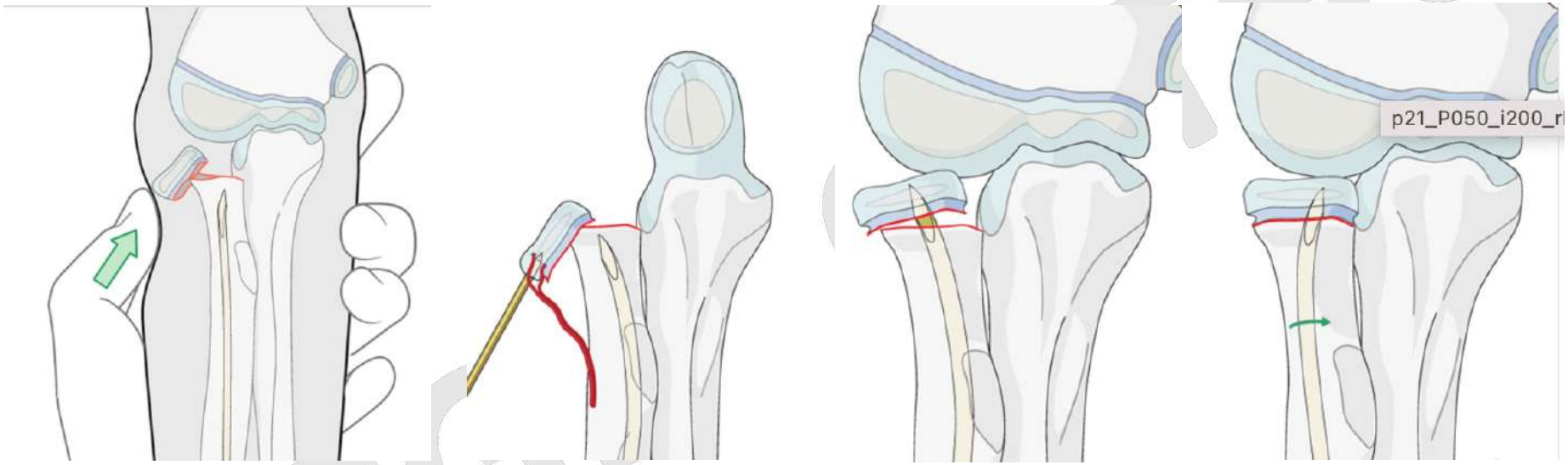
Journal of Pediatric Orthopaedics
13:355–360 © 1993 Raven Press, Ltd., New York

Reduction and Fixation of Displaced Radial Neck Fractures by Closed Intramedullary Pinning

J.-P. Metaizeau, *P. Lascombes, *J.-L. Lemelle, †D. Finlayson, and *J. Prevot



Reduction



Open Reduction

Closed vs Open reduction

- Results of open reduction significantly inferior
- Loss of ROM
- Due to AVN, premature closure of proximal radius physis

- If angulation < 45 degrees after closed reduction, leave alone

Zimmerman et al, JBJS 2013
Falciglia et al, JPO 2015

Radial Neck Fractures in Children: Results When Open Reduction Is Indicated

Francesco Falciglia, MD, Marco Giordano, MD,* Angelo G. Aulisa, MD,*
Antonio Di Lazzaro, MD,* and Vincenzo Guzzanti, MD*†*

JPO 2015

- Anconeus- ECU interval
- Carefully preserve periosteal attachments
- If fragment stable, no fixation
- Problems: stiffness, AVN, growth arrest, overgrowth of radial head

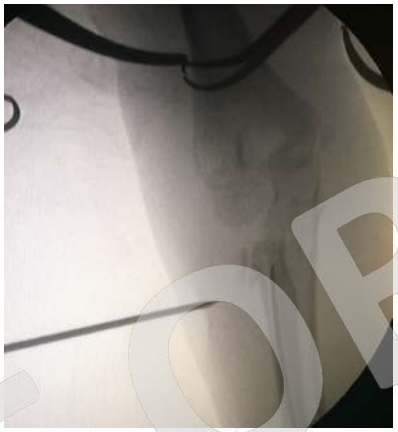
Complications

- Decreased range of motion
  loss of pronation more common than supination
- Radial head overgrowth
  20-40% of fractures
- Osteonecrosis
  10-20% of fractures
  Radial head in children is entirely cartilage and blood supply is primarily from the metaphysis
  up to 70% of cases occur with open reduction
- Nerve injury
  PIN may be injured
- Physeal arrest
  may lead to cubitus valgus deformity
- Synostosis
  most serious complication
  occurs in cases of open reduction with extensive dissection or delayed treatment

