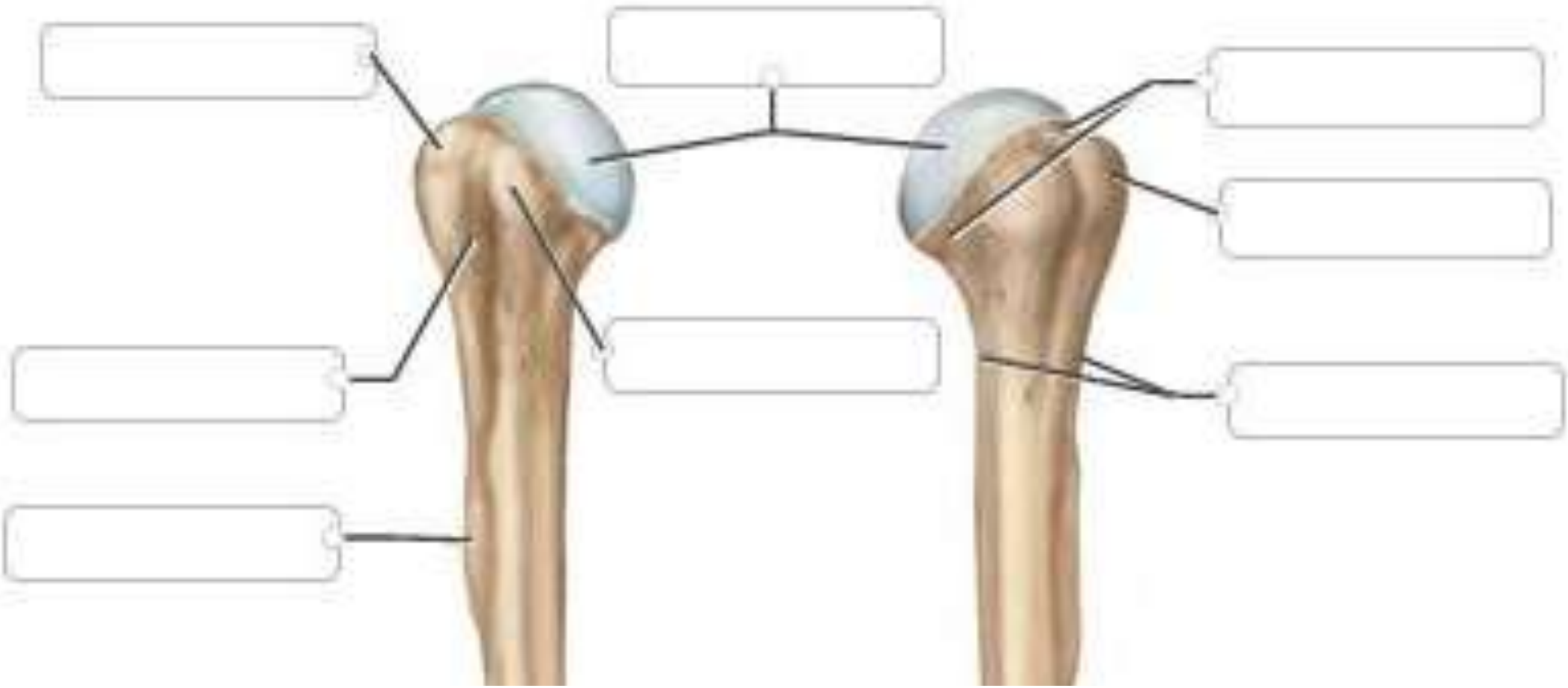
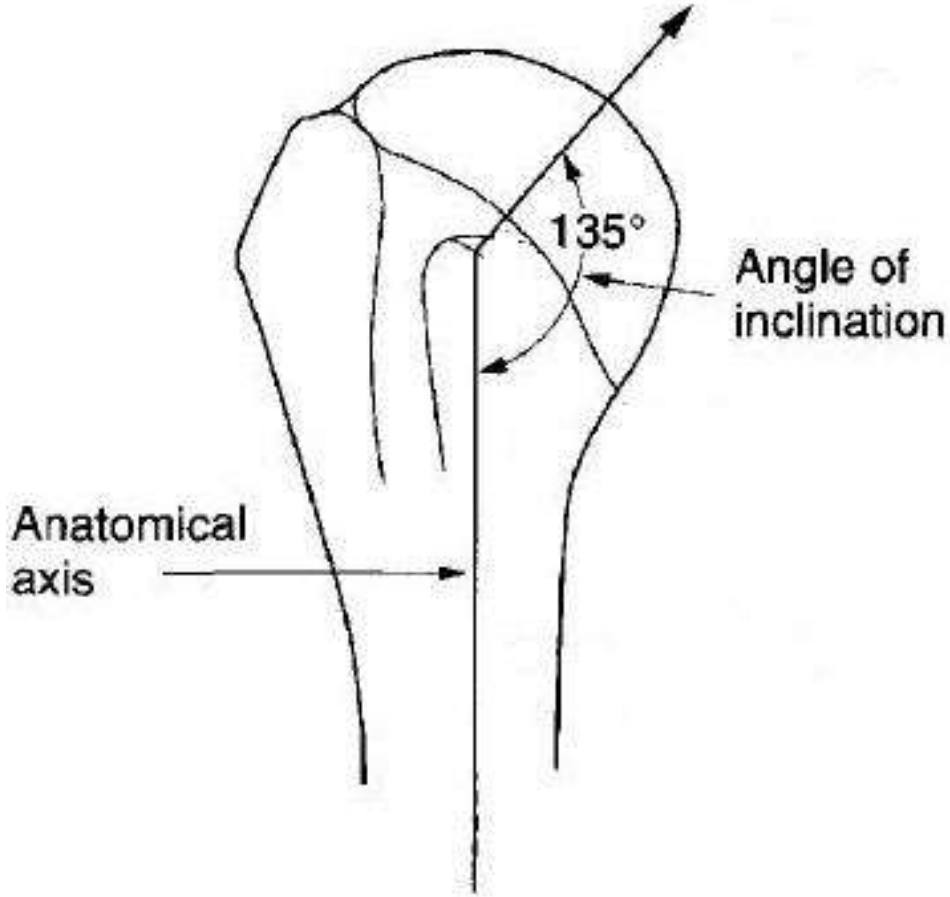
