Management of Pediatric Supracondylar Fractures of the Humerus

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Disclosure

- **UBC Department of Orthopaedics:** Kishore Mulpuri
- **Relationships with commercial interests:**
  - **Research Support:** Allergen, DePuy (A Johnson & Johnson Company), I'm a HIPpy Foundation, IPSEN, Pega Medical
  - **Board or committee member:** Canadian Orthopaedic Association, Canadian Pediatric Orthopaedic Group, International Hip Dysplasia Institute, Paradigm Creatives LLC, Pediatric Orthopaedic Society of North America
  - **Editorial or governing board:** Journal of Pediatric Orthopedics

Mitigating Potential Bias

- Not Applicable

Supracondylar fractures

- 70% of all elbow fractures in children
- Extension Type - 95%
  (fall on outstretched hand)
- Flexion type - 5%

Introduction

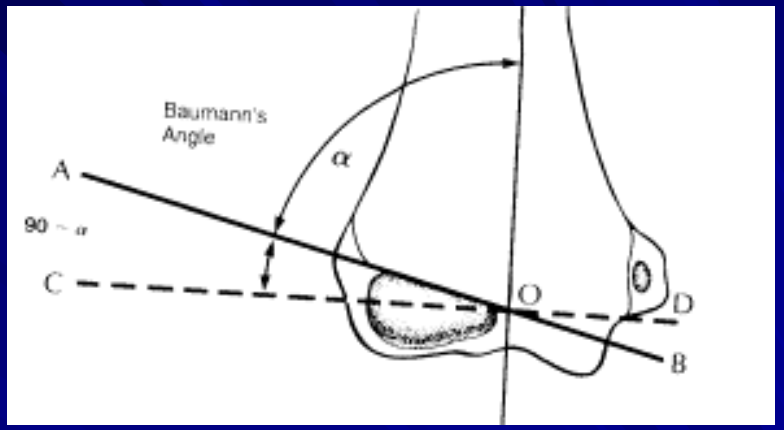
Gartland Classification (1959)

- Type I
  - non-displaced fracture
- Type II
  - displaced w/ intact posterior cortex
- Type III
  - displaced with no cortical intact

Wilkin's modification of Gartland's classification, 1984 :

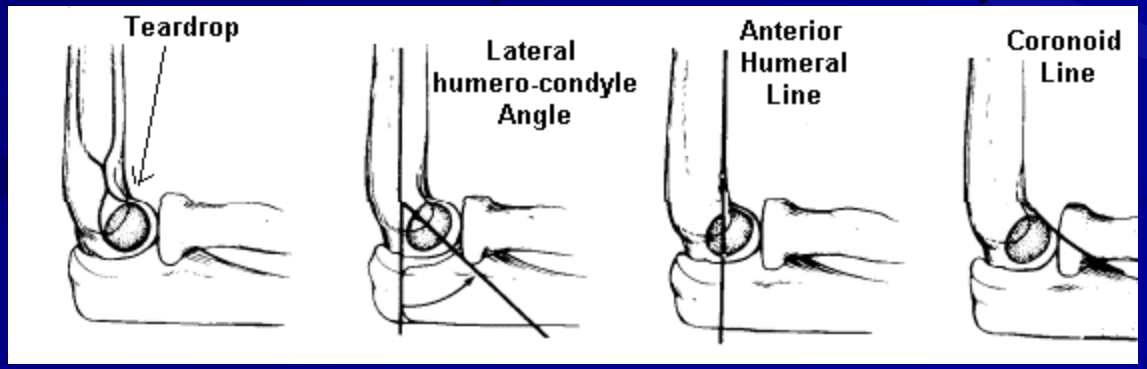
Type 1	Unddisplaced fracture
Type 2	2A Intact posterior cortex and angulation only
	2B Intact posterior cortex, angulation and rotation
Type 3	3A completely displaced, no cortical contact, posteromedial
	3B completely displaced, no cortical contact, posterolateral

Baumann's angle on AP film



Lateral Film:

- *Tear drop*
- *Shaft condylar angle*
  - -Normally 40 degrees
- *Anterior humeral line*
  - -Line should pass through middle 1/3 of the ossification centre of the capitellum ossification center
- *Coronoid line*
  - - A line directed posteriorly along coronoid process should just touch the anterior aspect of the lateral condyle



“Accepted deformity”

- Up to 20 degrees of angulation
- Less than 10 degrees displacement in the coronal plane

Management

- **Type 1:**

  Above elbow plaster in pronation for 3 weeks.

  Taping, Collar and Cuff

Non-operative Management of Type II Supracondylar Humerus Fractures in Children: A Prospective Randomized Clinical Trial Comparing Casting Versus Collar and Cuff with Taping

- **Primary outcome: Change in the lateral humeral Humerocapitellar Angle over the period of immobilization**

Cast

Splint

Tape

Management

- **Type 2:**

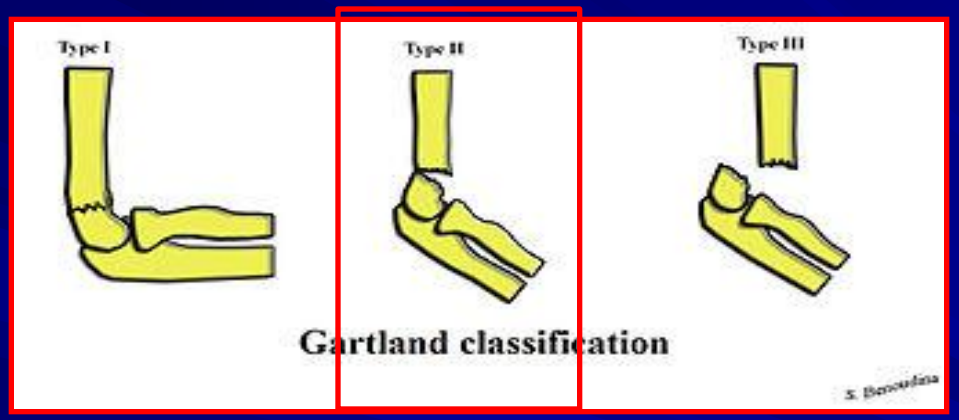
  Taping, Collar and Cuff

  A/E Plaster with elbow ~ 120 Degrees

  MUA +/- K wire (closed reduction)
  Especially 2B fracture

Pediatric Supracondylar Humerus (SCH) Fractures

- SCH = most common elbow fracture in pediatric population



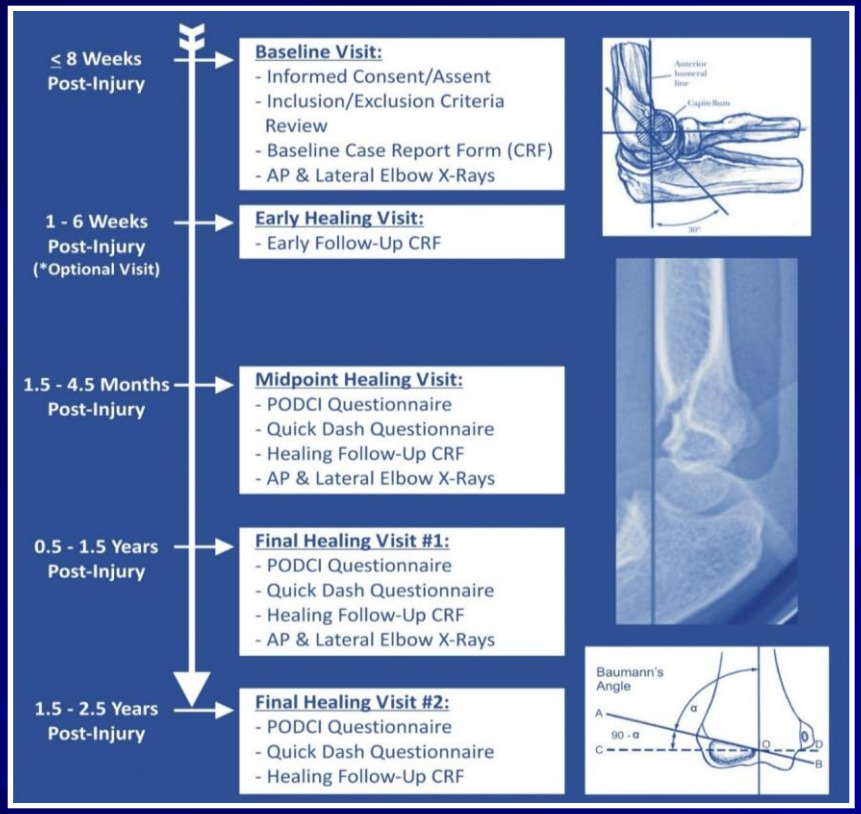
- Operative vs. non-operative treatment consensus exists for Type I and III
  - Remains debate, treatment controversy for Type II fractures

Can non-operative management maintain adequate reduction of Type II SCH fractures?