Case

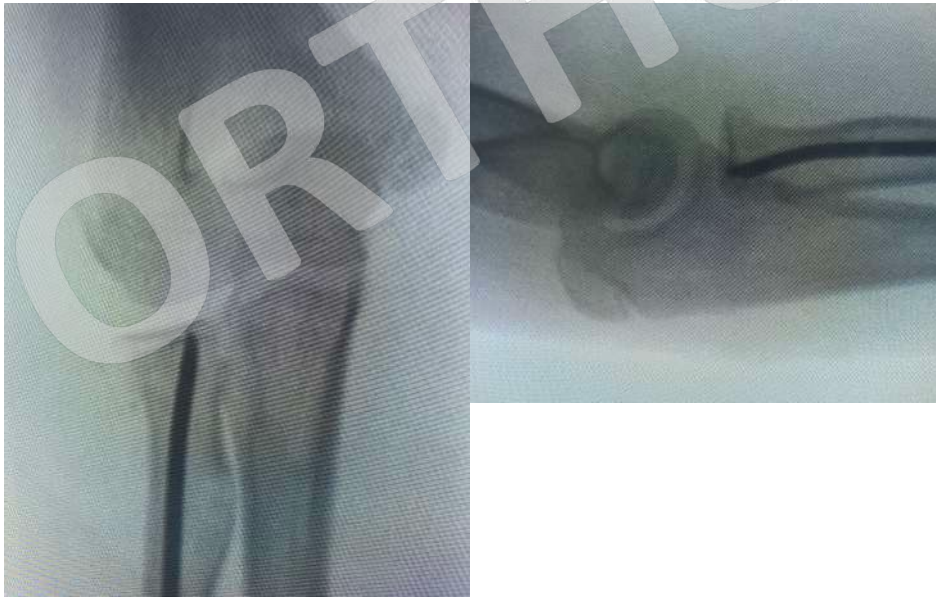
Minimally invasive reduction








Case



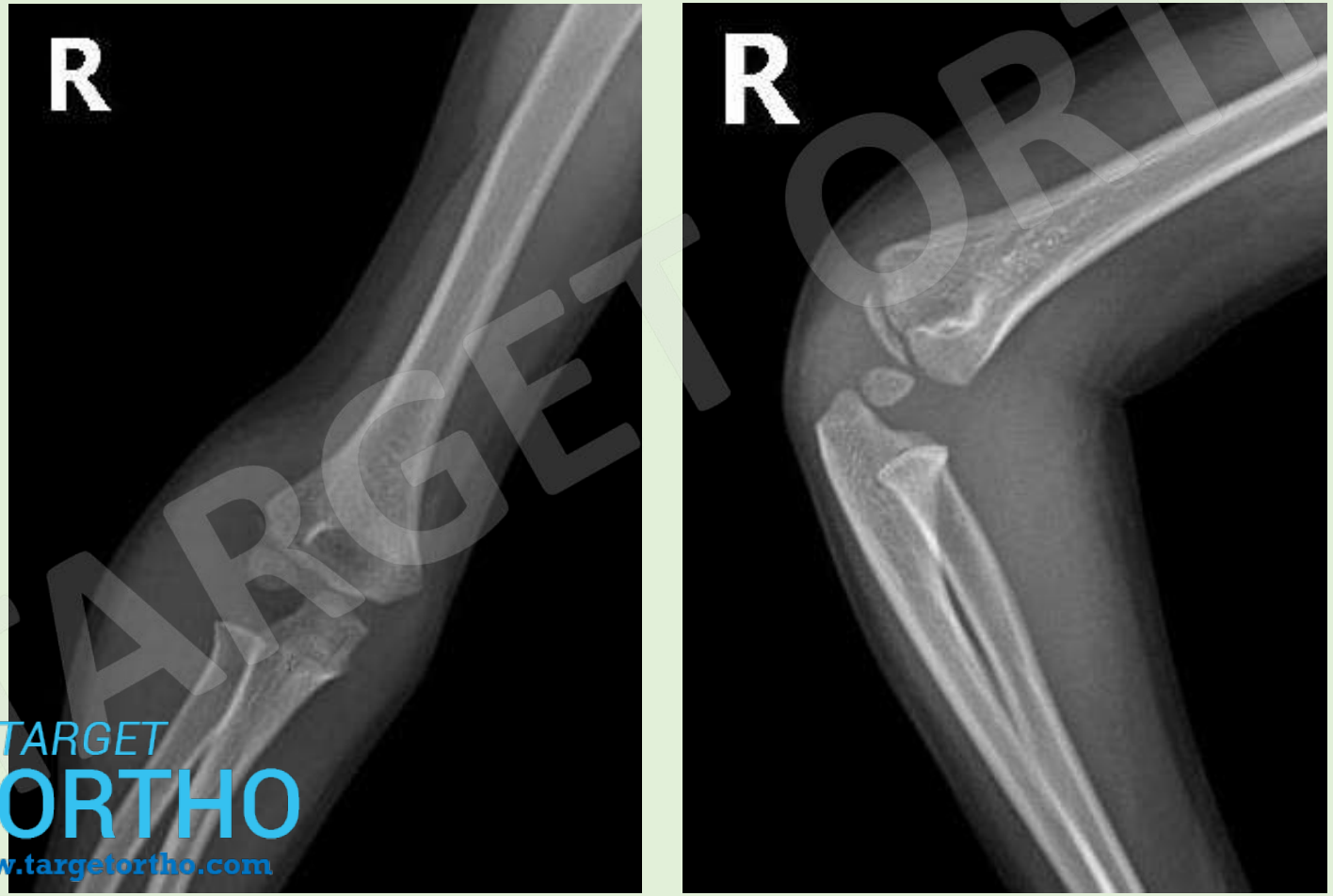
Case

- Olecranon # With Radial head #

Lateral Humeral Condyle Fractures in Children

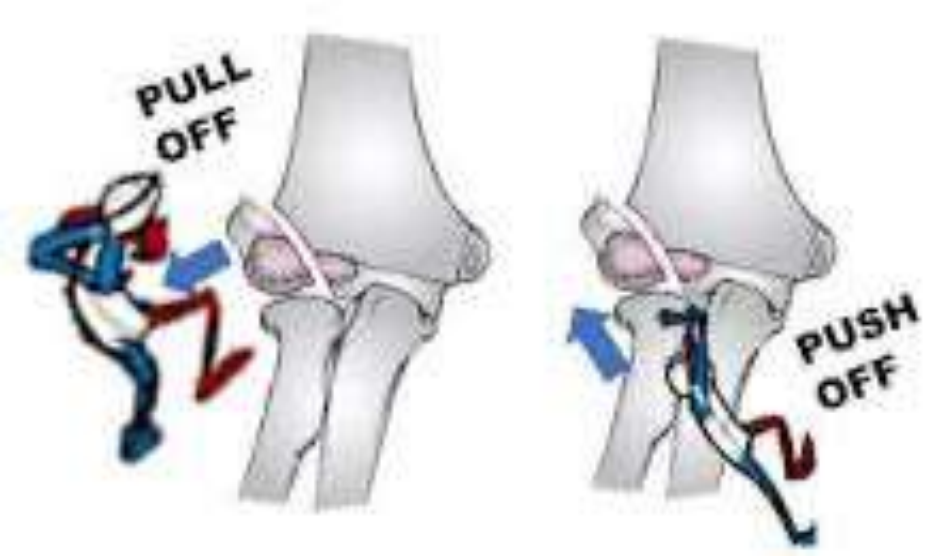
Prevention of Unacceptable alignment: Error in diagnosis

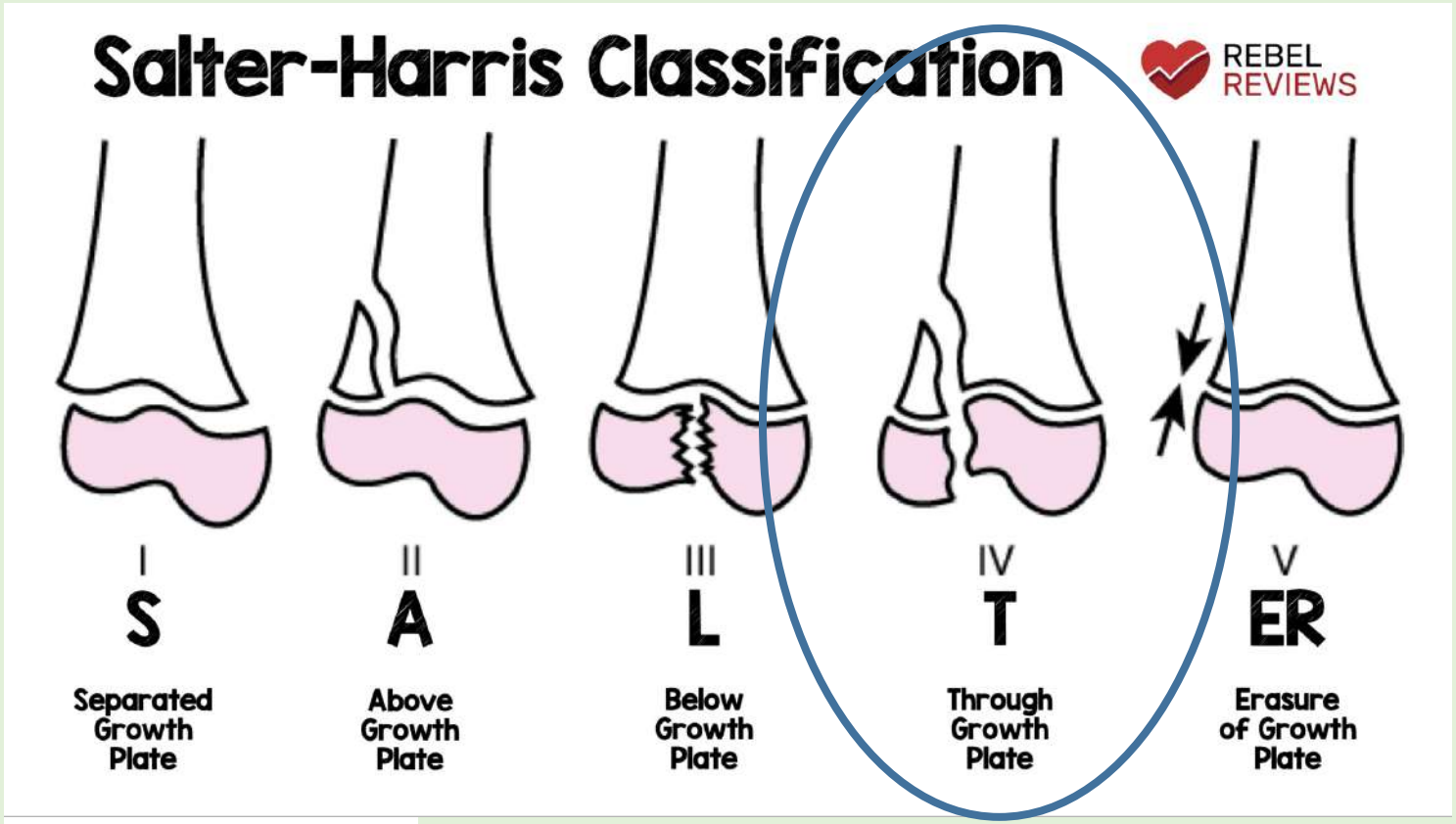
- 10-20% of all childhood elbow fractures
  - 2nd most common elbow fracture after supracondylar



Mechanism

- A varus force on the arm transmits through the forearm extensor muscles
- Causing the radial head to push off the lateral condyle.