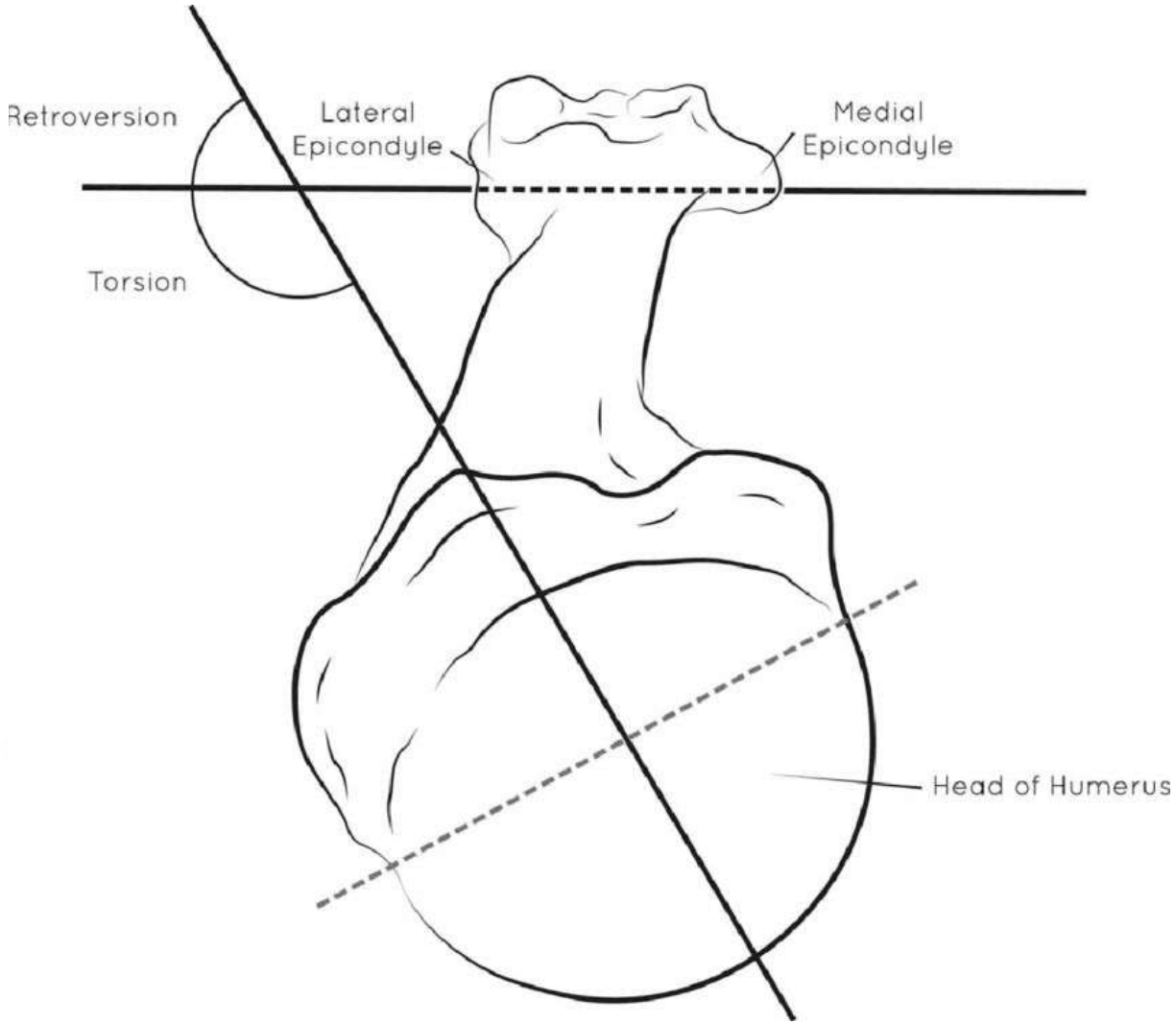