Study Objectives

To *examine* the clinical, functional and radiographic *outcomes* of pediatric *non-operatively* treated SCH fractures in a prospective observational study

Methods



- Patients **2-12 years old** with isolated, closed **Gartland Type II** SCH fracture
- **Closed reduction**, immobilization by **taping, long-arm casting or splinting** at BC Children's Hospital
- Primary Outcome Measure**: Lateral Humeral Capitellar Angle (LHCA)** from post-reduction to final follow-up

Patient Demographics

- **Total of 44 patients non-operatively managed for Type II SCH Fracture**

Participant Age (Avg,[95%CI]	Sex (Number [%])	Treatment Method	Gartland Classification (Number [%])		Post-Reduction Follow-up (Number)	
5.80 [5.21,6.38]	**Male**: 23 [52.3%] **Female**: 21 [47.7%]	**Casting:** 30 **Taping:** 13 **Splinting:** 1	**Type IIA** 29 [65.9%]	**Type IIB** 15 [24.1%]	**3 months** 34	**1 year** 24

- **LHCA, Baumann's Angle, PODCI scores collected 3 months and 1 year post-reduction**

Impact on Reduction

	Mean LHCA (Avg (˚) [95% CI]) Normal range = 30-45˚		Mean BA (Avg (˚) [95% CI]) Normal range = 9-26˚		Flynn's Elbow Score with Good to Excellent Range of Motion (Number [%])	
Non-Operative Group	**Casting**	**Taping**	**Casting**	**Taping**	**Casting**	**Taping**
Post-Reduction	31˚ [27,34]	34˚ [26,42]	21˚ [19,23]	21˚ [17,24]	N/A	N/A
3 Months Post-Reduction	29˚ [26,32]	39˚ [34,44]	19˚ [18,20]	21˚ [19,23]	18 (85.7%)	6 (85.7%)
1 Year Post-Reduction	31˚ [27,34]	40˚ [33,48]	21˚ [19,22]	22˚ [19,24]	15 (93.8%)	5 (100%)

Complications:

- **3 participants in casting group sustained a re-fracture**
- **No participants required conversion to operative management**

Conclusion and Significance

- ***Casting*** **adequately** ***maintained reduction*** **within normal LHCA range from post-reduction to 1 year post-reduction**
- ***Taping*** **allowed for** ***continued remodelling*** **throughout post-reduction follow-up**
- **Both** ***non-operative methods*** **produced** ***good functional outcomes*** **with good-to-excellent range of motion**
- **Results suggest that non-operative management of Type II SCH fractures maintains reduction comparably to operative management**

Ongoing and Future Directions

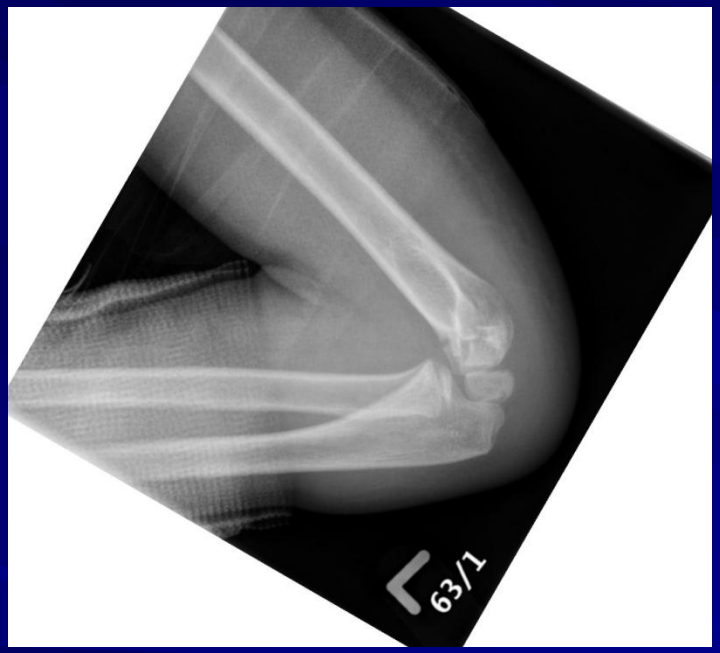
- Prospective, *multi-centre* observational study *comparing non-operative* and *operative management* of Type II SCH fractures
  - *Can we establish non-inferiority of non-operative management?*

- Currently performing this study with centres across Canada
  - take advantage of differences in standard of care (op. vs. non-op) at these centres

CANADIAN PAEDIATRIC ORTHOPAEDIC GROUP
CPOG

Your thoughts !!

CMPA



Management

- **Type 3:**

  - Closed/ Open reduction and stabilisation with 2/3 K wires

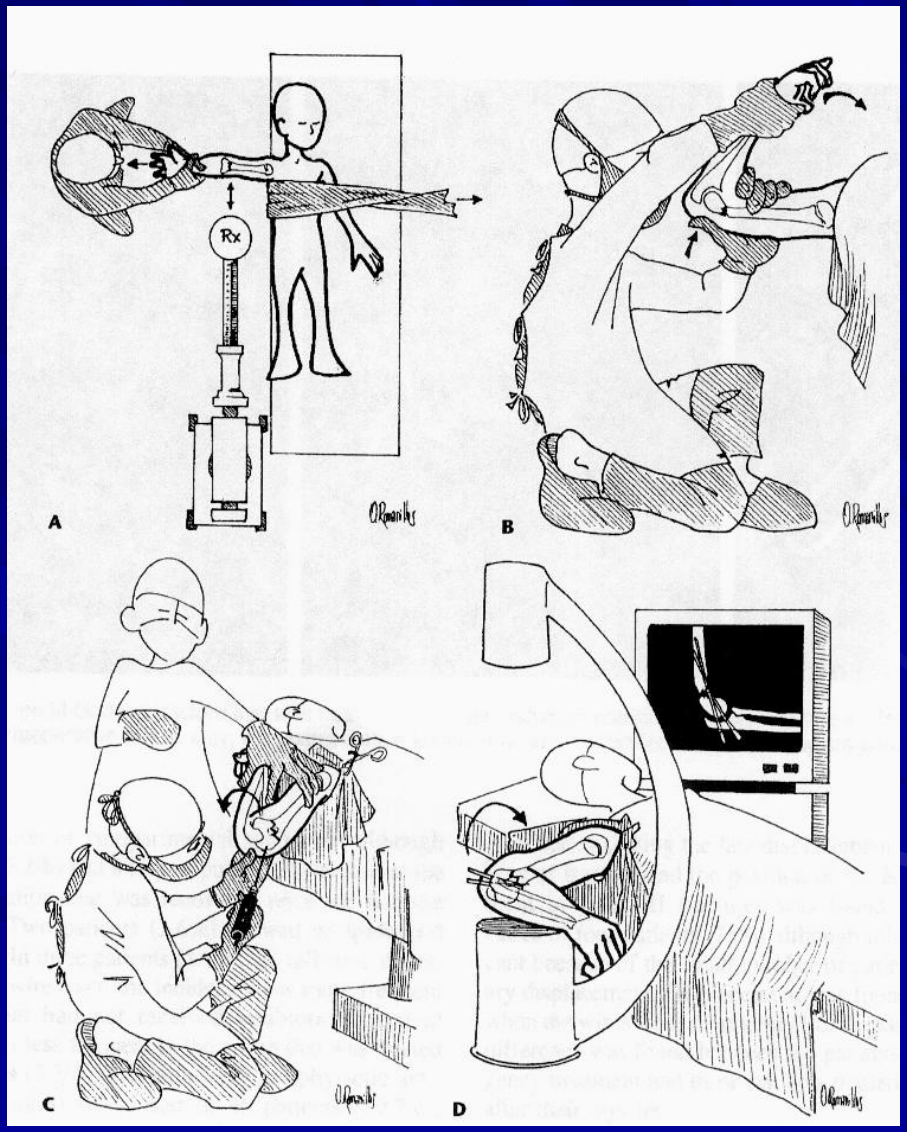
  - May require exploration of neurovascular structures

