



# **Complex Proximal Humerus Fractures in Young Adults**

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# Objectives

- **Importance of humeral head vascularity**
- **Importance of reduction**
- **Treatment options**
- **How to avoid complications ?**
- **Fracture-dislocations**

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# PHF in Young Adults

- **High energy trauma**
- **Displaced fractures**
- **Fracture-dislocations**
- **Associated neuro-vascular injuries**



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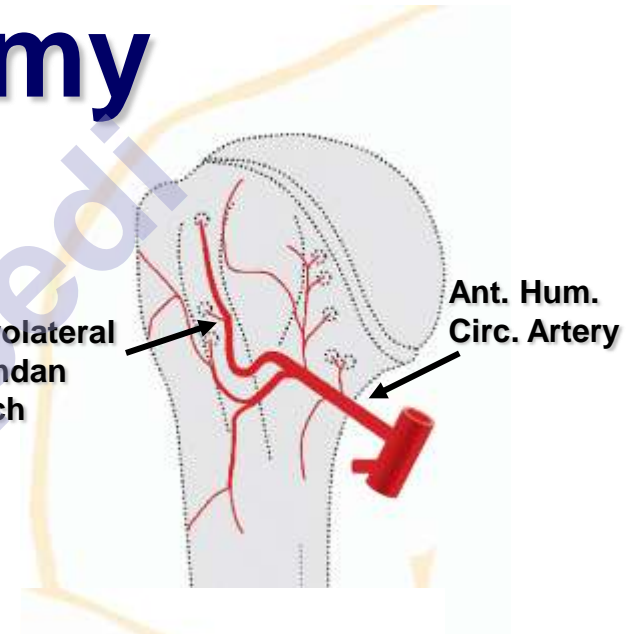
# Vascular Anatomy

- **Anterolateral ascendant artery**

- Provides primary vascular supply
- Branch of ant. humeral circumflex artery
- Courses along bicipital groove
- Terminal branch → **arcuate artery**

Anterolateral  
ascendant  
branch

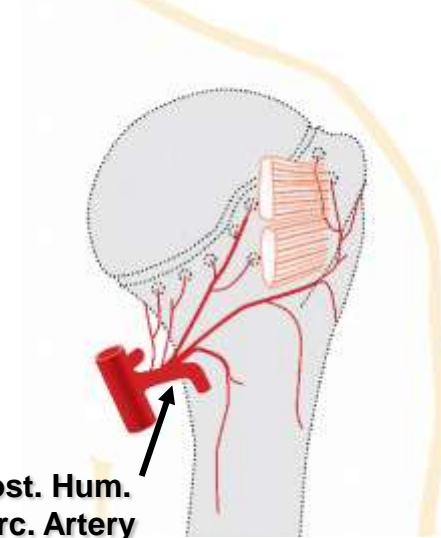
Ant. Hum.  
Circ. Artery



- **Post. humeral circumflex artery**

- Posterior GT
- Anastomosis with arcuate artery

Post. Hum.  
Circ. Artery

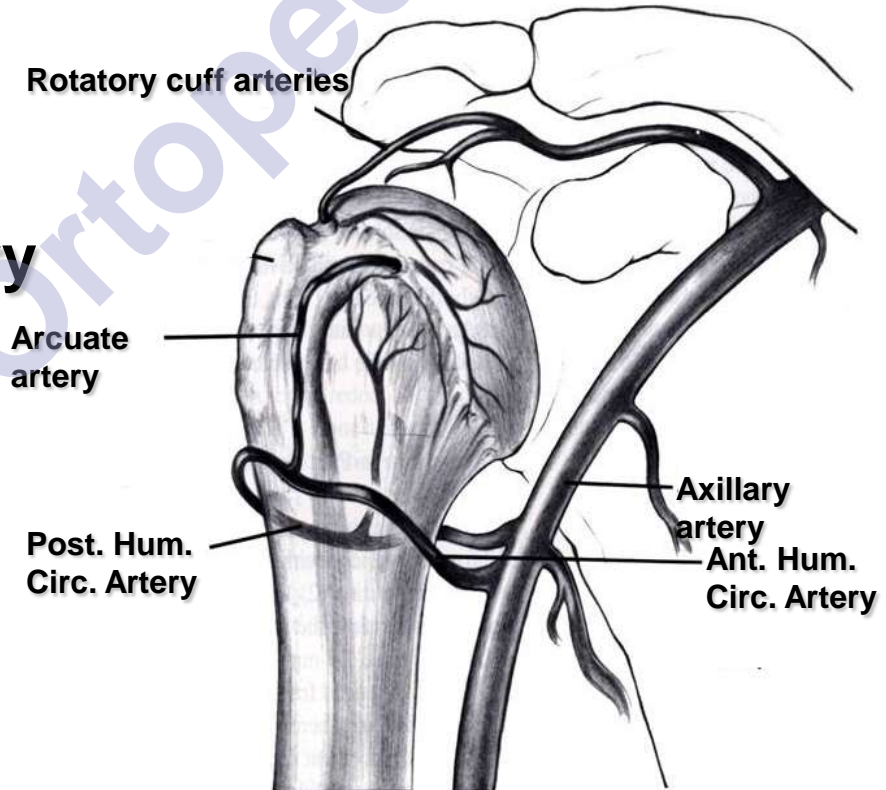




# Vascular Anatomy

## Anastomosis

- Arcuate artery
- Post. hum. circumflex artery
- Metaphyseal artery
- Rotatory cuff arteries

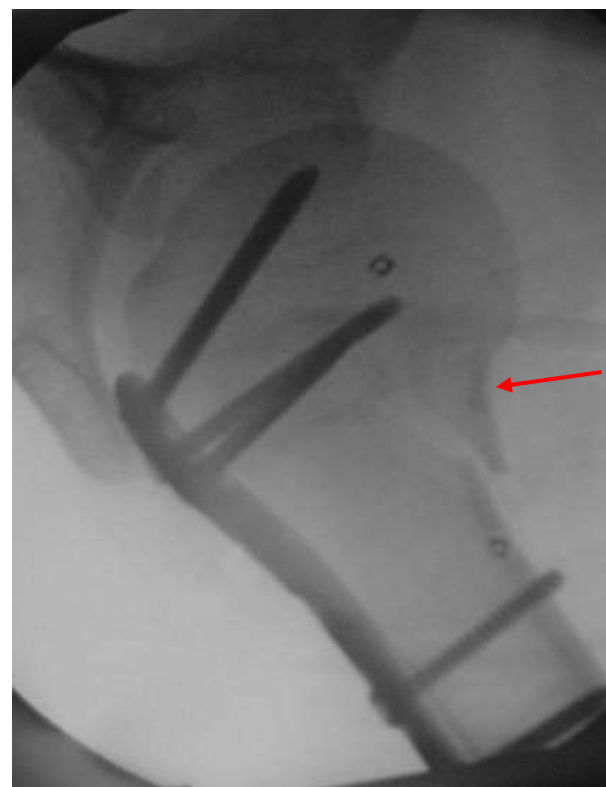


# Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus

R. Hertel, A. Hempfing, M. Stiehler, and M. Leunig, *Berne, Switzerland*

*J Shoulder Elbow Surg*, 13(4): 427-33, 2004

- **Perfusion study**
- **> 8 mm medial calcar fragment**
- **Intact medial hinge**