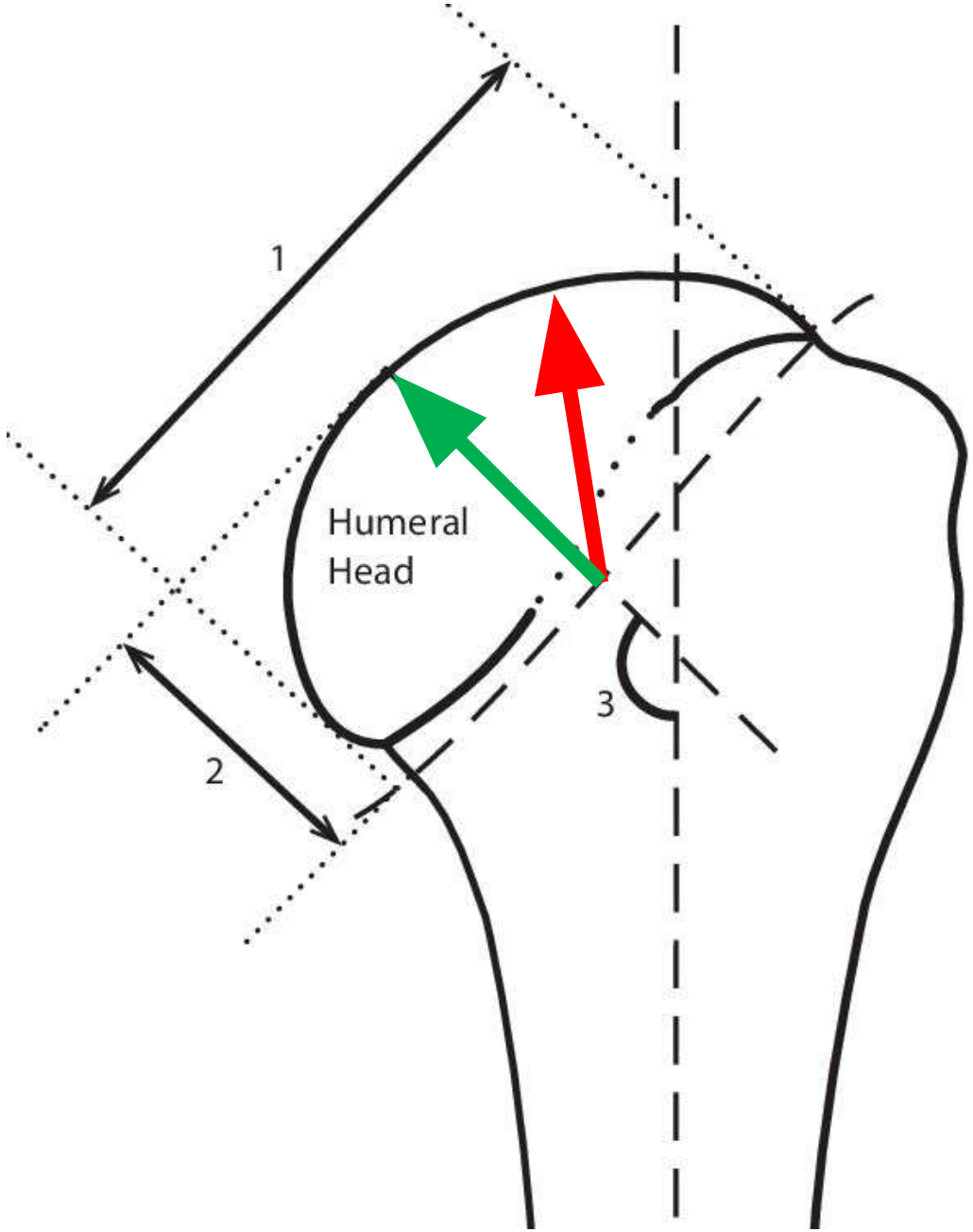
Proximal Humerus Fracture