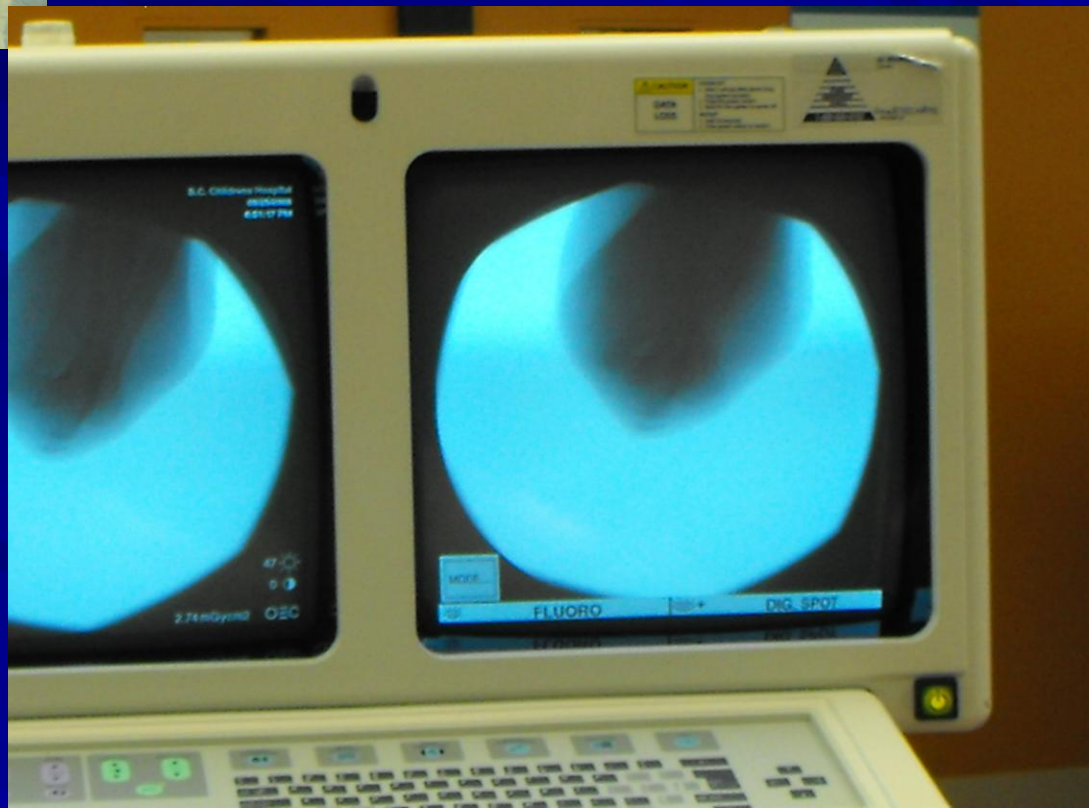
Treatment

- J. Judet (1940)
- Closed Reduction and Percutaneous K-Wire Fixation

Pin Configuration

- Lateral vs. Crossed




FLUORO
DIG. SPOT

The effect of surgical timing on operative duration and quality of reduction in Type III supracondylar humeral fractures in children

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J Child Orthop (2010) 4:153–158
DOI 10.1007/s11832-010-0240-3

Timing: Literature Review

Author	Subjects	Time to OR	No Difference Demonstrated
Iyengar (1999)	58	> 8 hrs	Rate of Open Reduction Clinical Outcome
Mehlman (2001)	151	> 8 hrs	Rate of Open Reduction Pin track infection Iatrogenic nerve injury
Leet (2002)	158	Continuous	Rate of Open Reduction Operative Time Length of Stay 'Unsatisfactory' Results
Gupta (2004)	69	> 12 hrs	Rate of Open Reduction Rate of Complications

Results

Sample

- 140 charts reviewed
  - 29 excluded for incorrect coding or missing data
  - 24 excluded for insufficient or inadequate films
  - N=87

Groups

- < 8 hours (Group 1): 48 subjects
- > 8 hours (Group 2): 39 subjects

Surgeon

- Five surgeons treated the study population

Results

Comparison of Groups

- No difference in mean age or gender ratio

First Presentation

- 60 (69%) subjects seen previously at other hospital
  - Group 1: 25 (52%)
  - Group 2: 31 (79%)

No cases of compartment syndrome

No cases required conversion to open reduction

Results: Operative Duration

	All Subjects	Group 1	Group 2	P Value
Injury to Surgery Time (IST)	669 min (11 h 59 m)	340 min (5h 40m)	1074 min (17h 54m)	N/A
Operative Duration (OD)	32.18 min	32.56 min	31.72 min	0.77

Results: Quality of Reduction

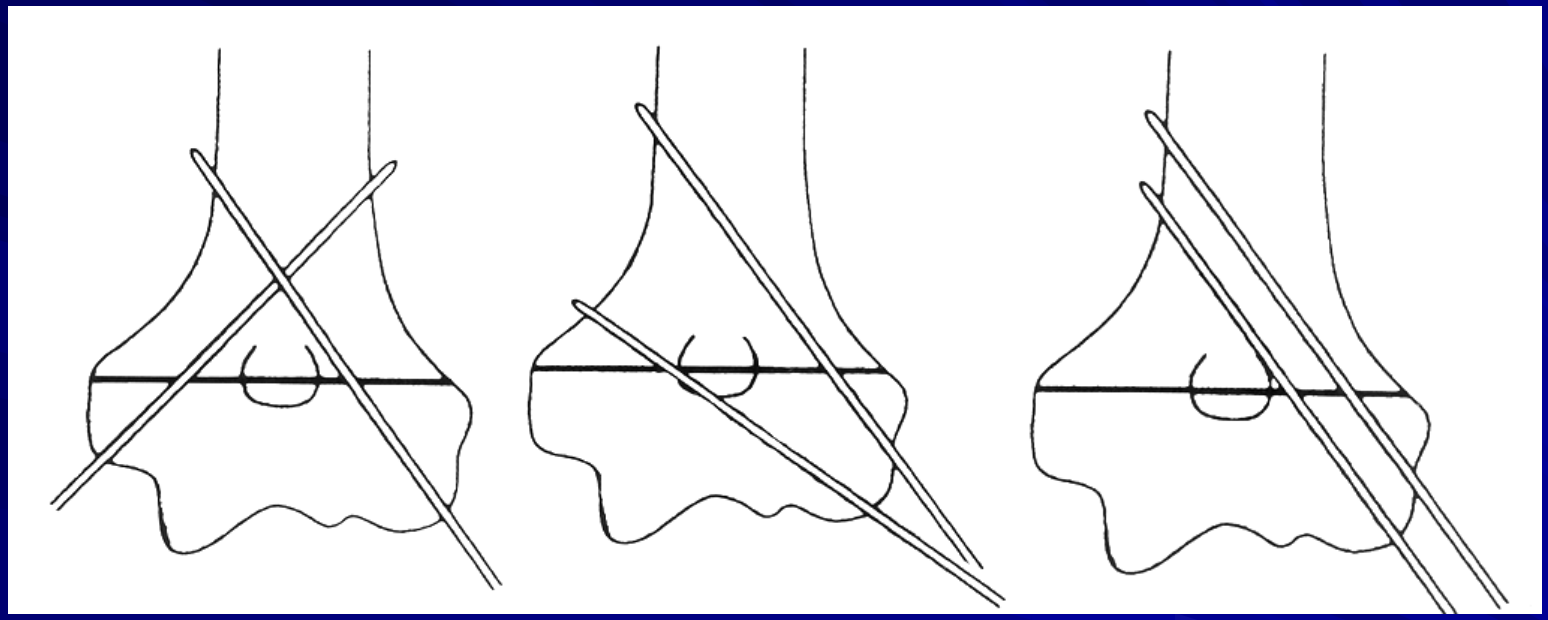
Parameter	Group 1	Group 2	P value
Baumann Angle Normal = 72°	71.9°	70.4°	0.2605
Humerocapitellar Angle Normal = 40°	32.9°	36.8°	0.1834
Gordon Index Normal = 0	32.9	25.4	0.0874
Griffet Index 1 Normal = 1.00	0.86	0.93	0.028
Griffet Index 2 Normal = 1.00	4.1	3.5	0.1108

Conclusions

1. No difference in operative duration demonstrated between IST < 8 hrs & IST > 8 hrs.

2. No difference in quality of reduction demonstrated between IST < 8 hrs and IST > 8 hrs.

3. Previous findings of rate of open reduction and major complications were replicated in this study.



Lee SS, Mahar AT, Miesen BS, Newton PO.
J Pediatr Orthop 2002; 22:440-3.

Iatrogenic Ulnar Nerve Injury After the Surgical Treatment of Displaced Supracondylar Fractures of the Humerus: Number Needed to Harm, A Systematic Review

Bronwyn L. Slobogean, PA-C, Heather Jackman, MD, FRCSC,† Sally Tennant, BSc, MBBS, FRCS (Tr & Orth),‡ Gerard P. Slobogean, MD, MPH,§ and Kishore Mulpuri, MBBS, MS (Ortho), MHSc (Epi)*§*

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Management of Displaced Supracondylar Fractures of the Humerus Using Lateral versus Cross K Wires: A Prospective Randomized Trial

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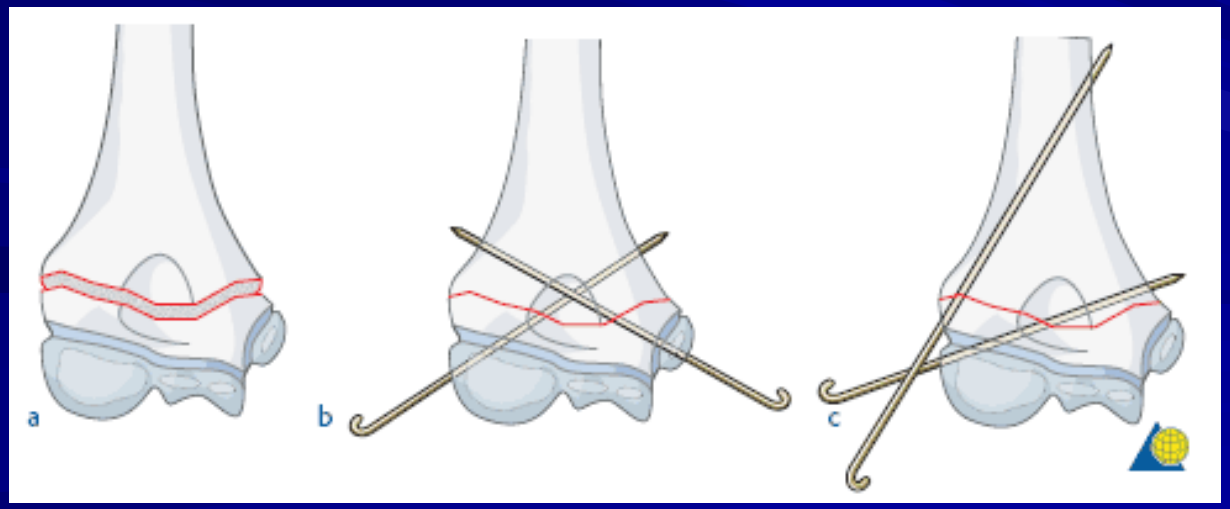
Background

- Treatment of Type III fractures
  - Historically - cast immobilization, skin traction to olecranon traction
  - Current – closed (possible open reduction) and percutaneous pinning or open reduction
    - Lateral pin configuration vs. crossed



Background

Twelve of 47 lateral-entry pin patients had a loss of reduction of greater than 6 degrees in Baumann's angle (25%) versus 10 of 57 in the medial and lateral-pin group (18%). This was not statistically significant ($P = 0.32$).