ELSEVIER

## Tetracycline labeling as a measure of humeral head viability after 3- or 4-part proximal humerus fracture

Lynn A. Crosby, MD<sup>a,\*</sup>, Ryan P. Finnan, MD<sup>a</sup>, Christopher G. Anderson, MD<sup>b</sup>, Jon Gozdanovic<sup>c</sup>, Mill W. Miller, PhD<sup>d</sup>

- **3-part and 4-part fractures**
- **Vascular preservation**
  - Anterosuperior part
  - Especially in young patients
- **Anastomosis ?**



# Complex PHF

- **3 and 4-part fractures**
- **Fracture-dislocations**







# Complex PHF

- **Hemiarthroplasty**
- **Open reduction-internal fixation**

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# Hemiarthroplasty

- **Long term**
  - Loosening
  - Glenoid erosion
- **Unpredictable poor functional results**
  - Not suitable for high demand patients



***Every effort must be made for internal fixation in young patients***



# Internal Fixation

- **Anatomical reduction**
- **Stable fixation**
- **Preservation of vascularity**

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# Evaluation

- **Associated injuries**
- **Displacement**
  - Misjudgement up to 60%
  - 3-D BT is mandatory
- **Humeral head viability**
  - > 8 mm medial calcar fragment
  - Intact medial hinge
- **Osteoporosis**
  - Comminution of tuberosity fragments
  - Density of head
  - Cortical thickness < 4mm



*Tingart MJ et al. The cortical thickness of the proximal humerus diaphysis predicts bone mineral density of the proximal humerus. JBJS Br. 85:611-7, 2009*



# Reduction

- **Mandatory for good functional results**

*Gerber et al. The clinical relevance of post traumatic avascular necrosis of the humeral head. J Shoulder Elbow Surg. 7:586-90, 1998*

*Robinson CM et al. Proximal humeral fractures with a severe varus deformity treated by fixation with a locking plate. JBJS Br. 92(5): 672-6, 2010*

- **Compromises the outcome of 2<sup>o</sup> hemiarthroplasty**

*Boileau P et al. Tuberosity malposition and migration: reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. J Shoulder Elbow Surg. 11:401-12, 2002*



# Greater Tuberosity

- **Anatomical importance**
  - Guide to anatomical reduction
- **Biological importance**
  - Provides a stable platform
  - Contributes to revascularization
- **Functional importance**
  - External rotators are key muscles for shoulder function
  - Posteromedial malposition → compromises daily activities





# Greater Tuberosity

- **Traction sutures**
- **Ext. rotation of the arm**
- **Correct place → lateral bicipital groove**

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# Lesser Tuberosity

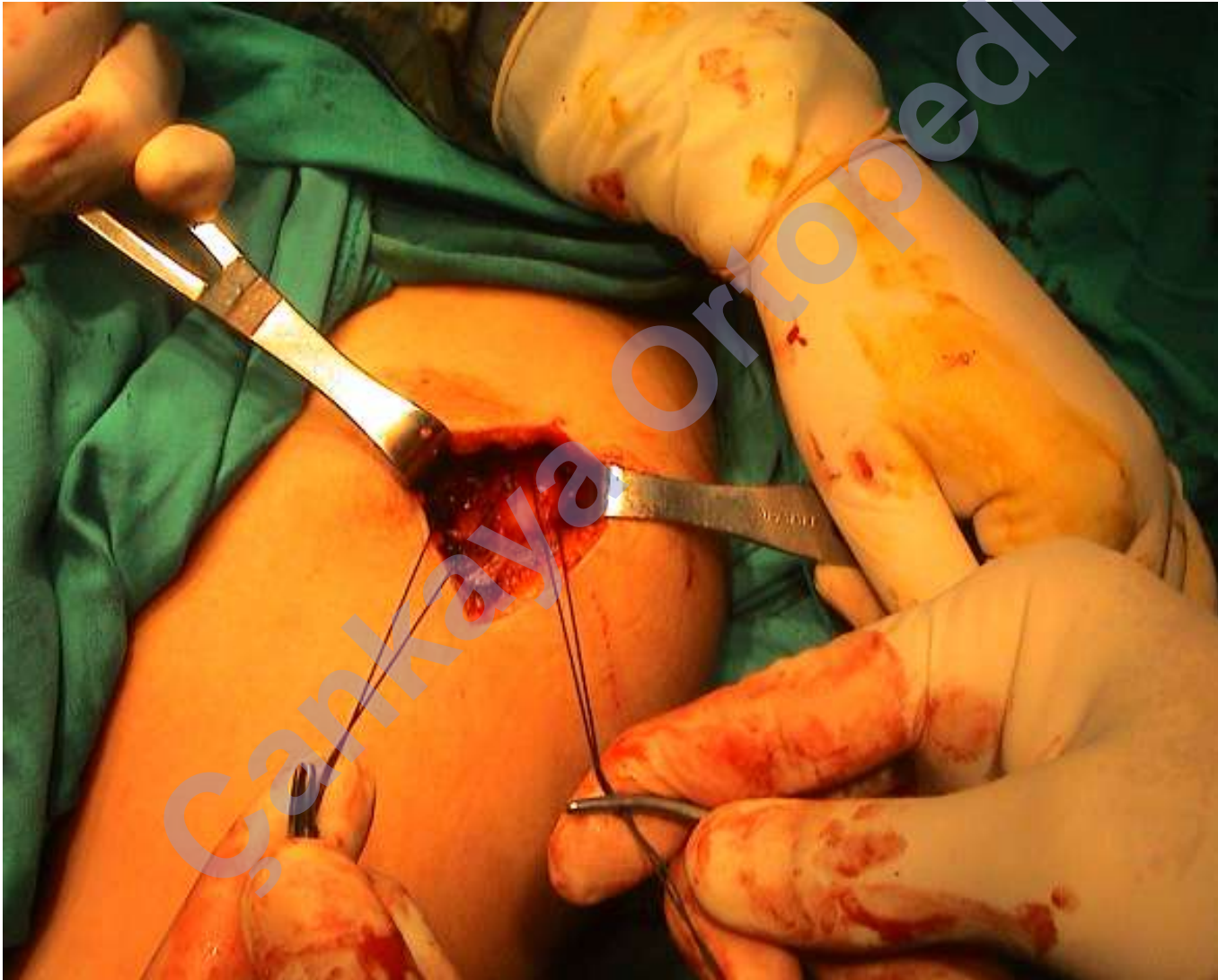
- **Less comminution**
- **Traction sutures**
- **Extension to bicipital groove**
  - Tenotomy or tenodesis of biceps tendon