By Dr Daivik T Shetty







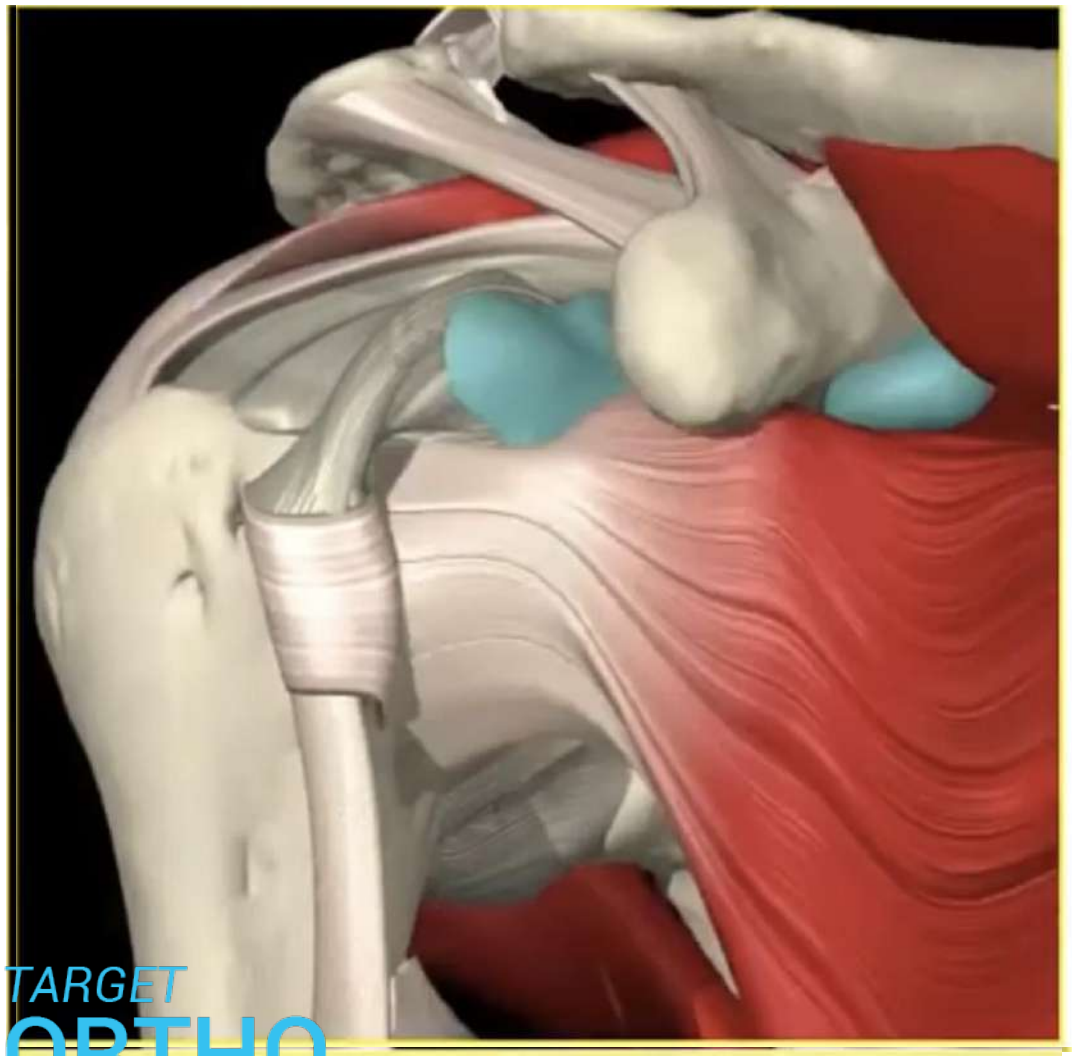


Radius of curvature of Humeral head = 25mm

Range = 23-29mm

Humeral head Height = 3/4th radius of curvature

18mm



Muscle Attachments

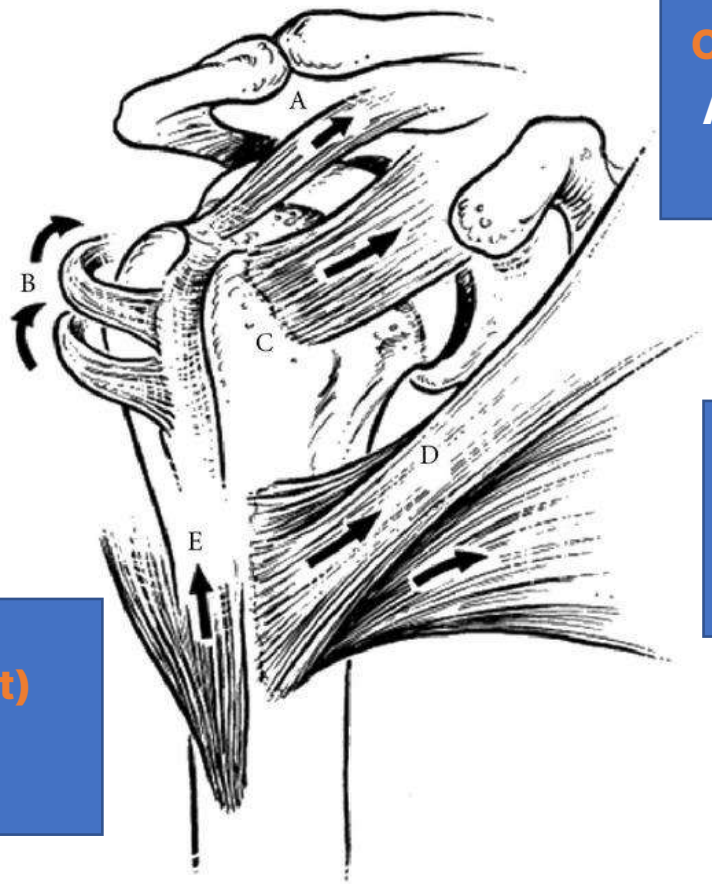
- Rotator cuff muscles
- Deltoid
- Pectoralis Major