- Gaston et al. JPO 2010

There were no significant differences ($p > 0.05$) between the groups regarding the Baumann angle, change in the Baumann angle, humerocapitellar angle, change in the humerocapitellar angle, carrying angle, elbow extension, elbow

- Kocher et al. JBJS 2007

present a prospective, surgeon-randomized study comparing crossed pin (group A, $n=20$) versus preferential lateral only pin (group B, $n=20$) fixation for displaced supracondylar humerus fractures. There was no difference in Baumann's angle ($P>0.75$), the humerotrochlear angle ($P>0.85$), or final elbow range of motion ($P>0.25$). Both

- Tripuraneni et al. JPO B 2009

Background

- Previous clinical trials are superiority trials done to show that crossed pinning is better than lateral pinning
- They did not find a significant difference; however, there is potential for Type II error
- To prove that lateral pinning is just as good as crossed pinning, a non-inferiority trial is required
- Thus a need for a non-inferiority trial was identified

Purpose

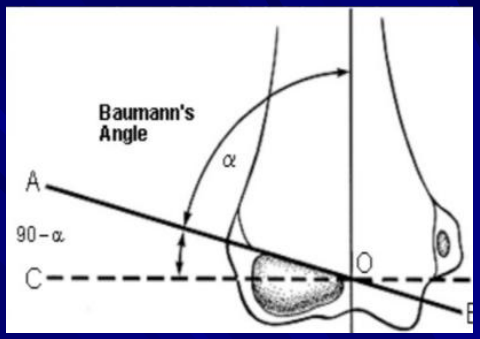
To evaluate whether the loss of reduction in lateral pinning is not inferior to crossed pinning in the closed reduction and percutaneous pinning of Type III displaced supracondylar humerus fractures.

Methods

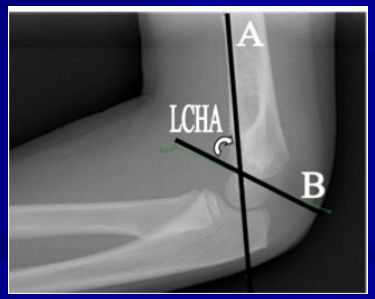
- Non-inferiority randomized controlled trial
- Two groups:

Crossed pinning vs Lateral pinning

Methods



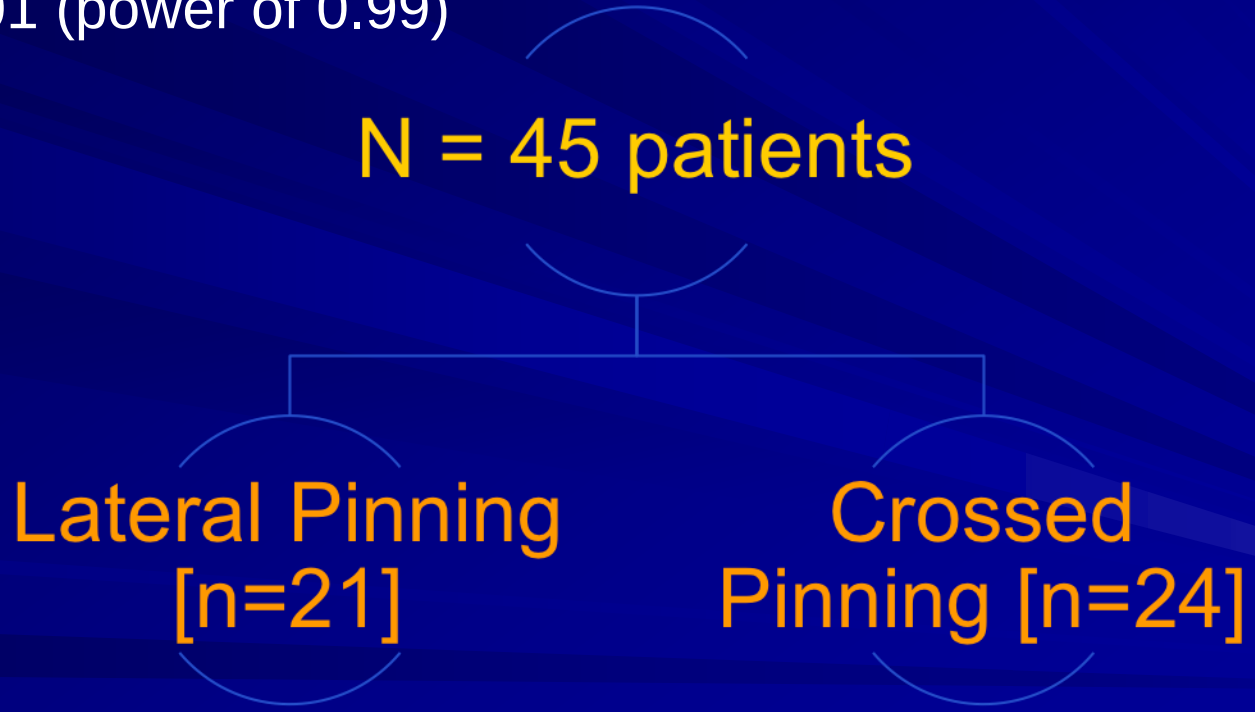
- **Primary Outcome Data**
  - Loss of reduction between immediate post-surgery and at pin removal
    - Measured from Baumann's angle
    - Non-inferiority interval: loss of reduction for lateral pinning within 6 degrees of loss of reduction for crossed pinning
      - Value determined from 6 degree measurement error due to rotation of elbow or inter-/intra-observer variability
- **Secondary Outcome Data**
  1. Lateral humero-capitellar angle (LHCA)
  2. Evidence of iatrogenic ulnar nerve injury



Results

Power analysis

- 42 patients (21 in each arm) was necessary to detect a difference within 6 degrees of loss of reduction with α=0.05, β=0.01 (power of 0.99)



Results

	Lateral Pinning	Crossed Pinning
Change in Baumann's Angle	-0.95° 95% CI [-2.33, 0.43]	-0.29° 95% CI [-1.65, 1.07]
Change in LHCA	0.37° 95% CI [-0.96, 1.69]	-0.91° 95% CI [-2.29, 0.47]
Iatrogenic Ulnar Nerve Injury	0	2

Discussion

- Studies to date have not shown superior outcomes either clinically or radiographically between crossed and lateral pin techniques
- This study demonstrates a clinically significant non-inferiority of lateral pinning compared to crossed pinning
  - <1 degree difference in the change in Baumann's Angle between lateral pinning and crossed pinning.

Conclusion

Closed reduction and percutaneous pinning using lateral K wiring is not inferior to crossed K wiring in the management of Type III supracondylar humerus fractures in children.

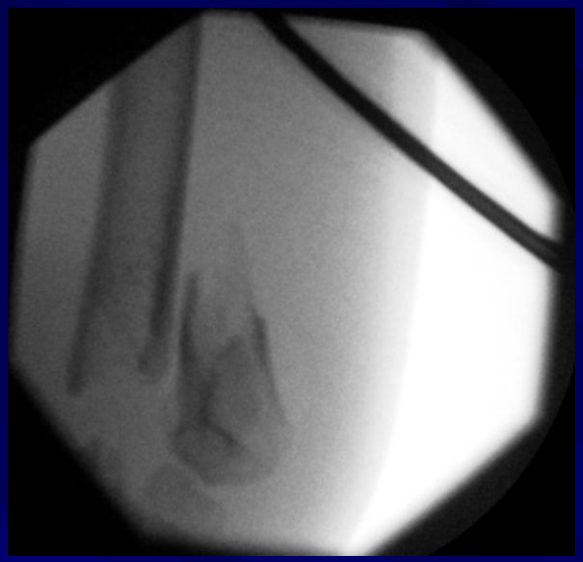
Conclusion

- Proving non-inferiority can be of interest in the following cases:
  - Experimental treatment is not expected to be better on primary efficacy endpoint (mortality), but is better on secondary endpoints (re-infarction).
  - Experimental treatment is not expected to be better on primary efficacy endpoint, but is safer.
  - Experimental treatment is not expected to be better on primary efficacy endpoint, but is cheaper to produce or easier to administer.
- There is a need for more non-inferiority trials in pediatric orthopaedics.