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# Traction Sutures





# Humeral Head

- **Varus** → **45%**
- **Valgus** → **30%**
- **< 20°** → **25%**

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# Varus Displacement

- **Varus impaction**
  - Intact lateral periosteum
  - Abduction and protraction
- **Varus separation**
  - Diaphysis → anteromedial
  - Traction
  - Varus → traction sutures from LT manipulation



***Residual varus should be less than 20°***



# Valgus Displacement

- **Valgus impaction**
  - Intact medial hinge
  - Tuberosities attached to diaphysis
  - Simple elevation
- **Valgus with lateral displacement**
  - Head is very unstable
  - Manipulation via instruments





# Humeral Diaphysis

- **Internal rotation must be prevented**
- **Rotatory malreduction**
  - Bicipital groove irritation → pain
  - Disturbance of shoulder muscle balance

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# Internal Fixation

- **Plate fixation**
- **Percutaneous pinning**
- **IM nailing**

***No prospective randomized clinical trails comparing different treatment options***

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# Locked plate vs IM nail

***Biomechanically superior to IM nail***

- **Varus bending**
- **Torsional stability**

*Foruria AM et al. Clin Biomech. 25(4): 307-11, 2010*

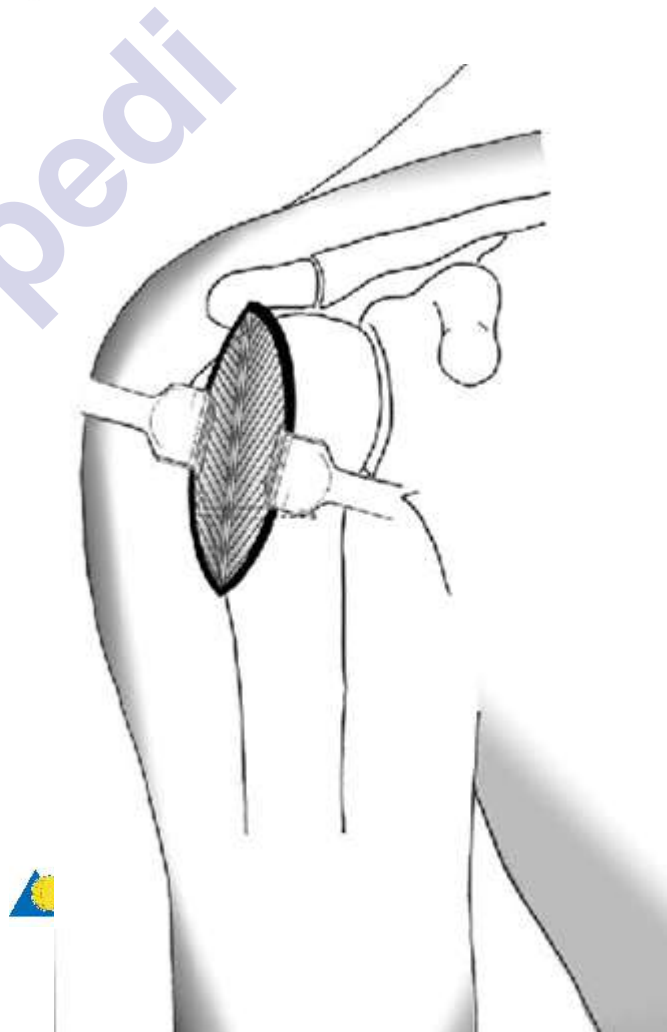
*Edwards SL et al. JBJS Am. 88(10): 2258-64, 2006*

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# Approaches

- **Deltopectoral approach**
  - Most commonly used
  - Difficulty in reduction of GT
  - More soft tissue damage → nonunion
  - 10-16% AVN
- **Anterolateral acromial approach**
  - Described by Gardner at 2005
  - Less invasive
  - Isolation of axillary nerve