A) Supraspinatus , (GT)

Posterior, superior, medial

B) Infraspinatus and Teres minor (GT)

Posterior, superior, medial and external rotated



C)Subscapularis (LT)

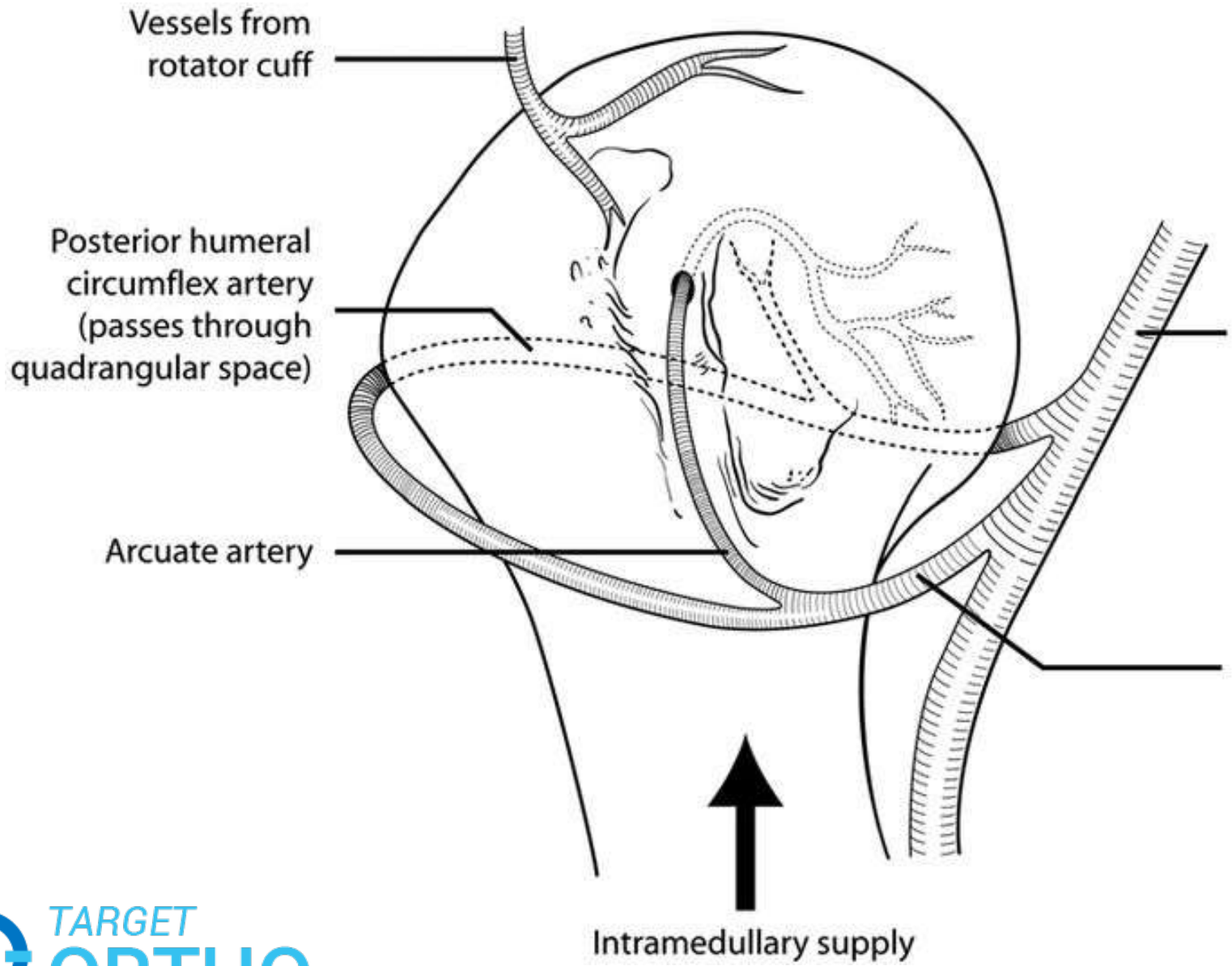