-TABLE

K D – 1/22/2004

9/28/2010



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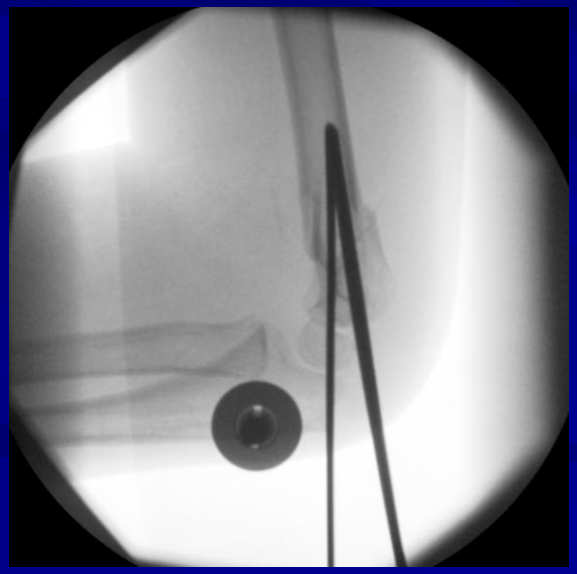
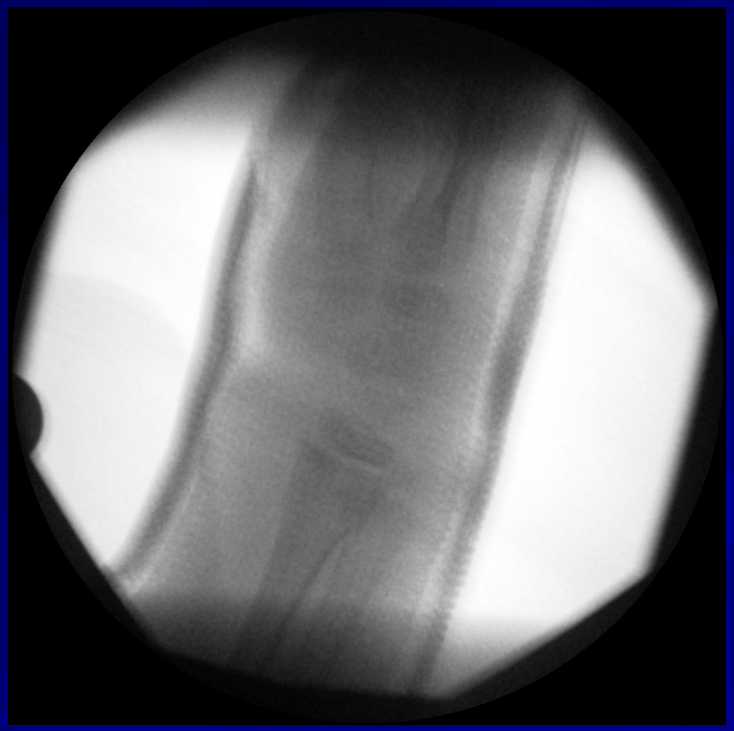



KD



KD

Complications

- **Vascular:**
  5% incidence of some compromise
  0.5% Serious

  Radial pulse Unreliable

  Direct injury to vessel by #, compression intimal tear, spasm

Complications

- **Management:**
  Prompt fracture reduction, elevation
  Extend elbow
  Angiography/Exploration of brachial artery
  Exploration <24 hrs post injury minimises risk of subsequent volkmanns contracture

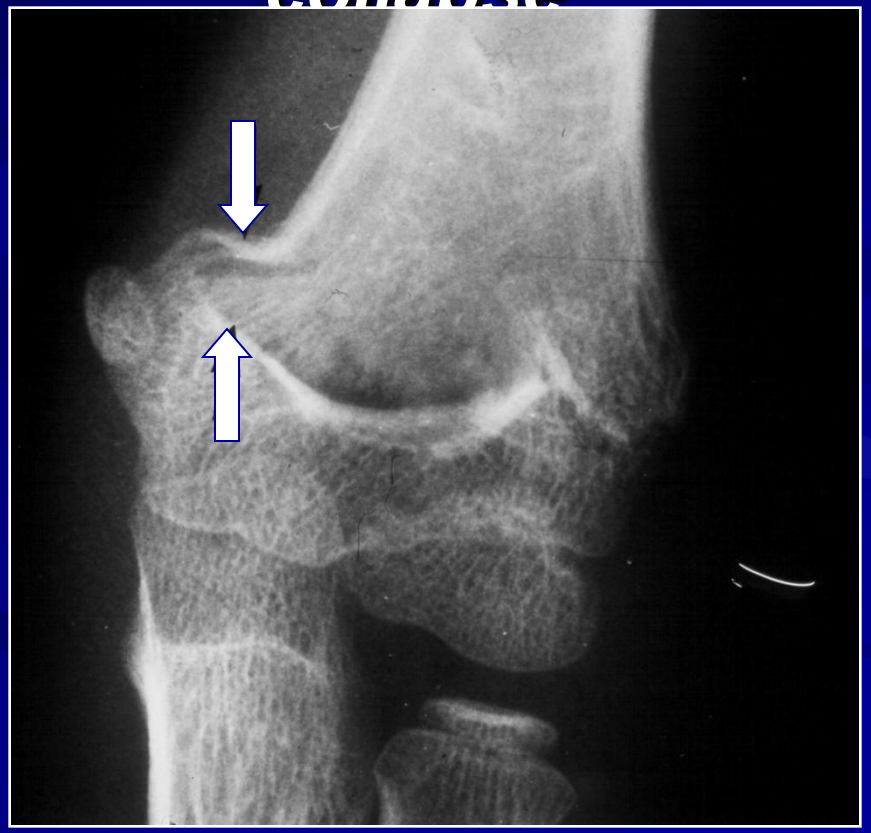
Other complications

- Nerve injury (3-8%)
- Median (ant. Interosseous) > R > U
- Elbow Stiffness
- Cubitus varus (2-50%), gunstock deformity
- Myositis ossificans
- Compartment Syndrome / Volkmanns contracture <1%

This is a true structural deformity

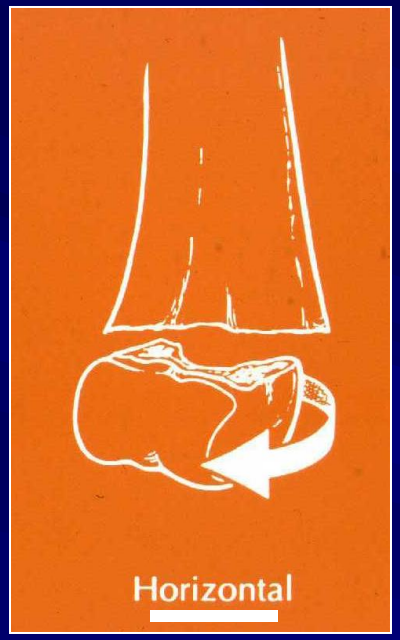
In rare instances it may be a uniplanar deformity in the coronal plane

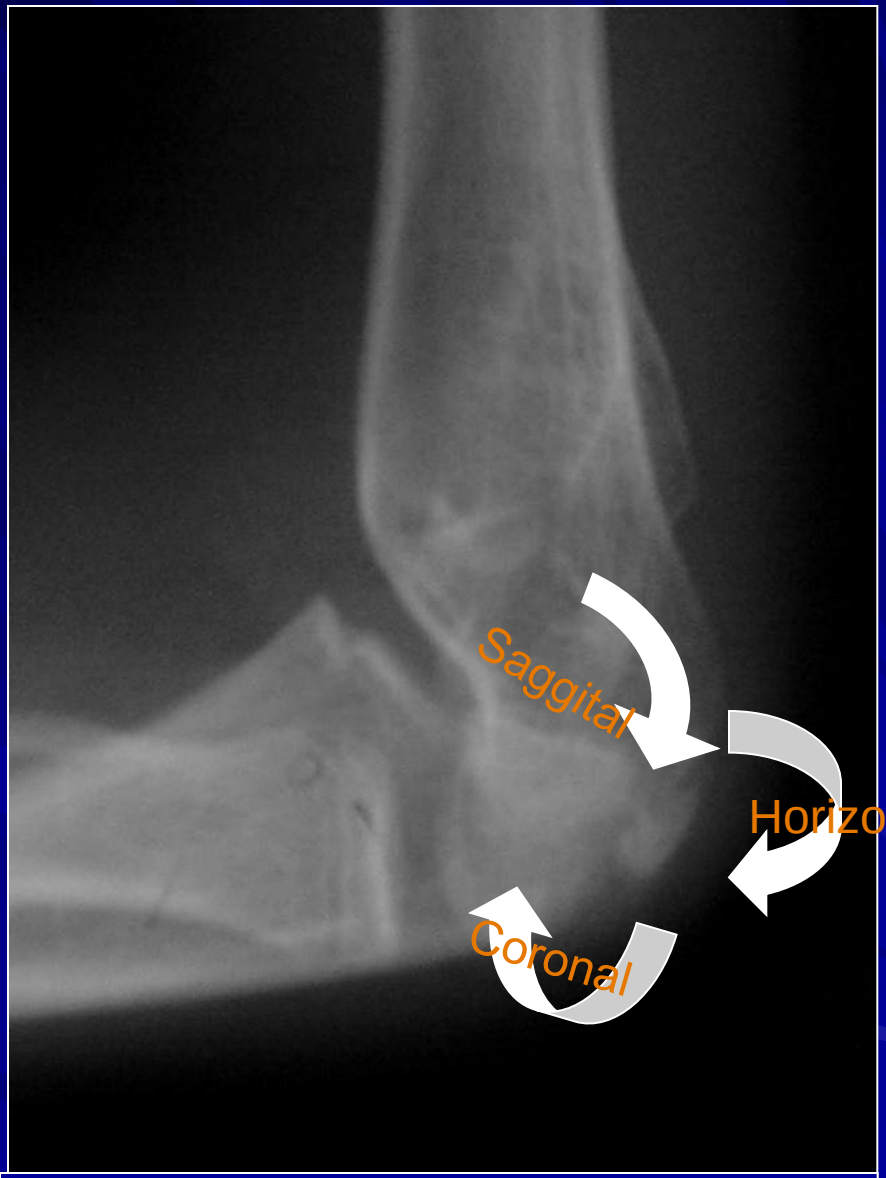
Due to medial greenstick collapse



The deformity usually is triplanar

What are
the three rotational components ?