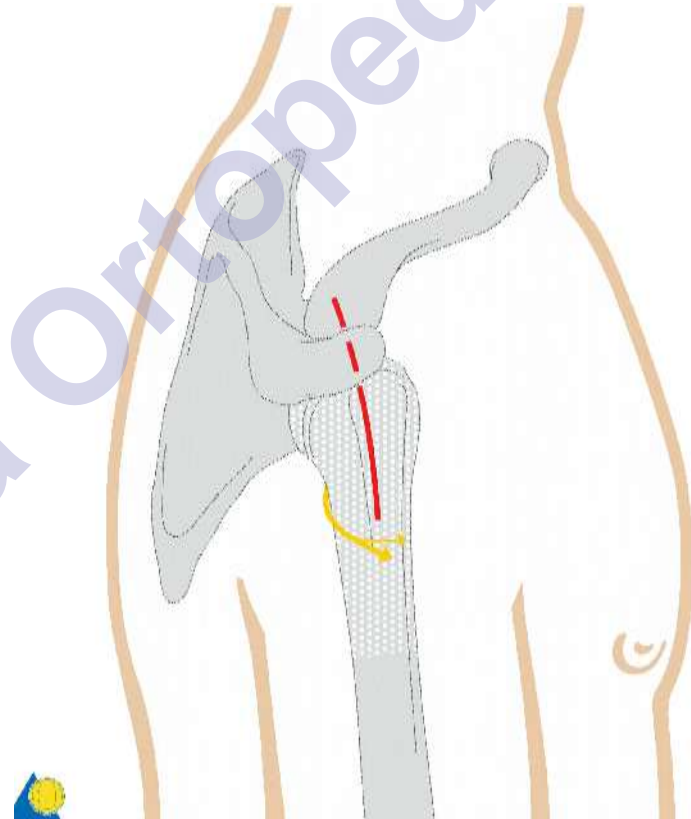






# Lateral Transdeltoid Approach

- Rotatory cuff surgery
- GT fractures
- IM nail
- MIPO with two incision



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# Position





# Proximal Incision

- **Ant. acromial corner**
- **5 cm**

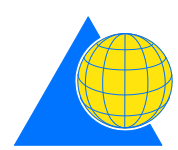




# Proximal Incision

- Anterior raphe





# Subacromial Space



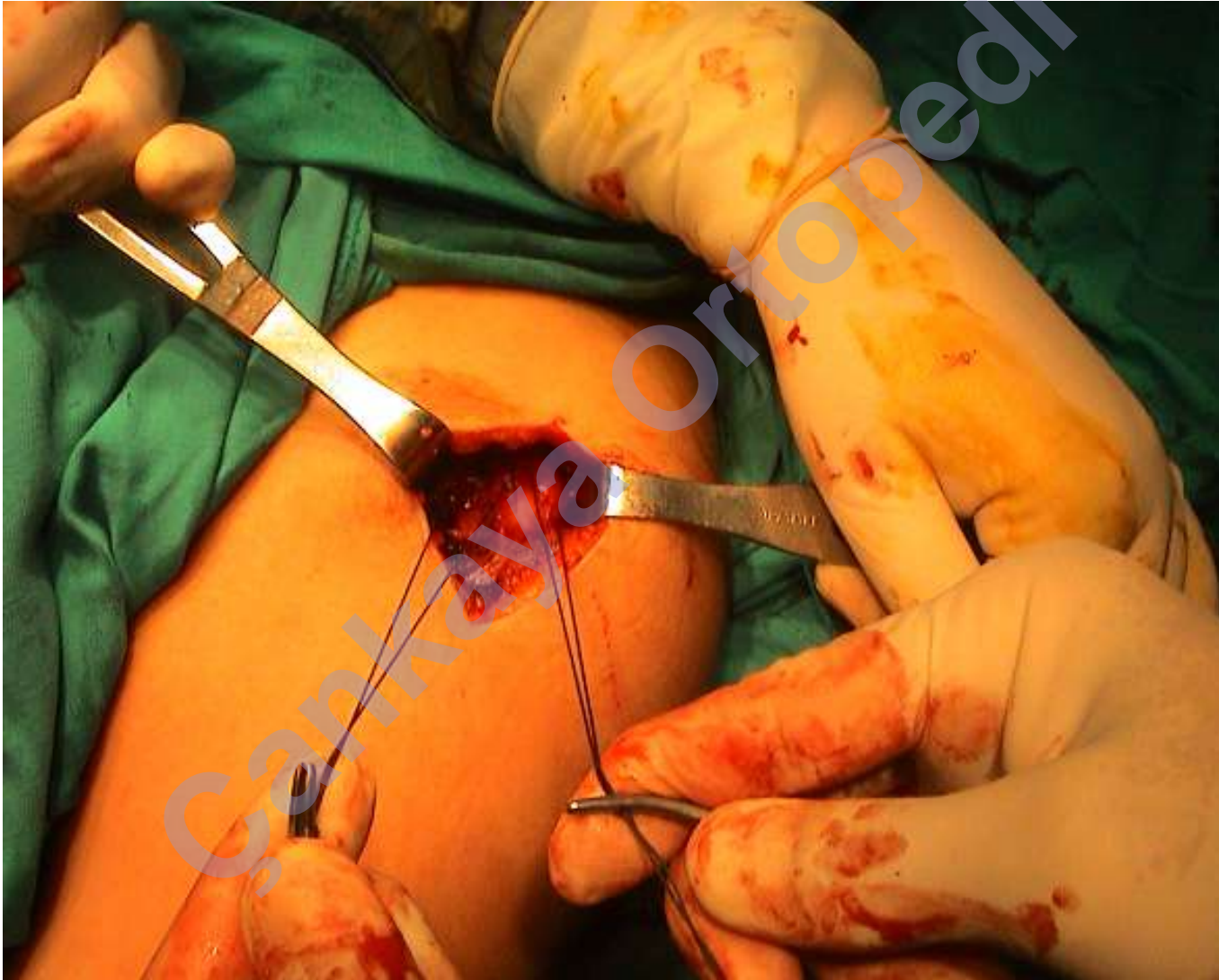


# Axillary Nerve





# Traction Sutures





# Temporary Fixation







# Tunnel Preparation





# Plate Insertion





# Plate Positioning

- **Laterally**
  - Posterior to bicipital groove
- **2-3 cm distal to humeral head**
  - 1-2 cm distal to GT
- **Close contact with bone**
  - Underneath axillary nerve !