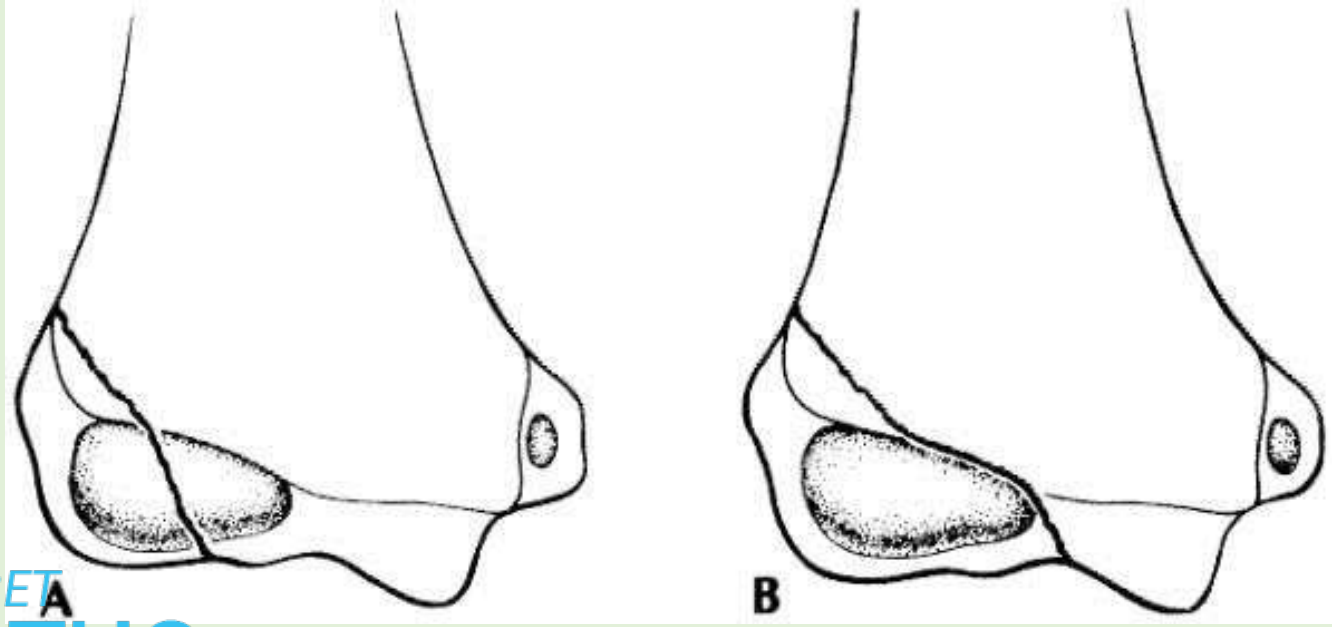




SH Type IV injury

Fracture Classification

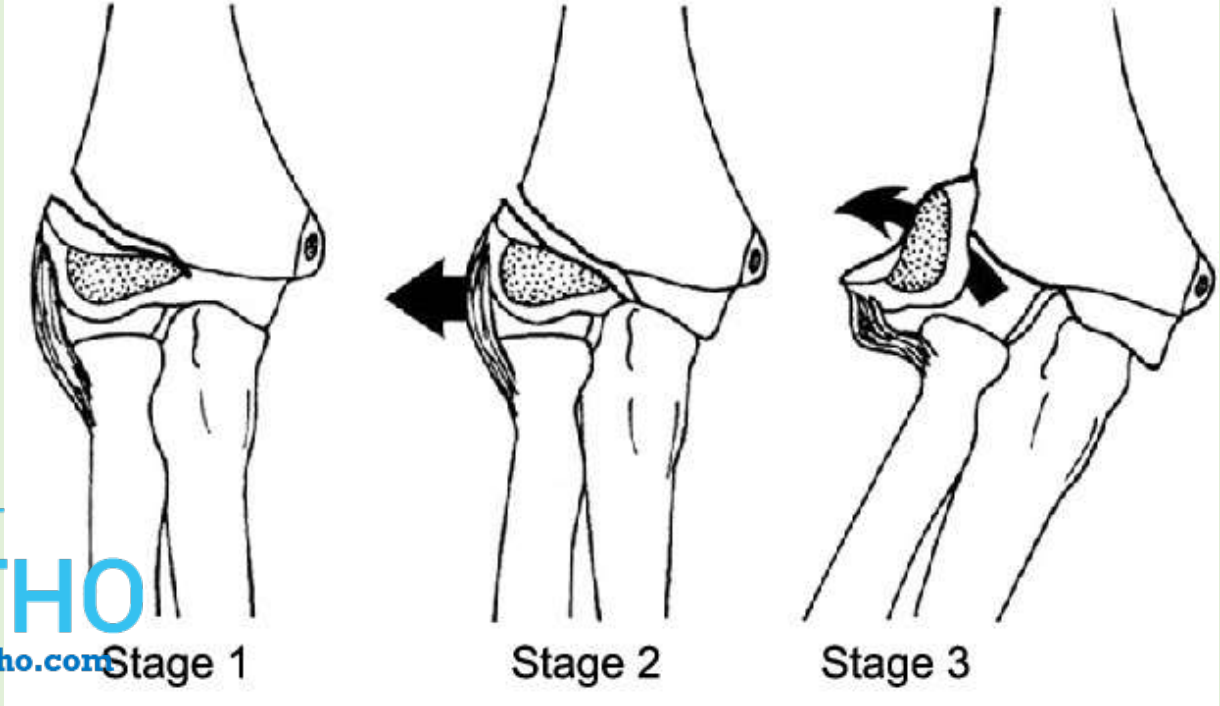
- Milch classification (1964)
  - Fracture location through the epiphysis
  - 2 Type , Type 2= Elbow unstable
  - Not predictive of outcome or suggestive for the treatment



Mirsky et al modififcation 3 types; JOT; 1997

Fracture Classification

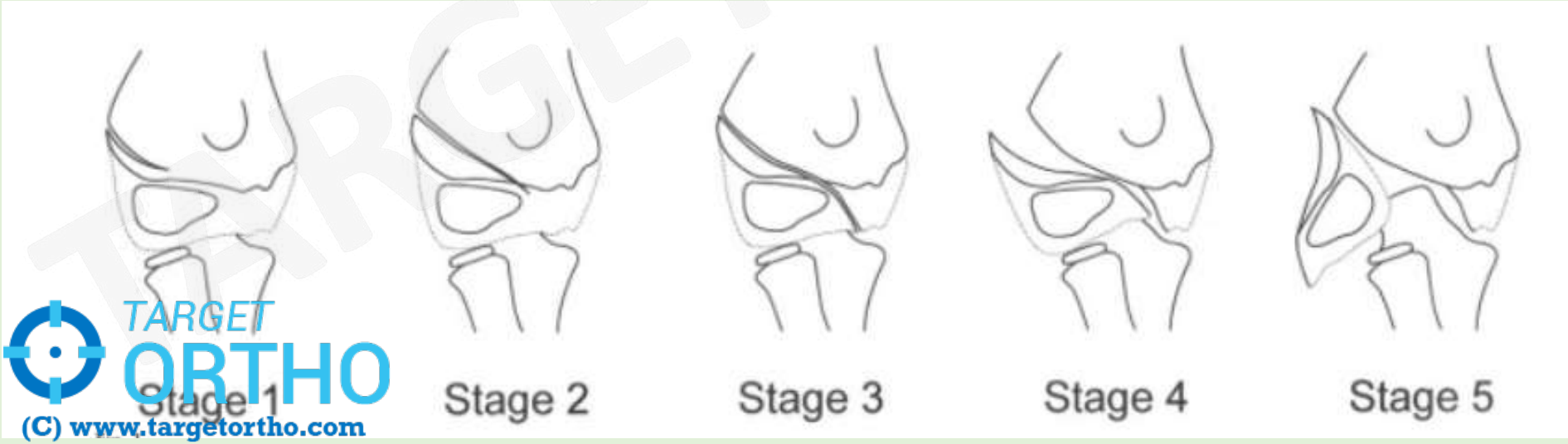
- Jacob et al (1975)
- Type 1 Intact medial hinge; <2mm displacement
- Type 2 complete; No malrotation; <2mm displacement
- Type 3 Displaces + rotation
- Displacement seen even in type 1

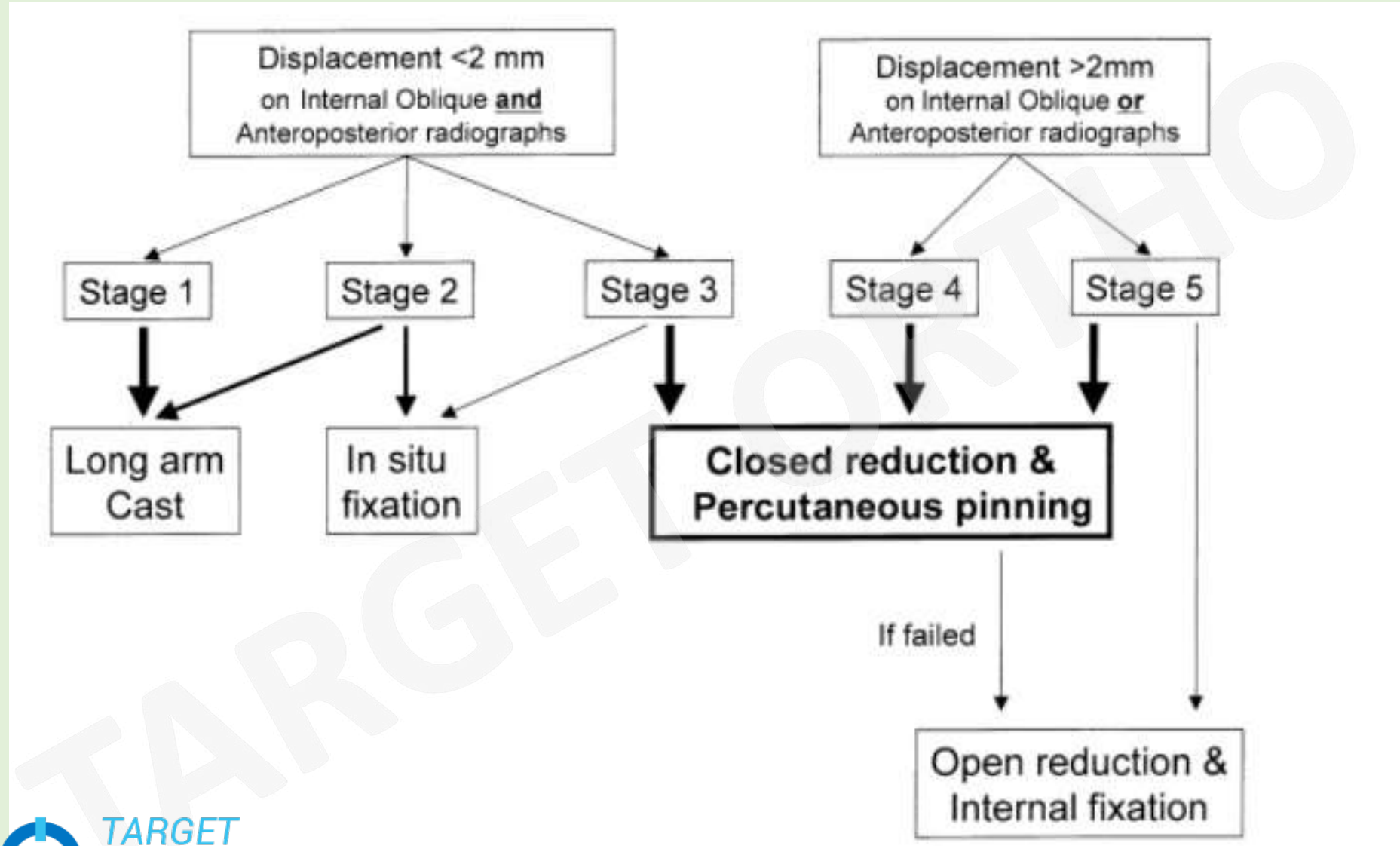


Internal Oblique Radiographs for Diagnosis of Nondisplaced or Minimally Displaced Lateral Condylar Fractures of the Humerus in Children