A three dimensional deformity

What type of supracondylar fracture does this patient have?

They present
in the same manner as the extension typ

Type I:

Criteria?

They are undisplaced. Therefore no reduction is needed.

Type II:

Criteria?

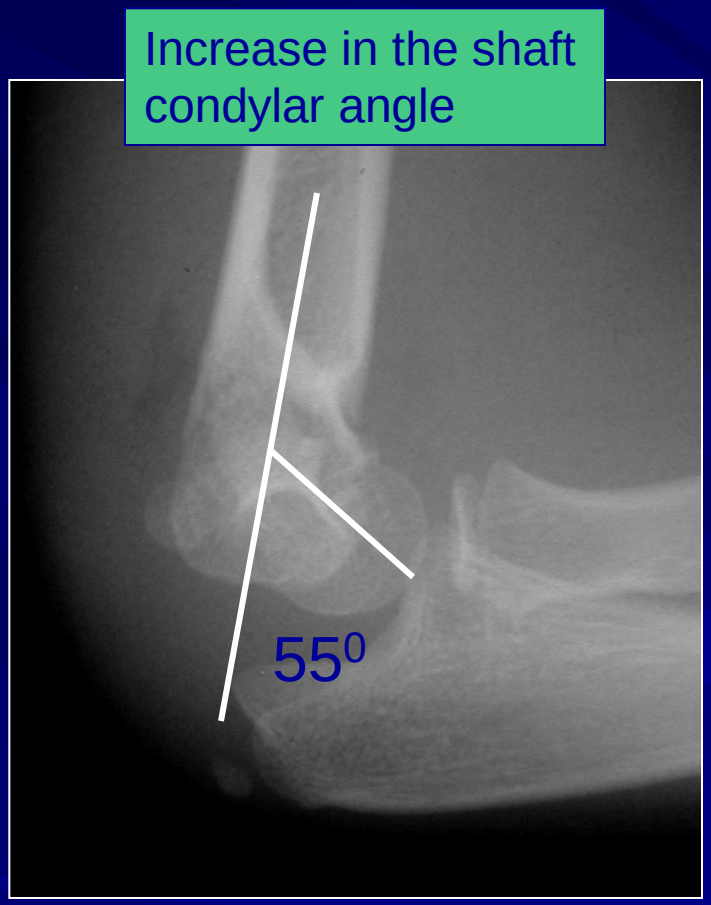
There is enough intrinsic stability to be treated with a cast alone.

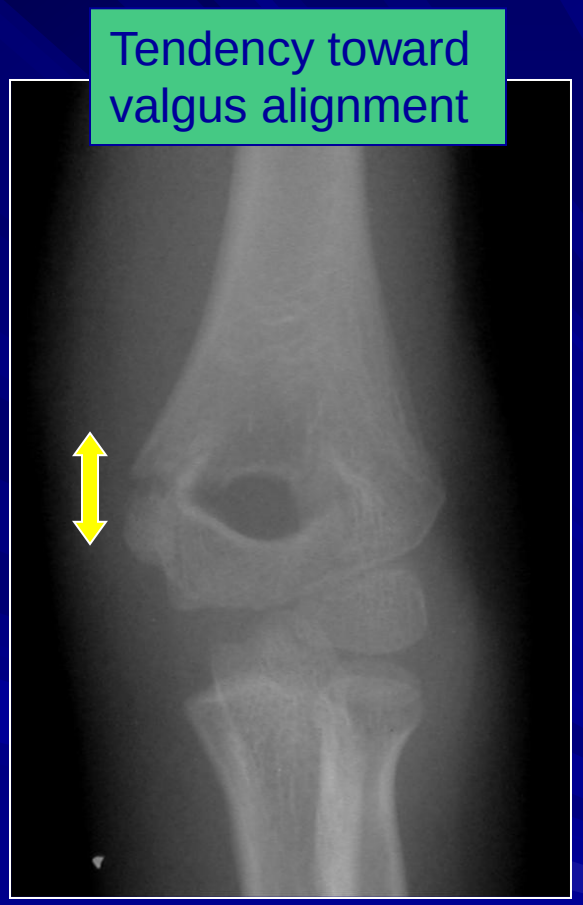
Type III:

Criteria

They have no intrinsic stability, thus they need surgical stabilization.

Type I Flexion Injury





What are the limits of acceptability ?

Because, if the flexion of the condyle is not aggressively

Type II Flexion Injury

The treatment entails a closed reductio

a long arm extension cast.

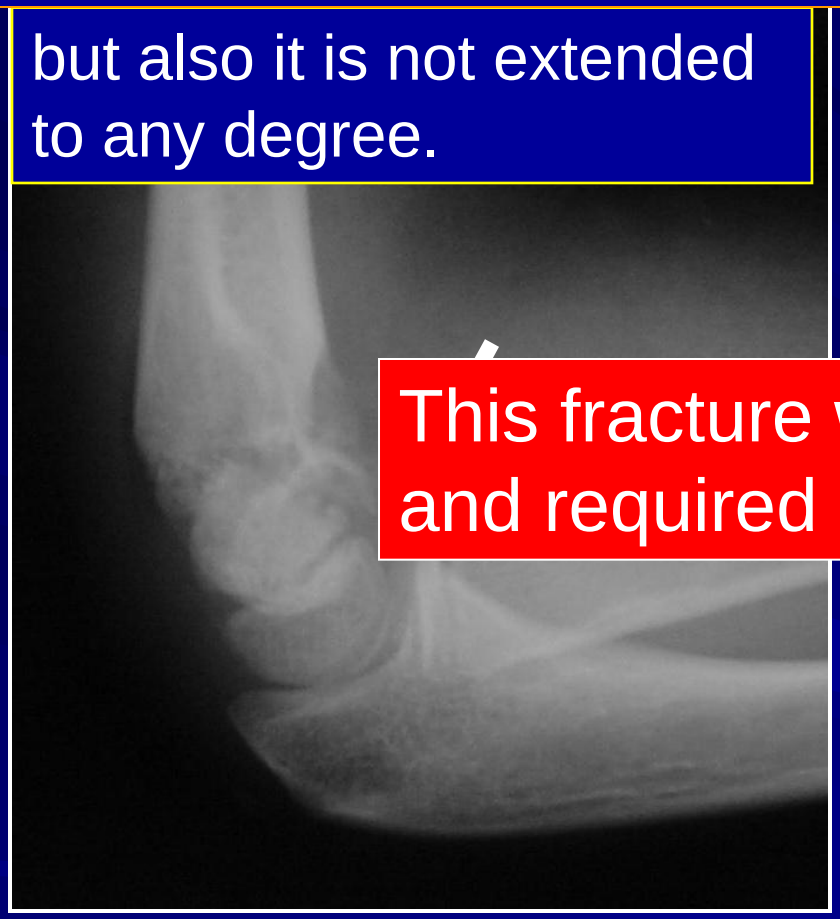
This classical Type III pattern is obviously a flexion injury.