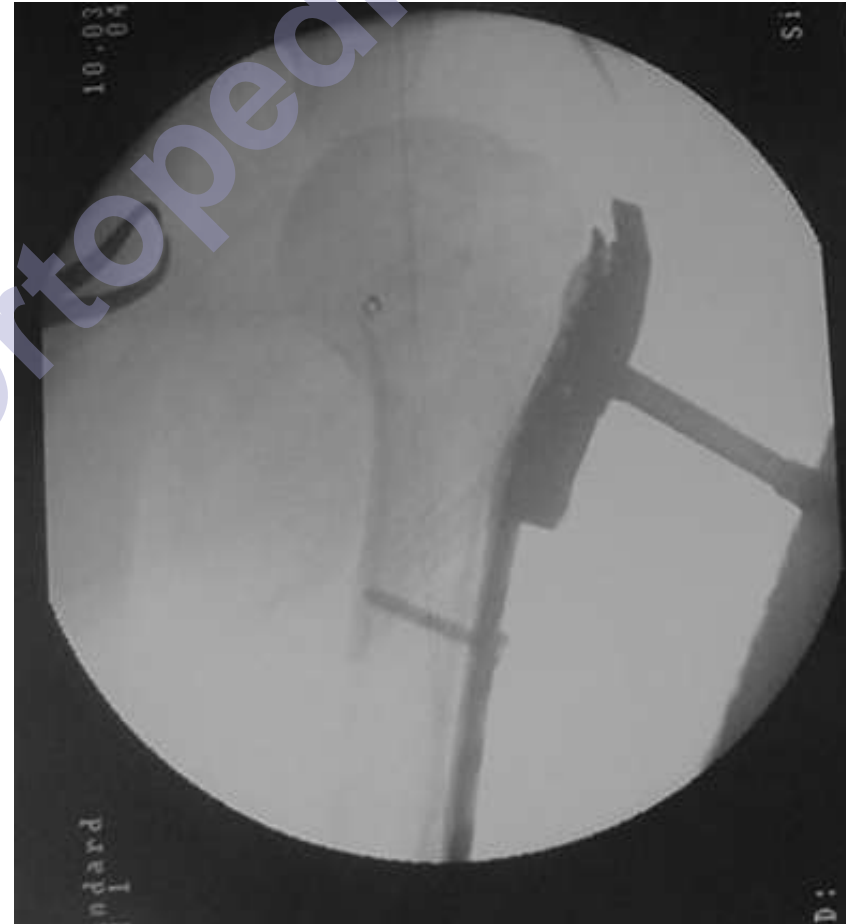


# Distal Incision





# Cortical Screw





# Proximal Screws

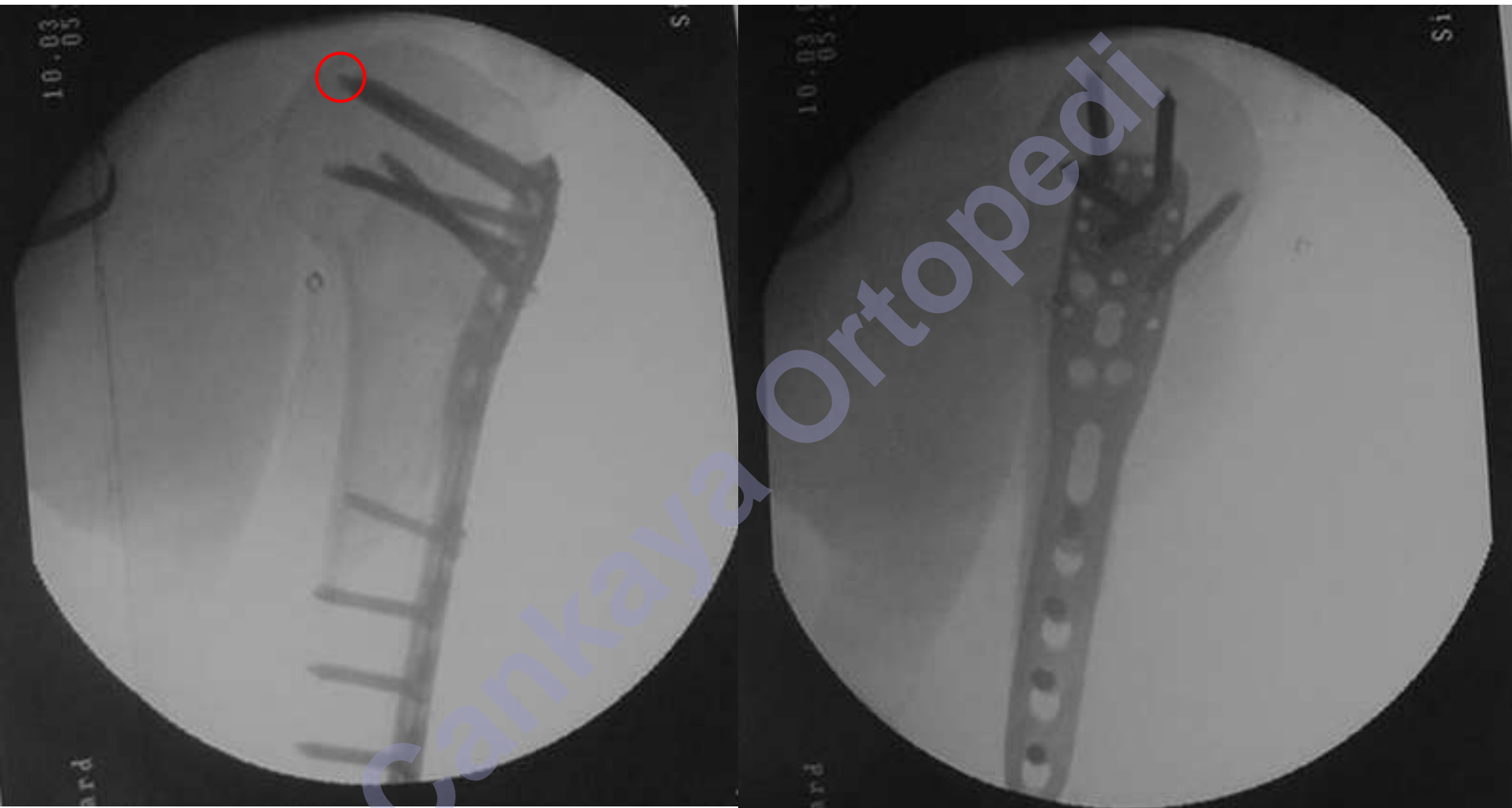


**At least five screws**



# Distal Screws





**5-10 mm to articular surface**





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# Advantages

- **Less soft tissue damage**
- **↓ risk of ant. hum. circum. artery injury**
- **Easy to place the plate laterally**
- **Easy to reduce GT**

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# Disadvantages

- **Axillary nerve injury**
- **Difficulty in reducing articular head fragment**
- **Difficulty in supporting inferomedial metaphysis**

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# Axillary Nerve

- **6-7 cm distal to acromion**
- **Anterior branch**
- **Loss of motor function is less**