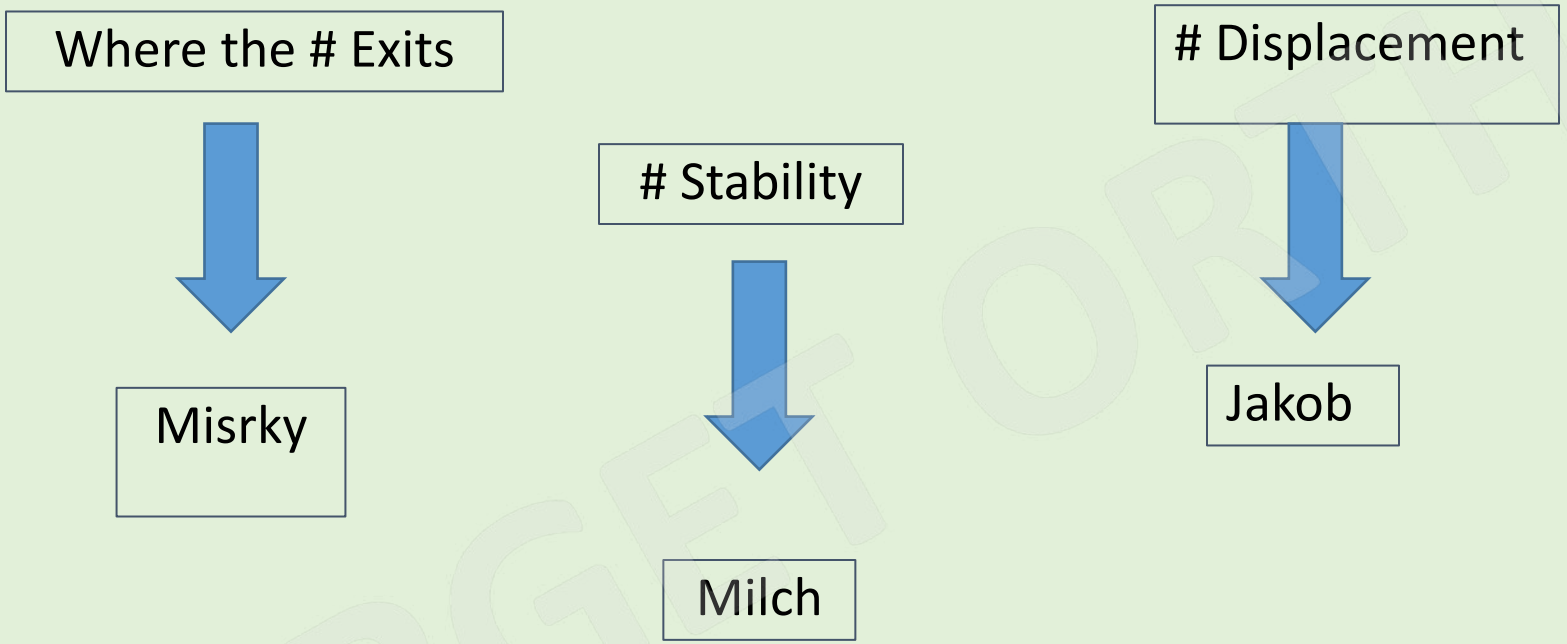
Fracture Classification

Stage	Definition	Stability
Stage 1	less than 2 mm of displacement limited fracture line within the metaphysis	stable
Stage 2	less than 2 mm displacement with lateral gap	indefinable stability
Stage 3	less than 2 mm displacement with gapping as wide laterally as medially on any of the 4 views	unstable
Stage 4	greater than 2 mm displacement without rotation of the fragment on any of the 4 views	Unstable
Stage 5	greater than 2 mm displacement with rotation of the fragment on any of the 4 views	unstable





Information based on classification



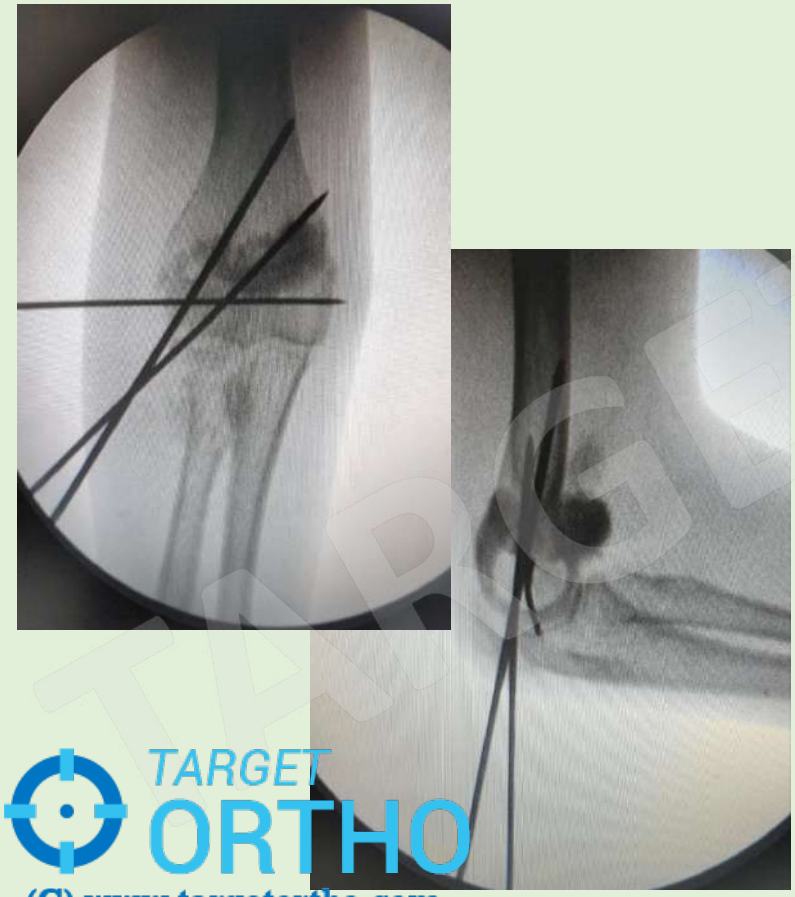
Imaging

- All attempts for the differentiation are either invasive or expensive
  - Arthrography
  - MRI
  - Ultrasonography

  are frequently used

Intraoperative Arthrogram

- Lateral soft spot



- Posterior Olecranon fossa

Arthrogram to demonstrate cartilage disruption. Closed Percutaneous pinning is advised to prevent dispalacment