Anterior, Medial and internal rotated

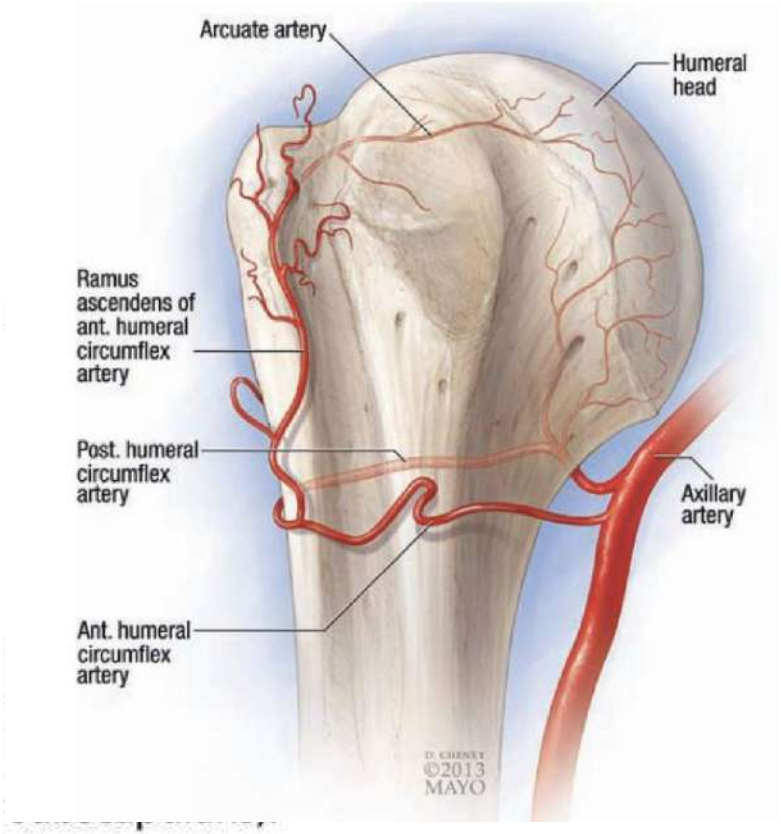
D) Pectoralis Major (Shaft)

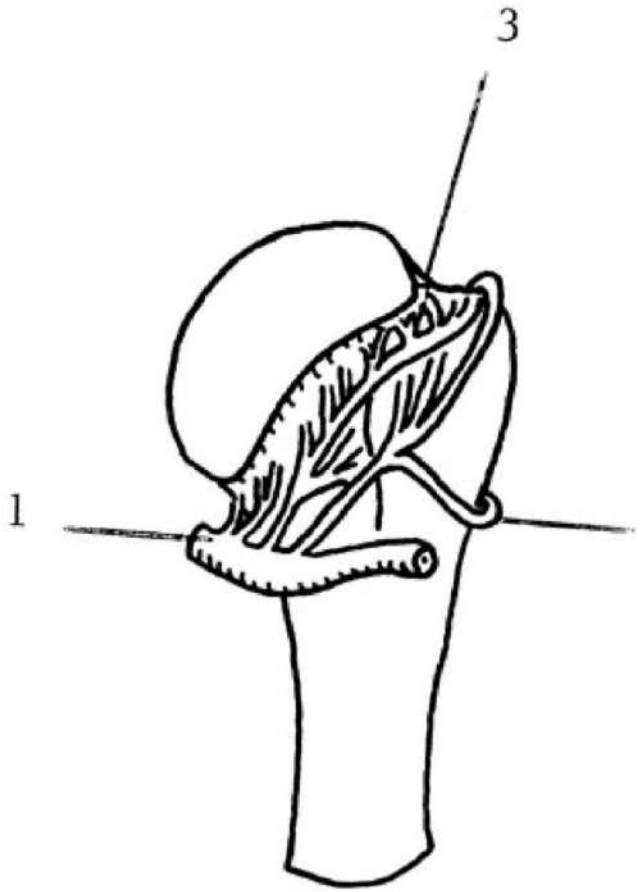
Internally rotates and adducts

E) Deltoid (Shaft)