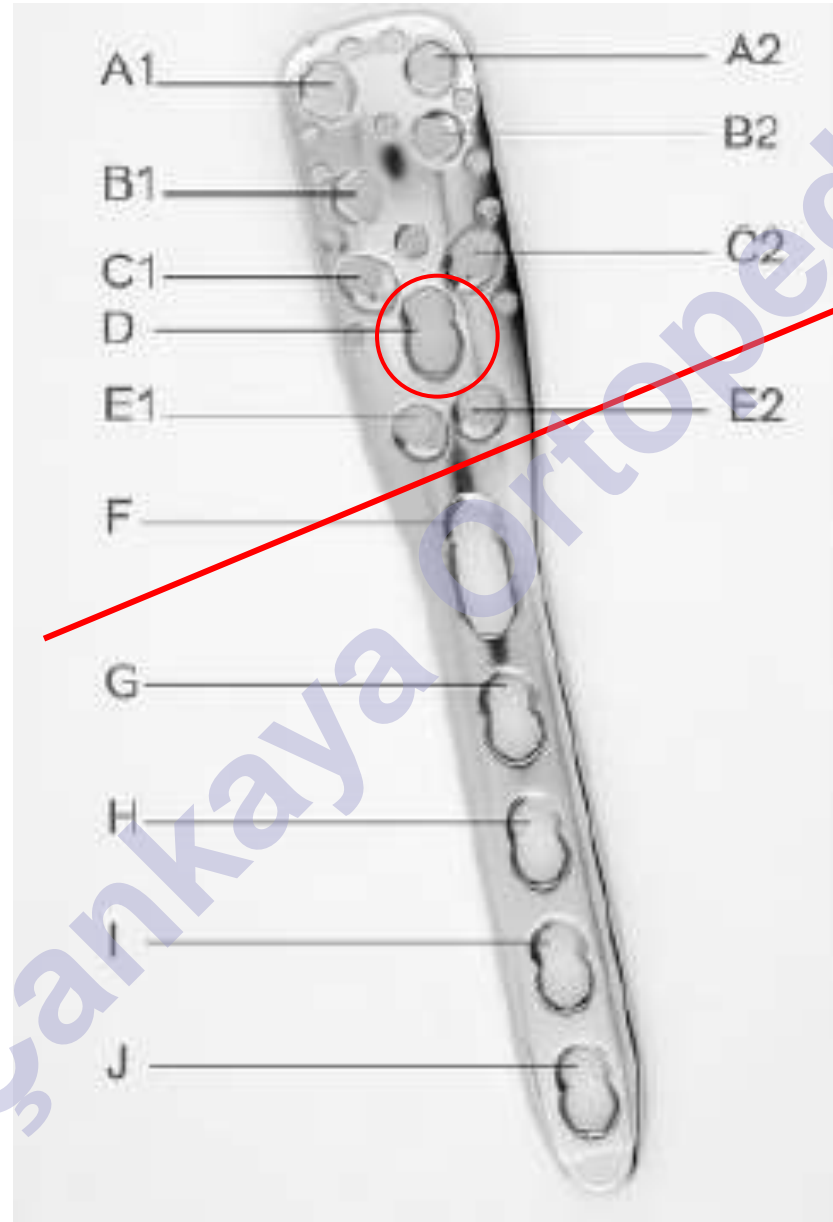




# Axillary Nerve

- **Proximal incision no more than 6 cm**
- **Palpation !**
  - Isolation if necessary
- **Plate insertion close to the bone**
- **Use long 5-hole plate**

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# Clinical Outcomes

- **Functional scores**

- Rehabilitation, reduction
- Young patients have better results

*Parmaksızoğlu AS et al. Acta Orthop Traumatol Turc. 44(2): 97-104, 2010*

- Better than hemiarthroplasty

*Wild JR et al. J Orthop Trauma, 26(4):212-5,2012*

- **Major complications**

- Avascular necrosis → 4-16%
- Malunion (varus, GT) → 12-15%
- Screw perforation → 12-23%

***Half of complications related to technical error***



Review

Benefits and harms of locking plate osteosynthesis in intraarticular (OTA Type C) fractures of the proximal humerus: A systematic review

Stig Brorson<sup>a,\*</sup>, Jeppe Vejlgaard Rasmussen<sup>a</sup>, Lars Henrik Frich<sup>b</sup>, Bo Sanderhoff Olsen<sup>a</sup>, Asbjørn Hróbjartsson<sup>c</sup>

- **12 studies, 282 patients AO type C fractures**
- **Relatively higher complication rates**
  - Avascular necrosis → up to 33%
  - Screw perforation → up to 20%
  - Loss of fixation → up to 16%
- **Reoperation rate 6-44%**



# AVN

- **Develop up to 4 years**
- **M.I. approaches → 0-6%**
- **Tolerated for many years**
- **Capacity of revascularization ?**
  - Reduced GT
  - Stable fixation





# Varus Malunion

- **Poor clinical outcome**

*Solberg et al. Surgical treatment of three and four part proximal humeral fractures. JBJS Am. 91(7): 1689-97, 2009*

- **Risk of implant failure**

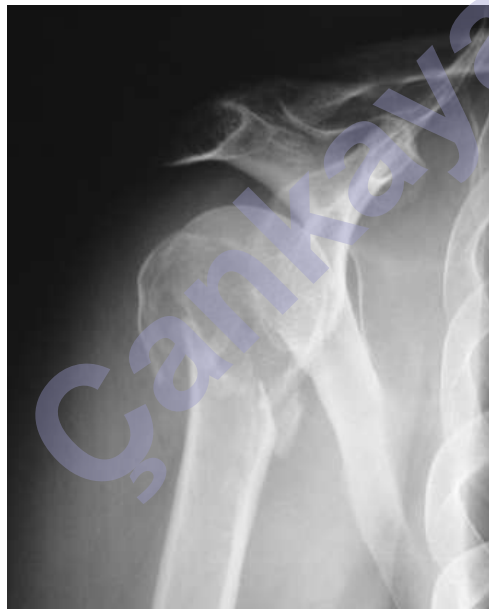
*Agudelo J et al. Analysis of efficacy and failure in proximal humerus fractures treated with locking plates. J Orthop Trauma. 21(10): 676-81, 2007*





# Medial Support

- **Plate function**
  - Varus → tension band
  - Valgus → buttress
- **Posteromedial comminution → varus collapse**