Treatment

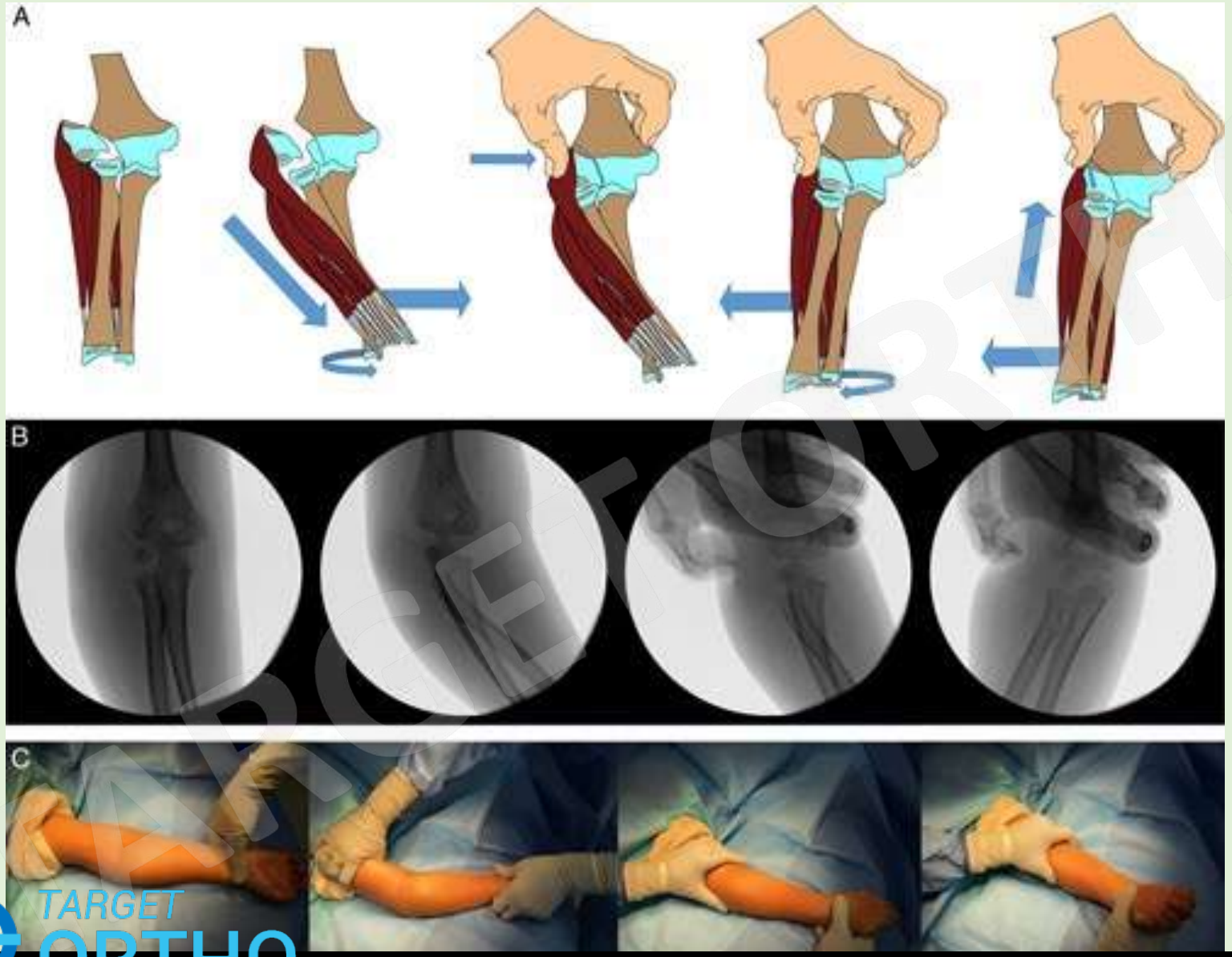
- There is consensus that the treatment of displaced fractures is closed or open reduction and internal fixation

- The treatment of nondisplaced or minimally displaced fractures remains controversial

  - <2mm Cast with watchful follow up

  - >2mm CRPP/ SOS Open

Reduction Manoeuvre



Surgical Technique for Closed Reduction and Percutaneous Pinning of Pediatric Lateral Humeral Condyle Fractures, Technqiues in Ortho, 2020

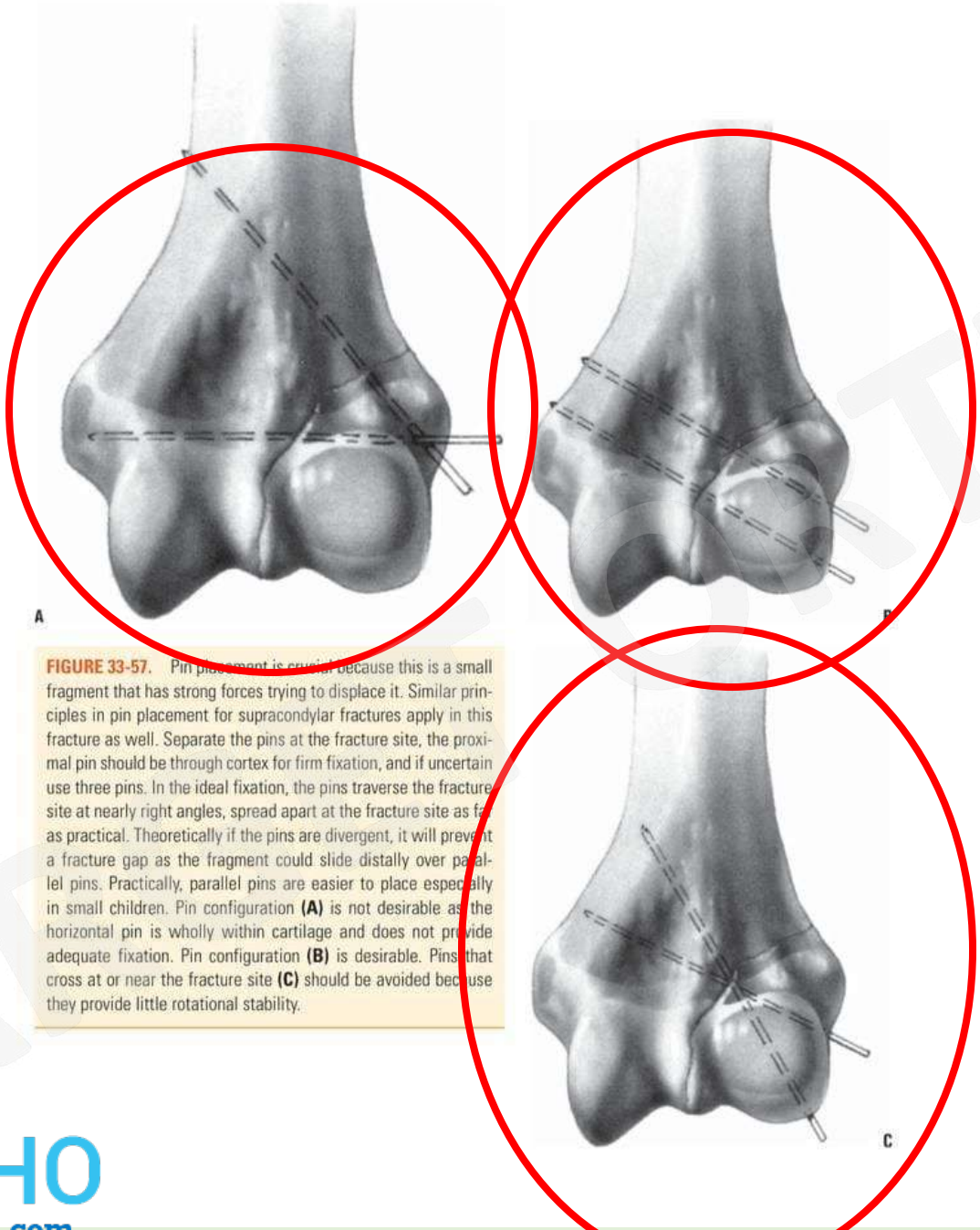


FIGURE 33-57. Pin placement is crucial because this is a small fragment that has strong forces trying to displace it. Similar principles in pin placement for supracondylar fractures apply in this fracture as well. Separate the pins at the fracture site, the proximal pin should be through cortex for firm fixation, and if uncertain use three pins. In the ideal fixation, the pins traverse the fracture site at nearly right angles, spread apart at the fracture site as far as practical. Theoretically if the pins are divergent, it will prevent a fracture gap as the fragment could slide distally over parallel pins. Practically, parallel pins are easier to place especially in small children. Pin configuration **(A)** is not desirable as the horizontal pin is wholly within cartilage and does not provide adequate fixation. Pin configuration **(B)** is desirable. Pins that cross at or near the fracture site **(C)** should be avoided because they provide little rotational stability.

Timing of pin removal

A) 4 weeks

B) 6 weeks

C) When Fracture heals

D) Not needed

Timing of pin removal

A) 4 weeks

B) 6 weeks

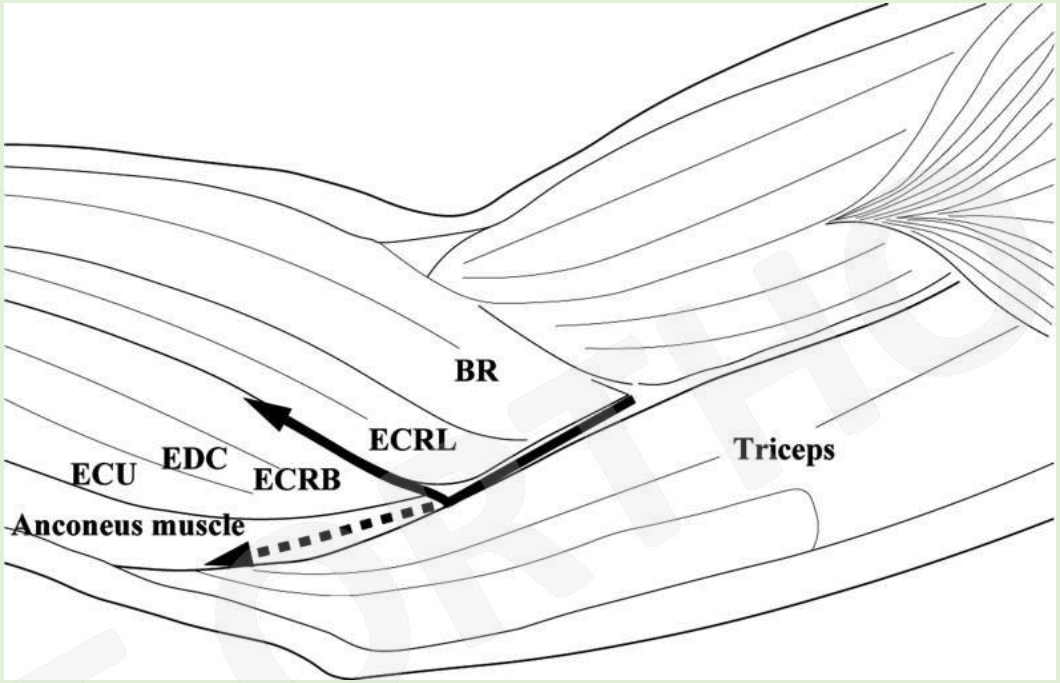
C) When Fracture heals

D) Not needed

➢ Review of Literature

- **Displaced Fractures of the Lateral Humeral Condyle: Criteria for Implant Removal.** Cardona, Riddle et al, JPO, Jan 2002.
- **Three Weeks of Kirschner Wire Fixation for Displaced Lateral Condylar Fractures of the Humerus in Children.** Philip, Cole. JPO,Sep 2001