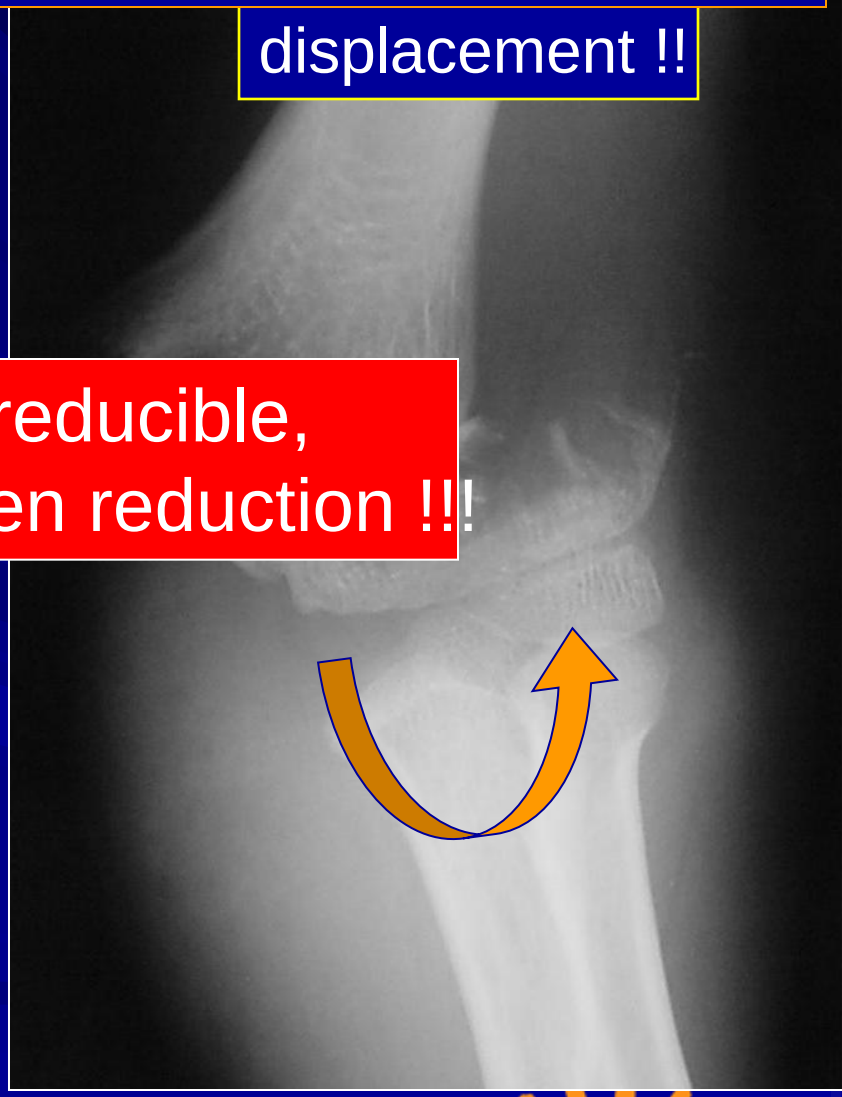
With these one needs to be prepared to do an open reduction !!

But, if not recognized as such, it may be a problem

but also it is not extended to any degree.

displacement !!



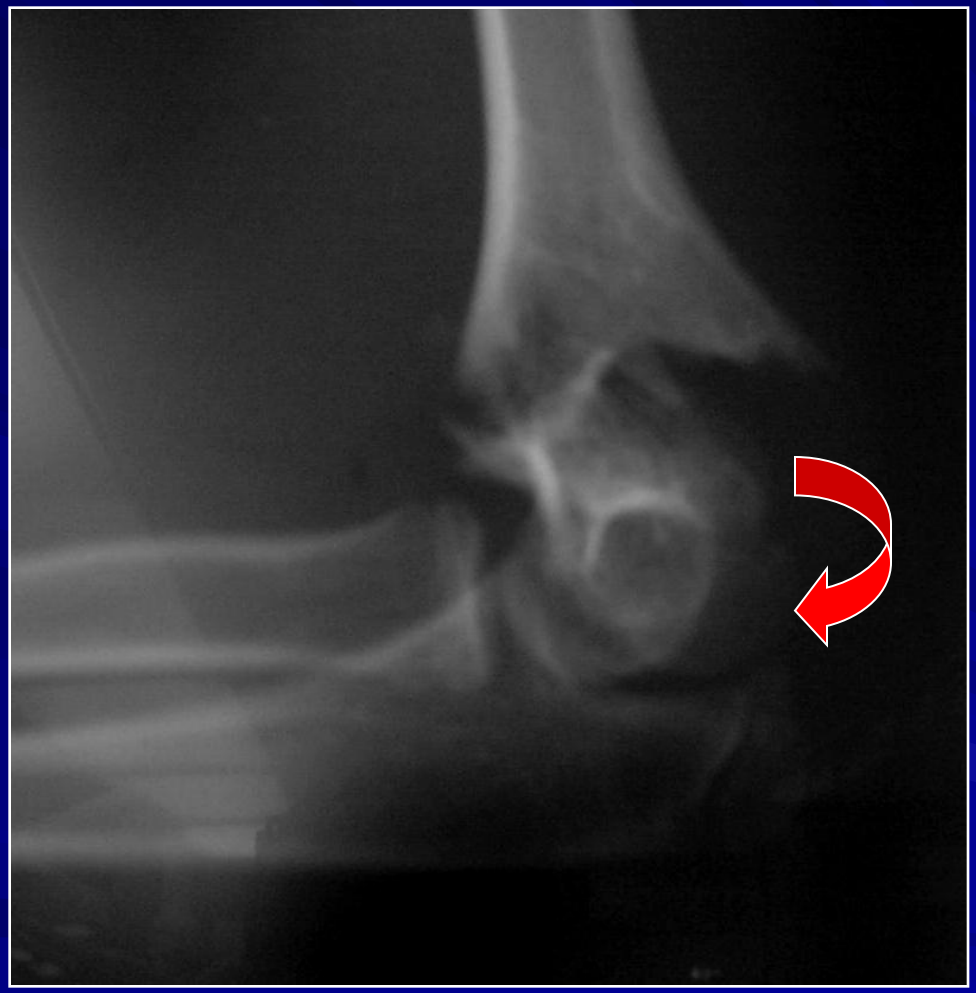


This fracture was irreducible, and required an open reduction !!!

What is different about this fracture? ?

There are some clues to these occult flexion injuries.

1. The distal fragment is not extended,

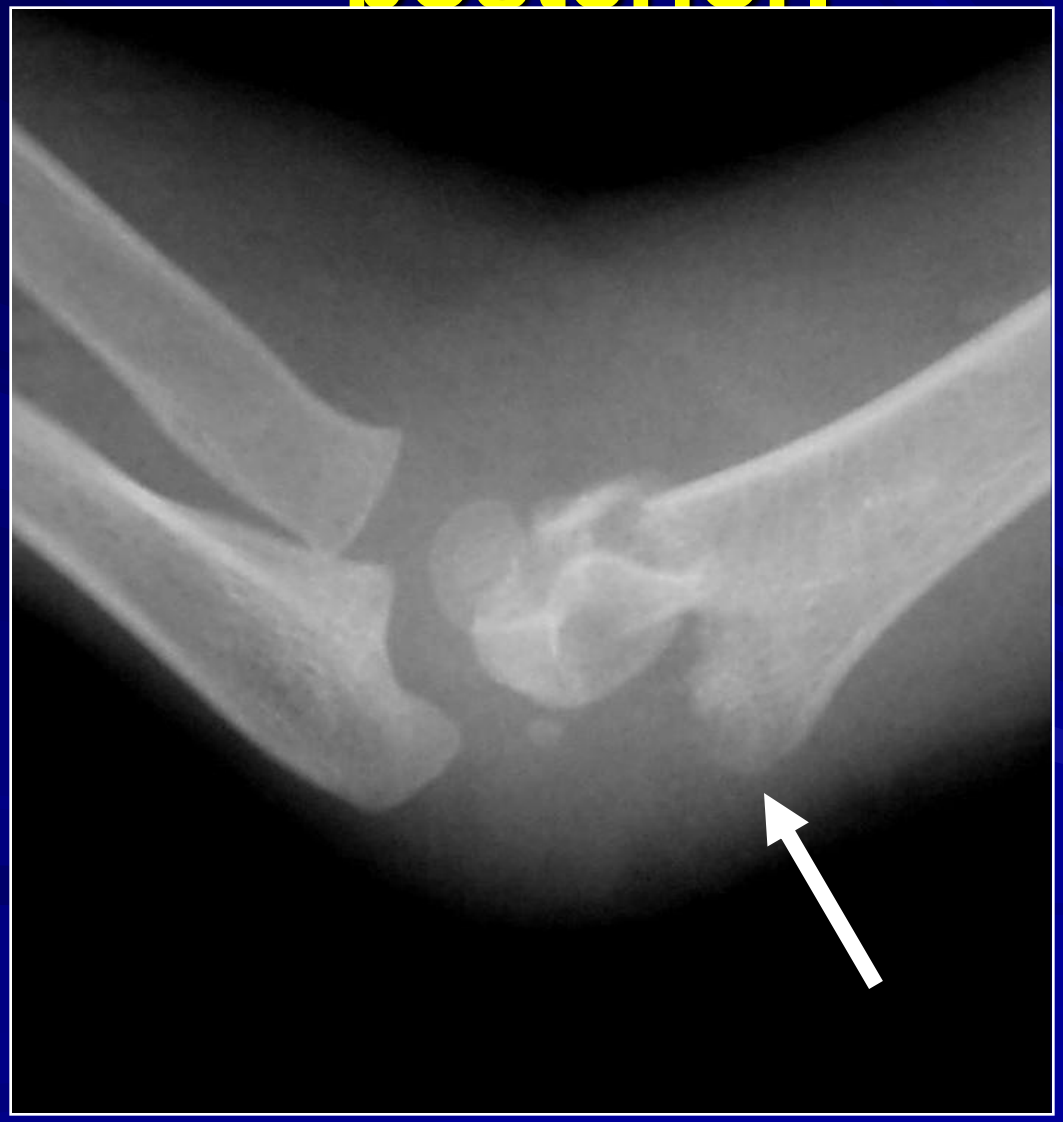


It may be rotated!!