# Augmentation

- **Inferomedial screw**

*Gardner MJ et al. J Orthop Trauma. 21(3): 185-91, 2007*

*Lever JP. J Orthop Trauma. 22(1): 23-9, 2008*

*Lescheid J et al. J Trauma. 69(5): 1235-42, 2010*

- **Fibula strut allograft**

*Gardner MJ et al. J Orthop Trauma. 22(3): 195-200, 2008*

*Robinson CM et al. JBJS Br. 92(5): 672-8, 2010*

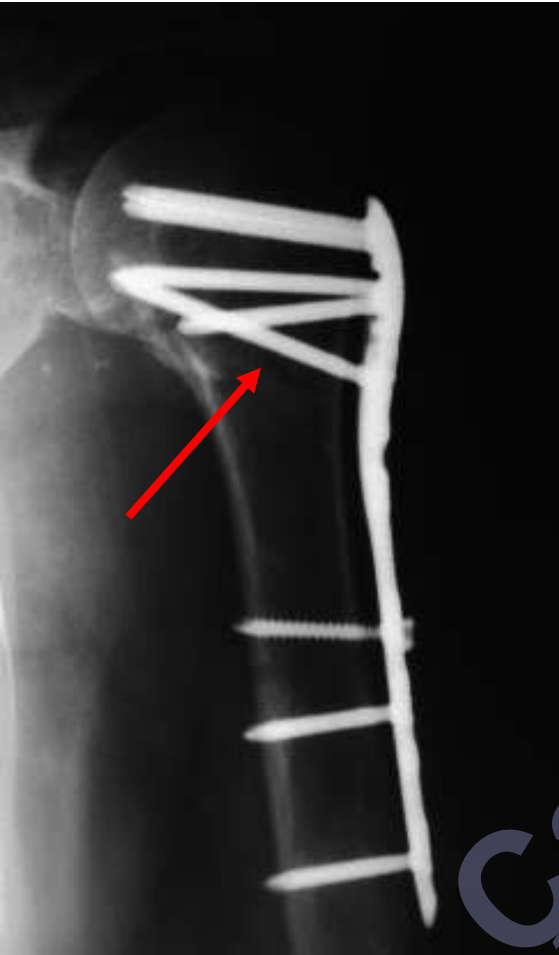
*Neviaser AS et al. Clin Orthop Rel Resarch. 469:3300-6, 2011*

- **Suturing of tuberosities to plate**

- Counterbalances rotator cuff deforming forces



# Augmentation



Robinson CM







# Screw Perforation

- **Wrong surgical technique**
  - Screw length
  - Plate position
  - Varus malreduction
- **After AVN or varus collapse**
  - Loss of medial support
  - Inadequate fixation of tuberosities
- **Long plate → less stiffness**



*Micic ID et al. Analysis of early failure of the locking compression plate in osteoporotic proximal humerus fractures. J Orthop Sci. 14(5):596-601, 2009*



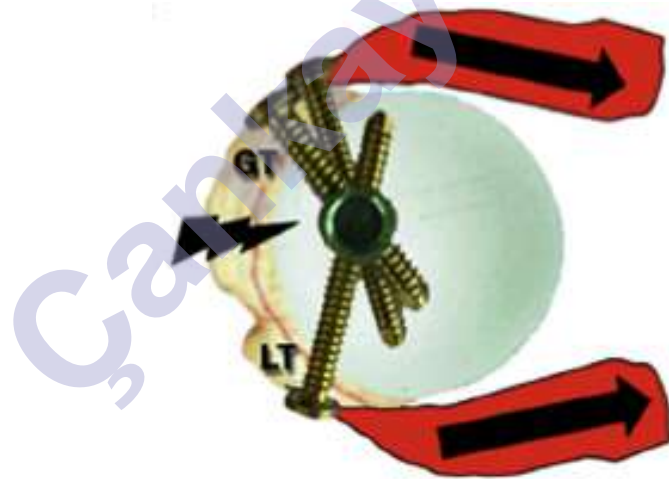
# IM Nail

- **Theoretical advantage over bending moment**
- **2 or 3-part fractures**
- **PHF with diaphysial extension**
- **Higher complication rate → 30% reoperation**
  - Shoulder pain
  - Screw back-out → 10-24%
  - Varus malunion → 8-37%
  - Fracture at entry → 18%



# New Designs

- **Straight nails**
- **Locking proximal screws**
- **Tuberosity oriented screws**
- **Oblique medial screws**
- **Tension band sutures**





# Percutaneous Pinnig

- **3 –part**
- **Valgus impacted 4-part**
- **Difficult technique**
- **Good bone quality**
  - Cortical thickness  $> 4\text{mm}$
  - No comminution at medial calcar or GT
- **Threaded pins**
- **Cannulated screws for tub.**





# Percutaneous Pinnig

- Pin migration
- Malunion
- Nerve injury





# Complex Fracture-Dislocations



**Anterior 3 or 4-part**



**Posterior 3 or 4-part**



# Treatment of anterior fracture-dislocations of the proximal humerus by open reduction and internal fixation

C. M. Robinson,  
L. A. K. Khan,  
M. A. Akhtar

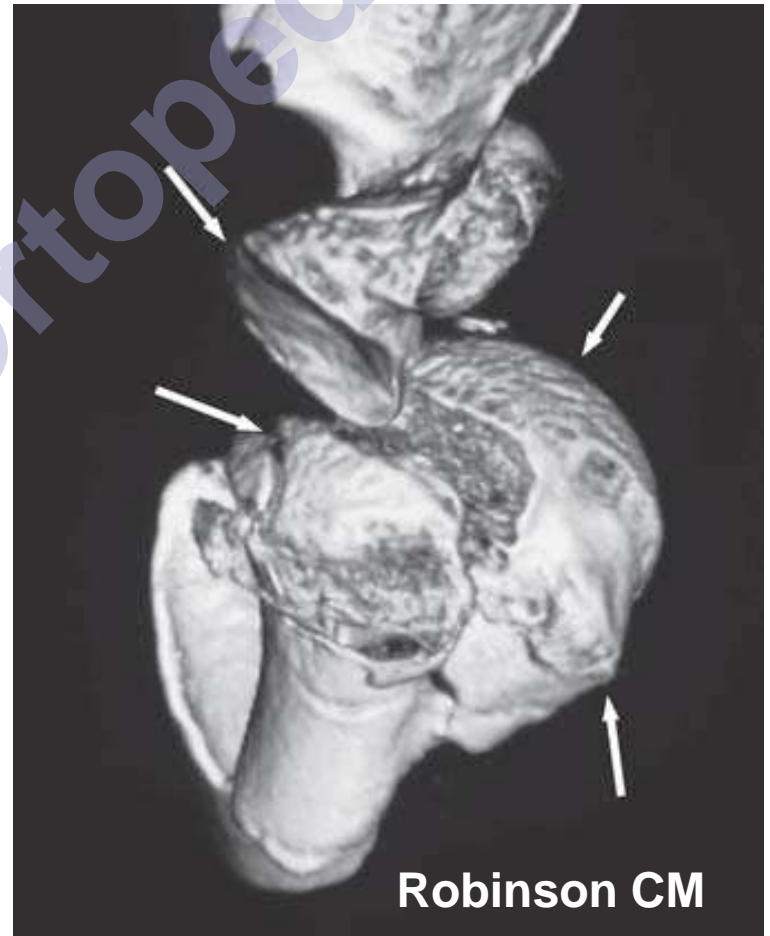
*J Bone Joint Surg Br. 88: 502- 8, 2006*