Open reduction



Anterolateral Versus Posterolateral Approach for Lateral Condylar Fractures of the Humerus in Children; JBJS 2020 Japan

- Anterolateral vs Posterolateral
- Digital manipulation
- Linner Fork technique

Atlas of Paediatric Orthopaedics

"DINNER FORK"

Jack Flynn

IF LARGE METAPHYSEAL FRAGEMENT

THEN SCREW FIXATION IN OLDER CHILD IS MORE SECURE

SIX-YEAR OLD GIRL

Clinical and Radiographic Results of Lateral Condylar Fracture of Distal Humerus in Children

Kyoung Hwan Koh, MD, Sung Wook Seo, MD, Kyung Mu Kim, MD, and Jong Sup Shim, MD

unions. In 135 (77.1%) of the 175 patients, obvious lateral condylar overgrowths were observed at 19.8 (± 16.8) months

Development of lateral elbow prominence revealed difference between the 3 treatment methods and it was caused by the difference between cast and ORIF (1 vs. 32, $P < 0.001$). It also

Lateral overgrowth related to surgery in displaced Type III fractures

Lateral Condylar Fractures Of Humerus In Children Following Varus Malunion Of Supracondylar Fracture

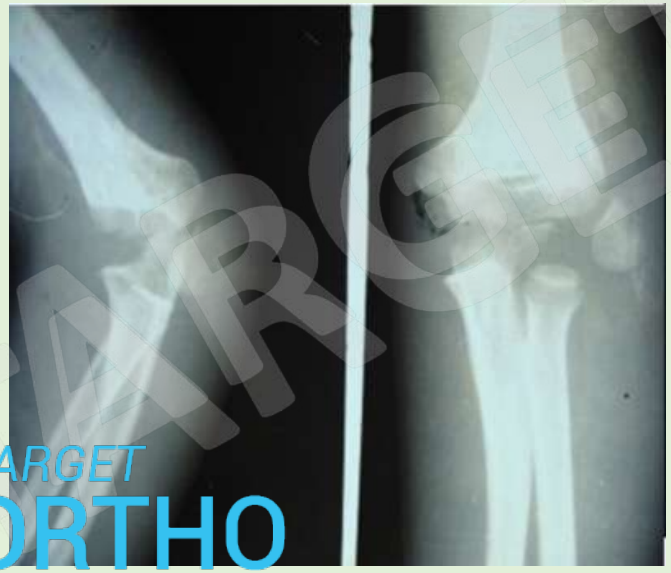
M Wani, A Sultan, M Wani, B Mir, A Bashir, M Halwai, M Malik, M Baba, N Masra

THE JOURNAL OF BONE & JOINT SURGERY (BI)

Second fracture of the distal humerus after varus malunion of a supracondylar fracture in children

Masatoshi Takahara, Isao Sasaki, Takumi Kimura, Hiroyuki Kato, Akio Minami, Toshihiko Ogino

From Yamagata University School of Medicine, Yamagata City, Japan



Lateral Condylar Humerus Fractures: Which Ones Should We Fix?

Kwan Soon Song, MD and Peter M. Waters, MD*†*

Aside from immobilizing the elbow in acceptable flexion consistent with the amount of swelling, placing the forearm in supination and the wrist in extension may

SUMMARY OF 3 MOST IMPORTANT POINTS

1. Watch all lateral condylar fractures that are treated nonoperatively very closely, especially with oblique radiographs.
2. Restore anatomic alignment of the distal humerus articular surface in all displaced lateral condylar humerus fractures.
3. Stabilize all displaced fractures until they are healed radiographically.

Complications

- Non Union
- Malunion
- Cubitus Valgus w/wout Tardy ulnar nerve palsy

Non-union

- Failure of bony healing at 3 months
- Issues: Nonunion; Malunion; Proximal migration; Deformity

- Treatment based on Symptoms
  Degree of deformity
  ROM
  Instability
  Nerve status

In situ Compressive screw fixation

- Early established non-union without proximal migration, good ROM

Osteosynthesis In Situ for Lateral Condyle Nonunion in Children

Hoon Park, MD, Jin Ho Hwang, MD, PhD,† Yong Uk Kwon, MD,‡ and Hyun Woo Kim, MD, PhD†*

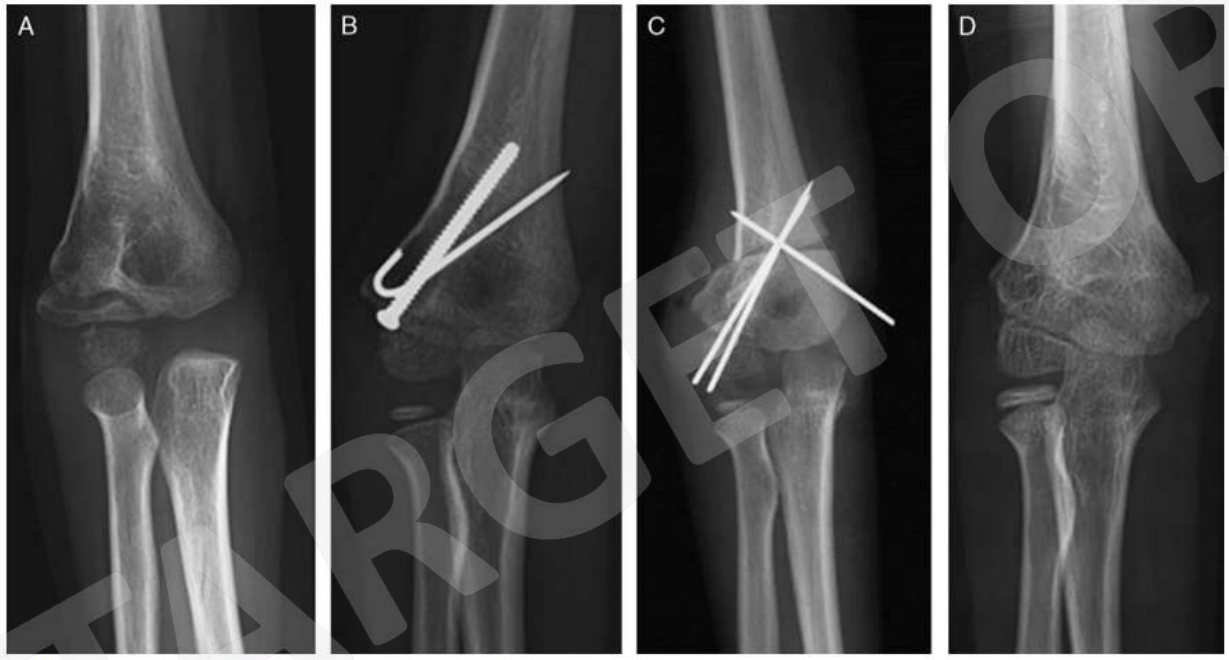
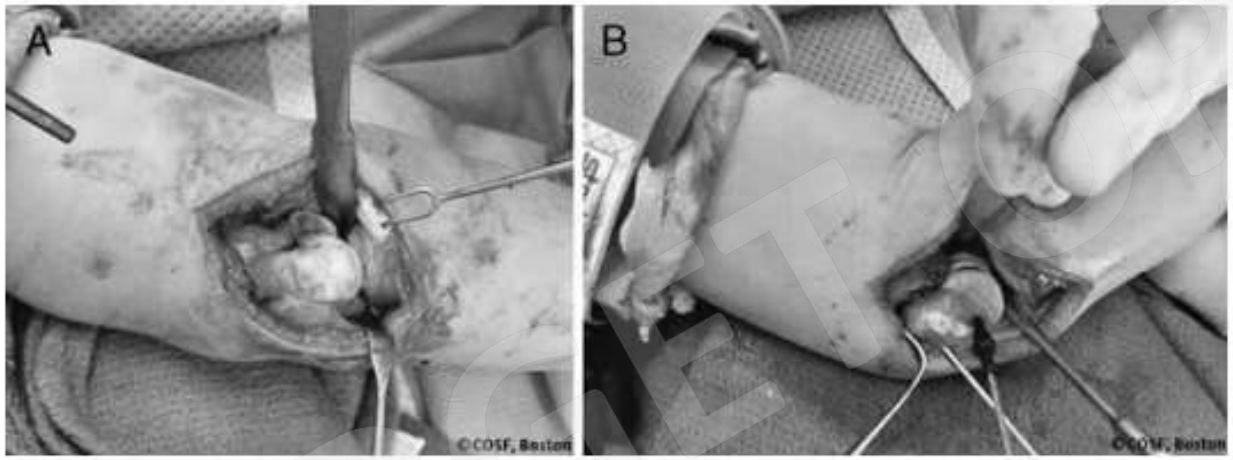


FIGURE 3. A, A 5-year-old boy (case 12) presented 4 months after injury. B, At 28 months of postoperative follow-up, solid bony union was observed without evidence of osteonecrosis nor premature growth arrest. Ten degrees of cubitus varus remained. C, Valgus corrective osteotomy was performed. D, Cubitus varus deformity was corrected.