Superior



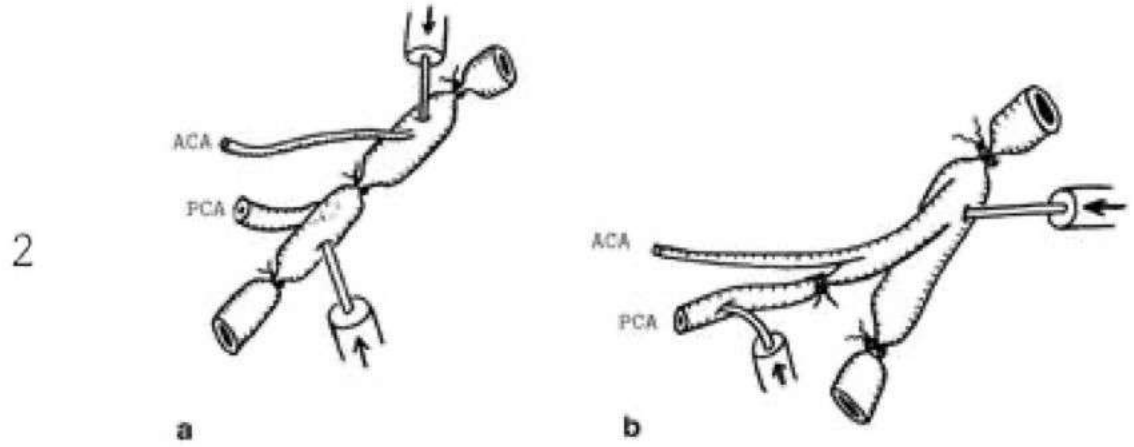




Arterial blood supply of the proximal humeral epiphysis

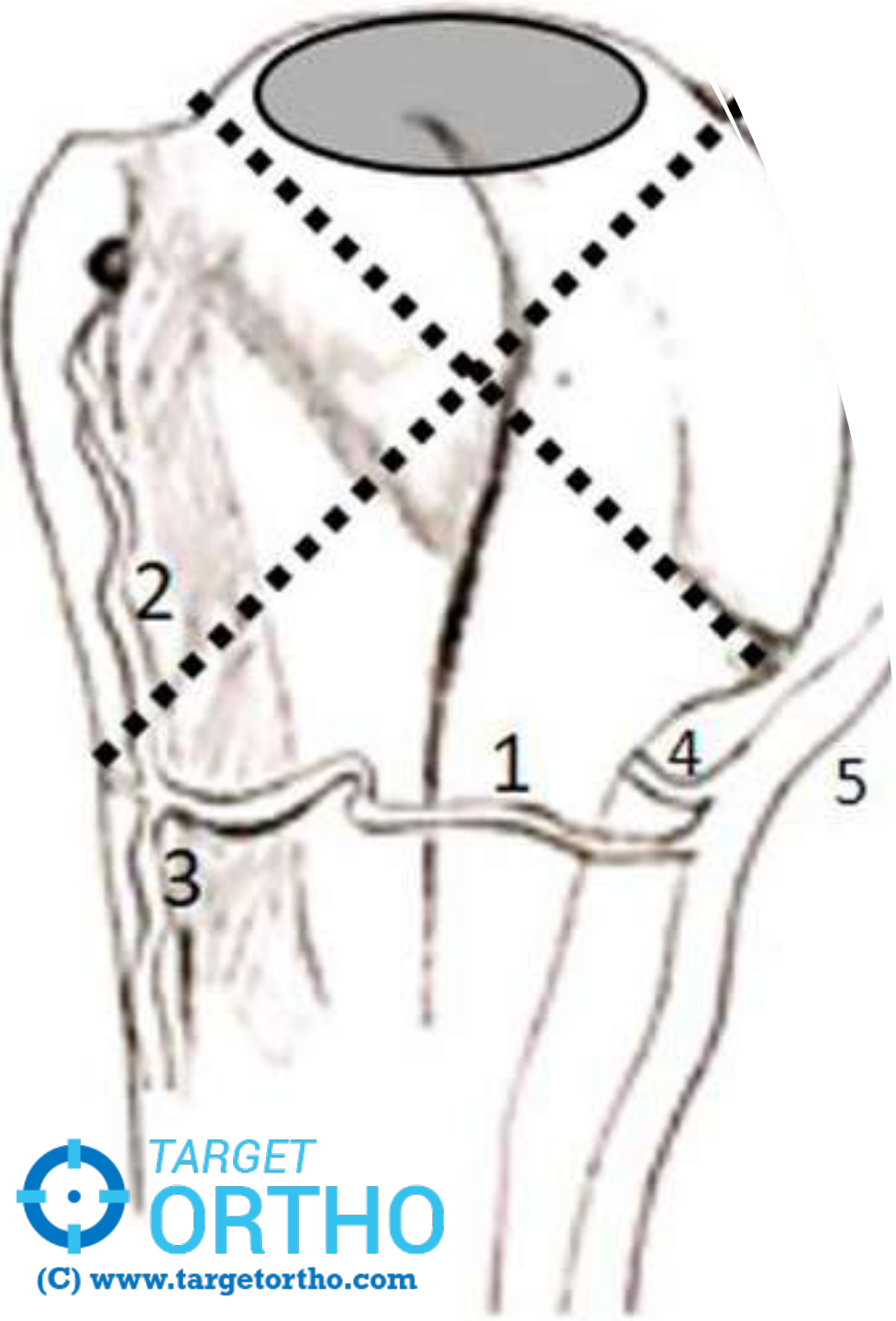
F. Duparc, J.-M. Muller and P. Fréger

Laboratoire d'Anatomie, Faculté de Médecine-Pharmacie de Haute-Normandie, 22, Boulevard Gambetta, F-76183 Rouen Cedex, France



Injected a series of blood vessels with barium sulphate solution and confirmed that the vascularization of the humeral head is attributed to the branches of the arcuate artery.