- **58 patients**
- **3 or 4-part fracture dislocations**
- **Type I**
  - > 2cm capsular attachment
  - Arterial back bleeding
- **Type II**
  - Significant capsular detachment
  - No arterial bleeding



# Type I Fracture-dislocation

- **Young males**
  - High energy trauma
- **Hill-Sachs lesion**
  - Propogated to humerus neck
- **Fracture after dislocation**
- **Caps. attachments around LT**
- **All treated with ORIF**
- **2 / 23 AVN**







# Type II Fracture-dislocation

- **Older females**
- **4-part valgus impaction**
  - Difficult to see in X-rays
- **Dislocation after fracture**
  - Anteroinferior capsular tear
  - No Bankart lesion
- **No Hill-Sachs lesion**
  - Head splitting
- **7 / 35 treated with ORIF**
  - 4 developed AVN



# Complex Posterior Fracture-Dislocation of the Shoulder

Epidemiology, Injury Patterns, and Results of Operative Treatment

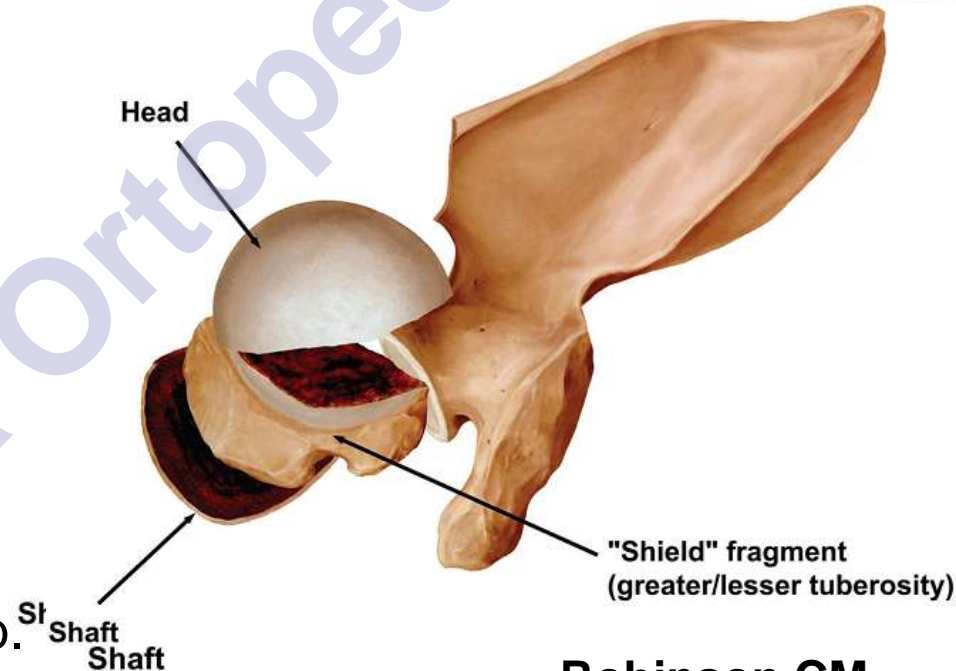
By C. Michael Robinson, BMedSci, FRCSEd(Orth), Adeel Akhtar, MRCSEd, Martin Mitchell, MRCSEd, and Cole Beavis, MD

- **26 patients**
- **Middle aged males**
- **Reverse Hill-Sachs lesion**
  - Propagated to anatomical neck
- **Reverse Bankart lesion**
  - Intact posterior capsule
  - Intact periosteal sleeve
- **All treated with ORIF**
- **1 / 27 AVN**



# Subtypes of Post. Fx-disloc.

- **Type I**
  - 2-part anatomical neck
- **Type II**
  - Anatomical neck and LT
- **Type III**
  - Anatomical neck and both tub.
  - Composite “shield” fragment



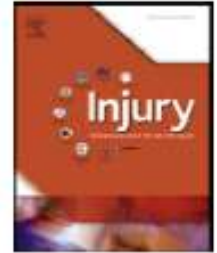
**Robinson CM**



Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: [www.elsevier.com/locate/injury](http://www.elsevier.com/locate/injury)



## Four-part fracture dislocations of the proximal humerus in young adults: Results of fixation

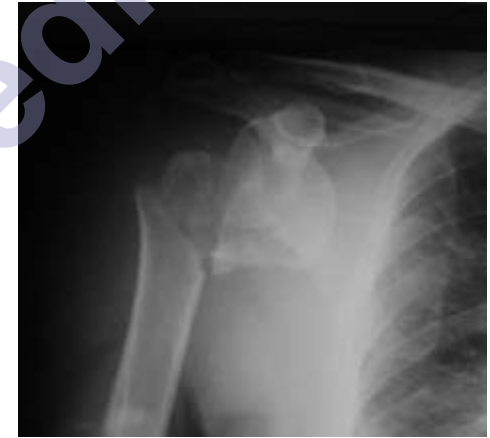
Omar A. Soliman, Wael M.T. Koptan \*

- **39 patients < 40 years**
  - 18 anterior, 21 posterior dislocations
- **3 nonunion**
- **8 AVN**
- **Anatomical neck fracture has worse prognosis**



# Hemiarthroplasty in Young Patients

- **Head splitting fractures**
- **Impression fractures > 40%**
- **4-part fractures**
  - Loss of medial hinge
  - Type II anterior fracture dislocations
- **Prognostic factors**
  - Reduction of GT
  - Height
  - Retroversion
- **Trend → reverse prosthesis**





# PHF in Young Patients

- **Evaluation of humeral head viability**
  - > 8 mm medial calcar fragment
  - Intact medial hinge
- **Chance of revascularization**
- **Anatomical reduction**
  - Greater tuberosity
  - Varus displacement
- **Stable fixation**



# PHF in Young Patients

- **Locked plates are primary option**
- **Minimally invasive techniques**
- **Medial calcar support**
  - Inferomedial oblique screw
  - Strut allografts
- **Fracture-dislocations**
  - Intact capsular attachments → Internal fixation
  - Case based decision