No deformity
Good ROM
Instability
Normal Nerve status

Intra-articular Corrective Osteotomy of Humeral Lateral Condyle Malunions in Children: Early Clinical and Radiographic Results

Andrea S. Bauer, MD, Donald S. Bae, MD,† Katherine A. Brustowicz, BA,† and Peter M. Waters, MD†*



No deformity
Restricted ROM
Instability
Normal Nerve status

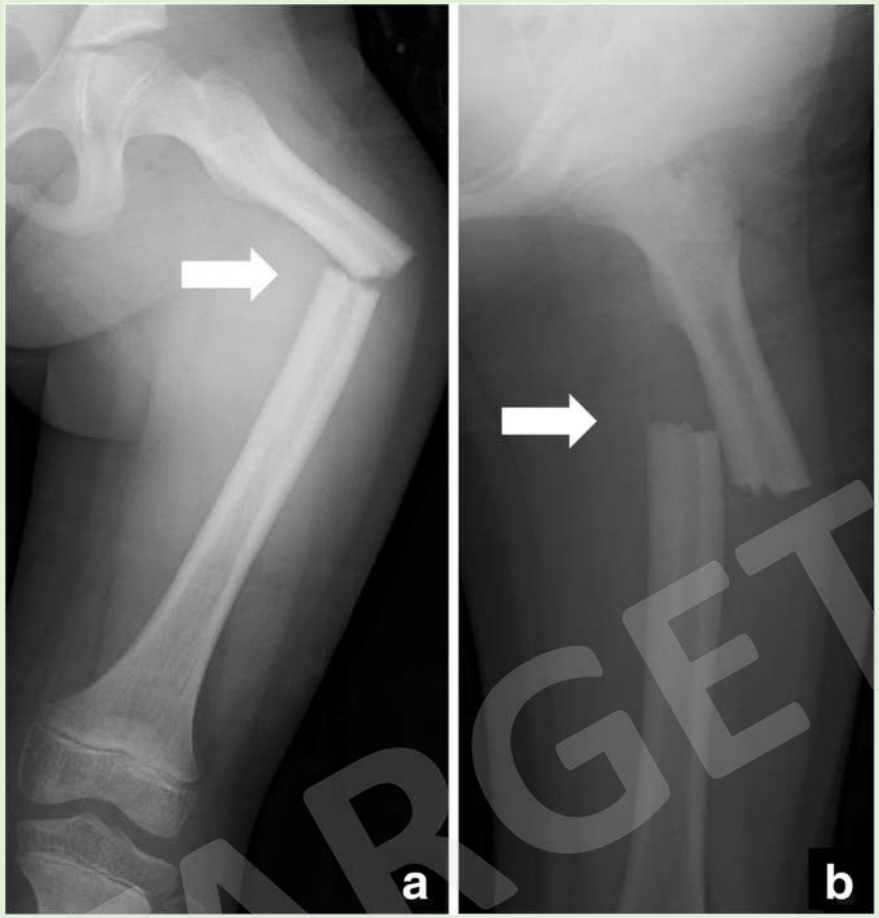
Good for Milch type 1 fractures

Degree of deformity
ROM
Instability
Normal Nerve status

Corrective osteotomy + in situ fixation

Paediatric Distal Radius fractures

Myth Busters



6 Year old with these fractures

J Bone Joint Surg Am. 2012 Feb 1;94(3):246-52. doi: 10.2106/JBJS.K.00163.

Closed treatment of overriding distal radial fractures without reduction in children

Scott H Crawford [1], Lorrin S K Lee, Byron H Izuka

Is it safe to pass K wire across distal radius physis?

The Effect of Pinning Across the Physis for Stabilization of Fractures in Children: An MRI Evaluation

Jeremy T. Smith, MD, James R. Kasser, MD, Peter M. Waters, MD, Diego Jaramillo, MD, MPH, and Mininder S. Kocher, MD, MPH

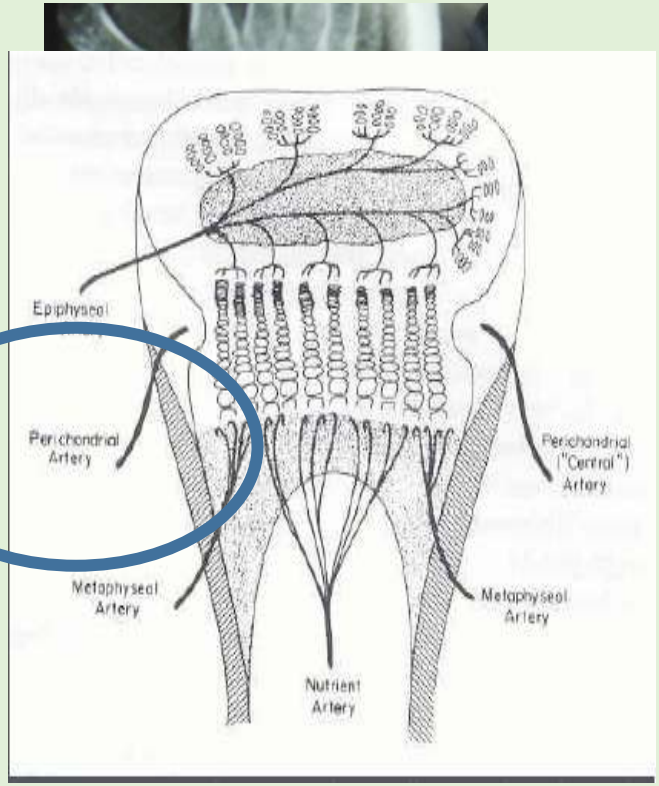
From the Department of Orthopaedic Surgery, Children's Hospital Boston (J.T.S, J.R.K, P.M.W, M.S.K) and The Department of Radiology, The Children's Hospital of Philadelphia (D.J.)

- Pinning with a temporary smooth wire across a physis **does not cause** physeal growth disturbance.

- However multiple failed attempts at wire passage and thick wires (>2.5mm) may be detrimental and should be avoided.

Principles of Pinning

- Smooth wire
- Single attempt
- No multiple passes
- Low torque/ T-handle
- Crossing beyond physis
- Not too central/ not too peripheral



Principles of Pinning

Single or maximum 2 attempts

*It is not the **final xray** which is important, but the **Intra-operative attempts** made which determine the outcome in physeal injury fixation……*

Physeal arrest

Current Concept Review

Traumatic Physeal Arrests at the Wrist

Laura L. Bellaire, MD[1]; Carley Vuillermin, MBBS, MPH, FRACS[2]

[1]University of Wisconsin/American Family Children's Hospital, Madison, WI; [2]Boston Children's Hospital, Boston, MA

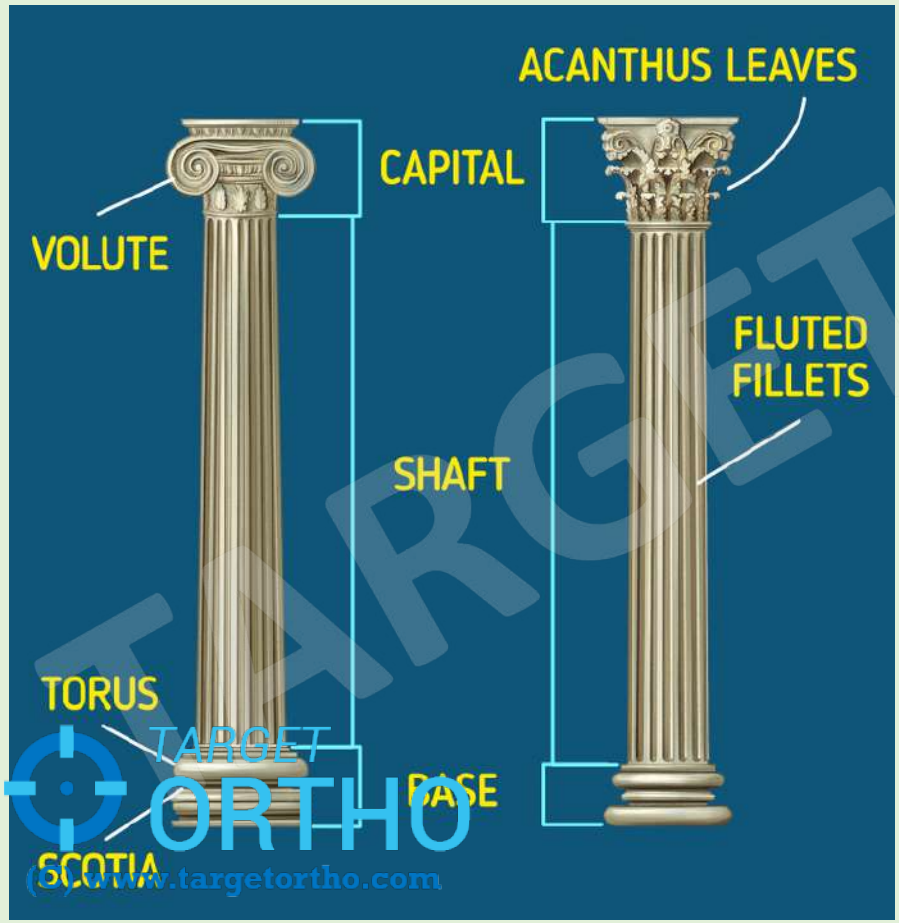
Expert Panel
Suzanne Steinman, MD[1]; Walter Truong, MD[2]; Donald Bae, MD[3]; C. Douglas Wallace, MD[4]; Christine Ho, MD[5]