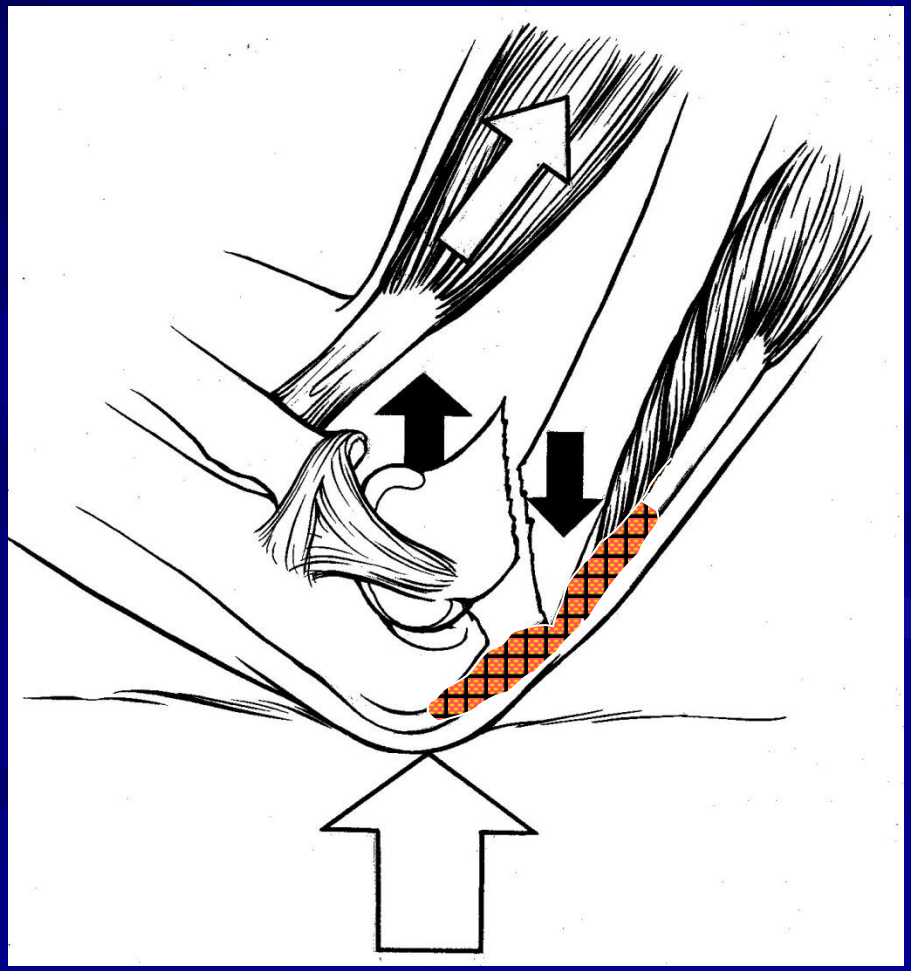
however,it may not be flexed to any degree

2. The distal fragment is in valgus.

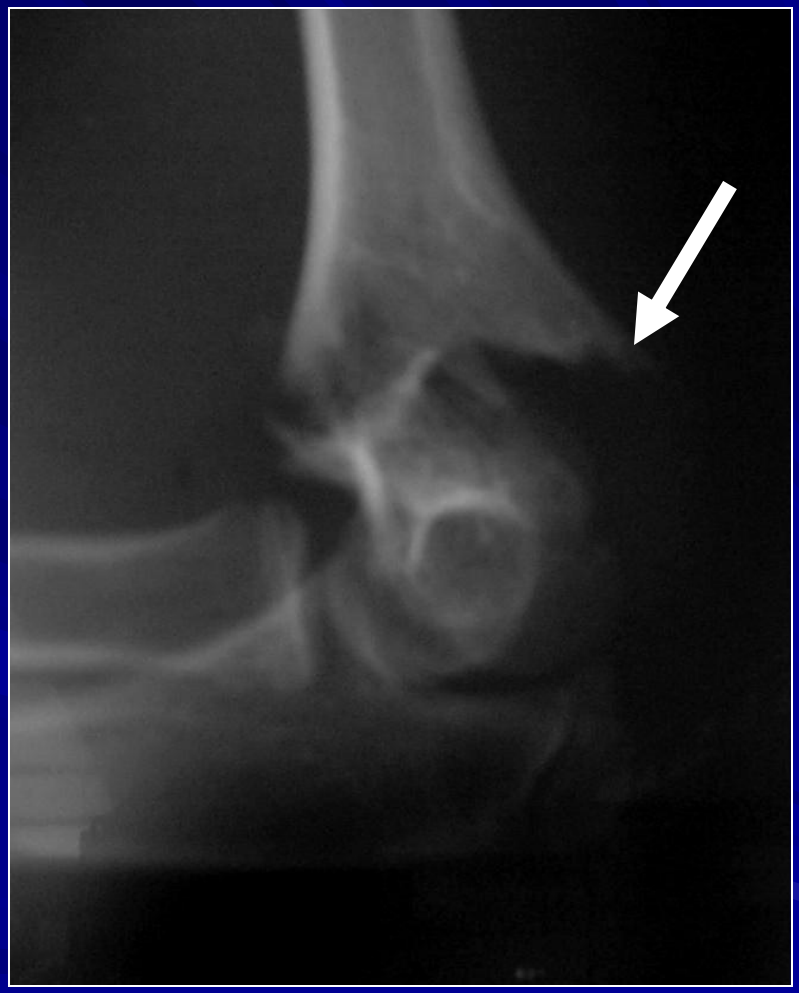
3. The medial spike of the proximal fragment is usually posterior.



4. There may be clinical signs of ulnar nerve dysfunction.



Why are these fractures irreducible ?



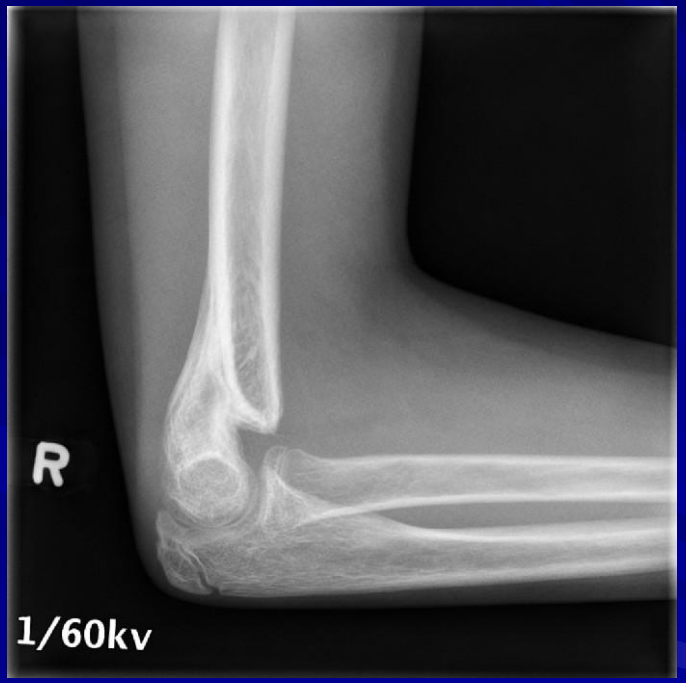
The location of the proximal medial spike is critica

9-17-2008

9-29-2008

10-16-2008

1-15-2009



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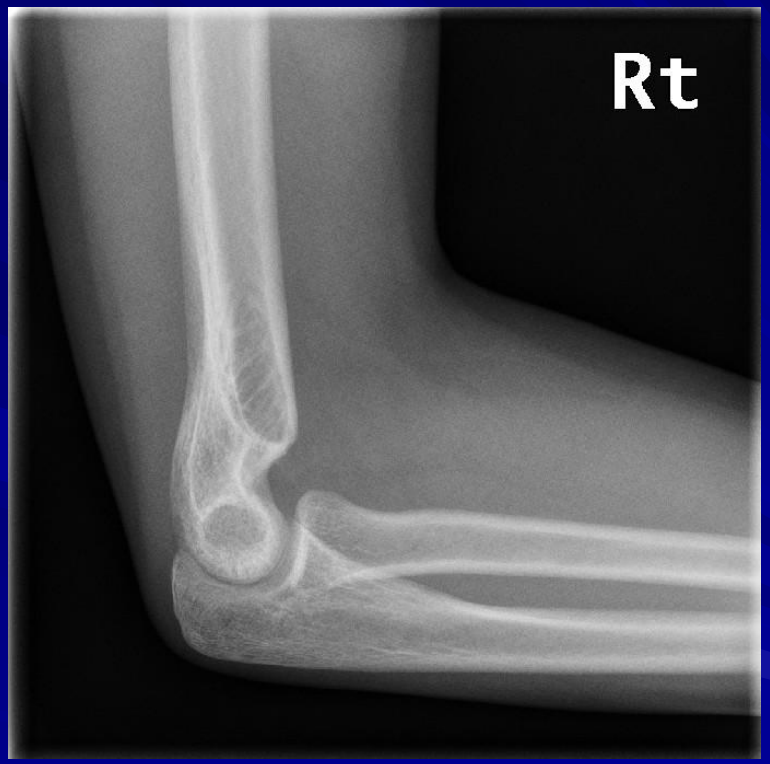

9-28-2010

Thank you