[1]Seattle Children's Hospital, Seattle, WA; [2]Gillette Children's Hospital, St. Paul, MN; [3]Boston Children's Hospital, Boston, MA; [4]Rady Children's Hospital, San Diego, CA; [5]Texas Scottish Rite Hospital for Children, Dallas, TX

Bellaire et al, Recommendations:

- All #s of DER/U – follow-up needed till at least 6-12 months
- Options:
- Ulnar physeodesis only – in case of distal radial growth arrest when at risk of ulnar abuttment
- Only ulnar shortening osteotomy- when only radial shortening without deformity
- Ulnar shortening with radial corrective osteotomy- Radial shortening + deformity

Torus Fractures (vs Greenstick)



Case

6 / F
Fresh trauma
Plan…??

After 4 weeks of POP

Now what…??

Re-manipulate and cast?
CRIF?
ORIF?

Remodeling of Salter Harris type 2 epiphyseal plate injury of distal radius _Houshian S et al
J Pediatr Orthop, 2004; 24: 472-476

- Excellent remodeling of volar as well as radial inclination especially in children less than 10 years age

What about repeat manipulation and Open reduction….??

Distal radius and ulna fractures _Waters PM

In *Rockwood and Wilkins Fractures in Children, 7th Ed, Pg 307*

- Repeat manipulation of a distal radius physeal injury or forceful OR should not be attempted 7 days after injury due to risk of physeal damage with growth arrest
- Watch for remodelling for 6 to 12 months
- Metaphyseal osteotomy performed for fractures which fail to remodel
- PHYSEAL INJURIES: DON'T REDUCE AFTER 7 DAYS

Characteristics of distal radial physis

- DER fastest growing physis in forearm and 2nd fastest in UL
- Contributes to 75% of forearm growth
- Relatively good compensatory proximal radio-ulnar and intercarpal movements

Characteristics of DISTAL RADIAL PHYSEAL INJURIES

- DER fractures- commonest upper limb injuries in childhood
- 30% of all wrist injuries= physeal injuries
- Majority treated with casts
- Excellent healing potential
- Physeal arrest unusual

Case :

- 7 year old female
- FOOSH
- Severe pain and swelling –wrist
- TYPE 1 SH injury

Type 1 SH injury

- 2nd most common
- Usually seen on lateral view with non-alignment of anterior and posterior cortices
- Has significantly more swelling than the xray implies….
- Treated usually with cast

Case

- 6 year old girl
- FOOSH
- Pain, swelling and deformity wris
- SH type 2 # DER

Type 2 SH injury

- Commonest physeal injury of DER
- Usually dorsally displaced with a dorsal Thurston-Holland fragment
- Usually amenable to cast
- Growth arrest unusual

Is it always the case….??!!

- Acceptability criteria…??

ORIGINAL ARTICLE

Fractures of the Distal Radius and Ulna: Metaphyseal and Physeal Injuries

Chris Stutz, MD and Gregory A. Mencio, MD†*

Acceptable position of pediatric DER physeal fractures

Age	Angulation	Displacement
< 8	45	60 %
8 -12	30	50 %
>12	15	40%

Indications for fixation

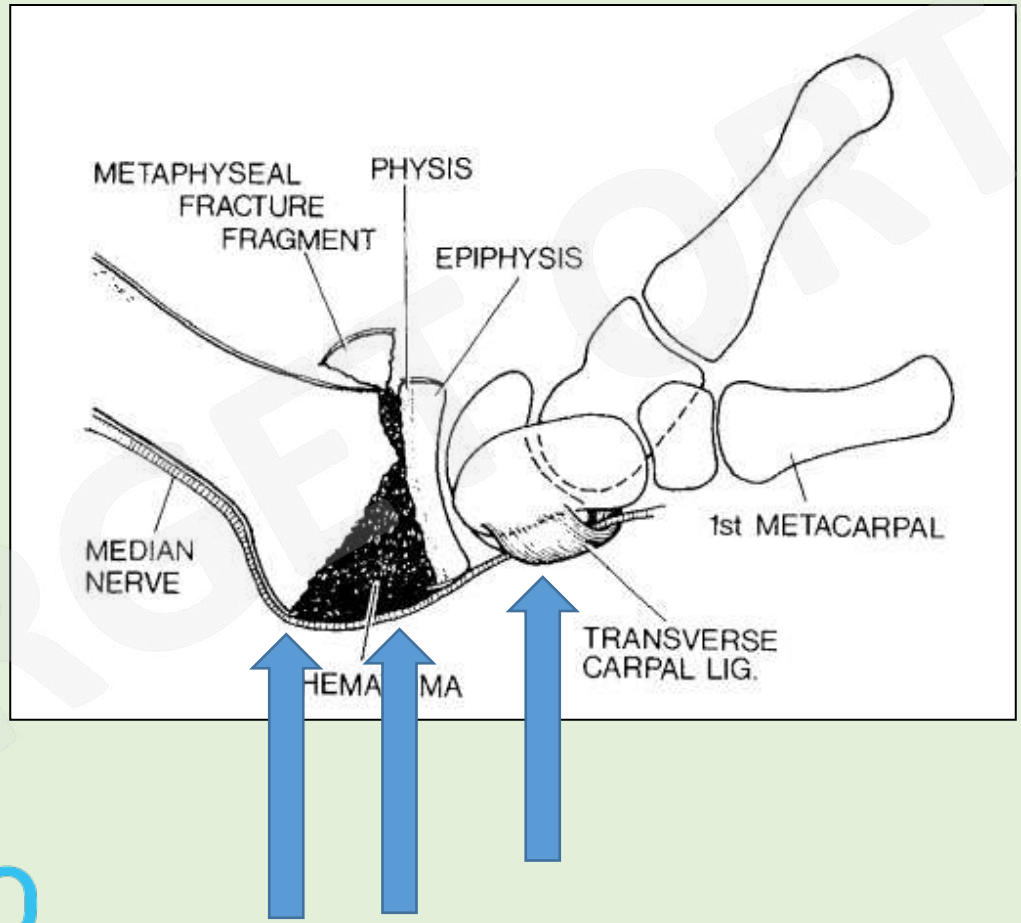
- “Floating elbow”
- Severe pain with median nerve symptoms
- Compartment syndrome
- Unacceptable angulation and displacement

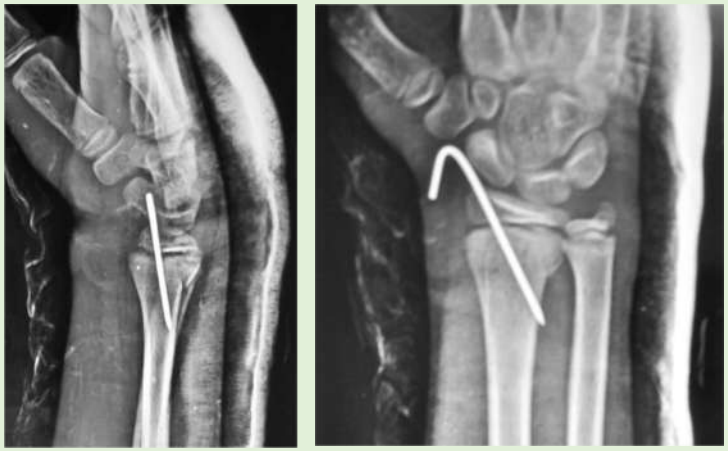
Case 3

11/ F
? Closed Reduction
? K wire

Has severe median nerve symptoms

Why median nerve symptoms..?





Take Home Points

- 2nd fastest growing physis of UL
- SH type 2 commonest
- Usually good prognosis
- Indications of CRIF- >12 years/ Severe pain due to median nerve compression/ floating elbow/ compartment syndrome
- Physeal bars- due to injury itself or due to vigorous manipulation or multiple k-wire passes
- Don’t attempt reduction after 7 days