Old fact : Arcuate artery (ACHA) supplies majority of the humeral head

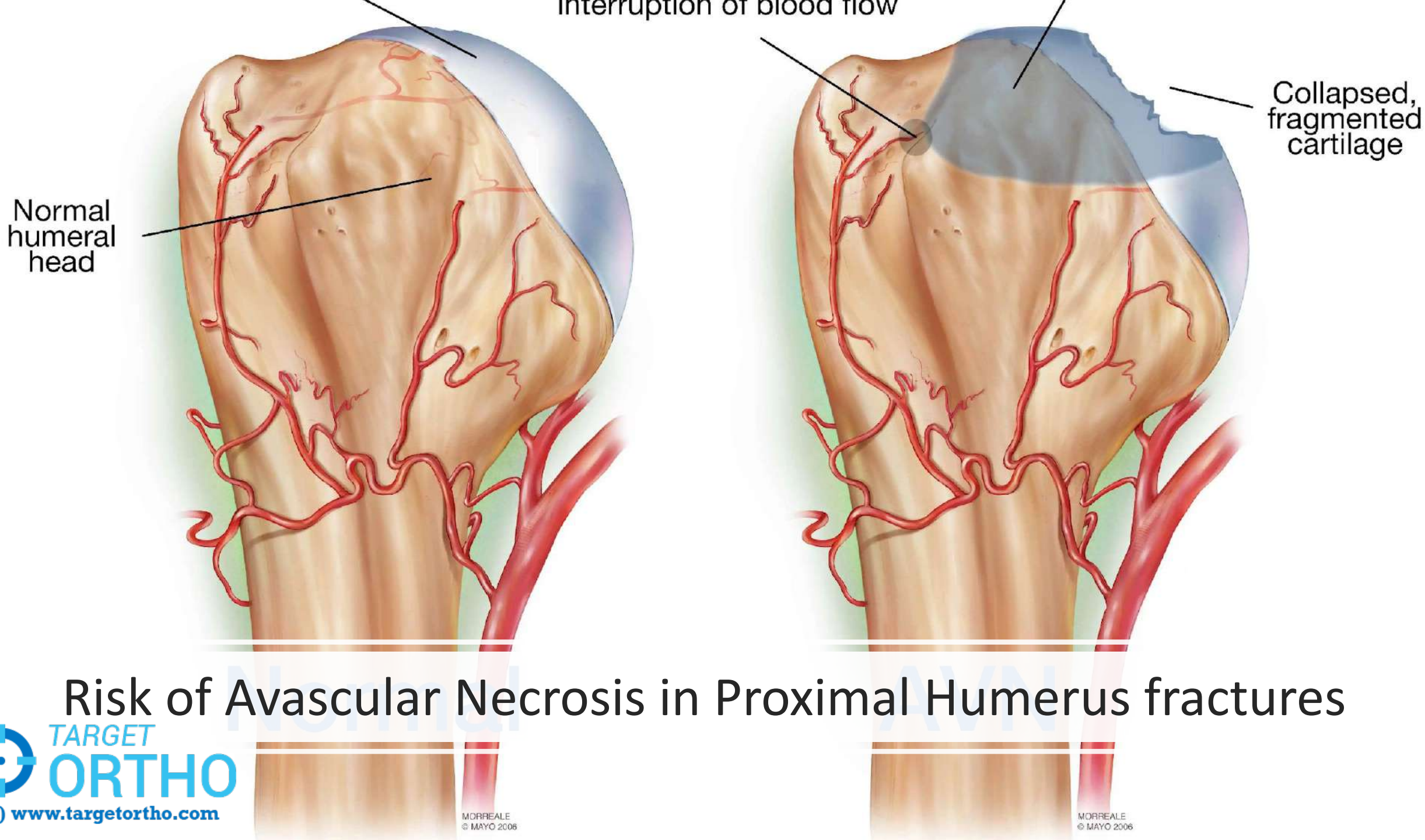


Current Consensus

PHCA supplies 64% of the Humeral Head (Superior, Lateral and Inferior)

Hettrich et al

Keough et al



Risk of Avascular Necrosis in Proximal Humerus fractures

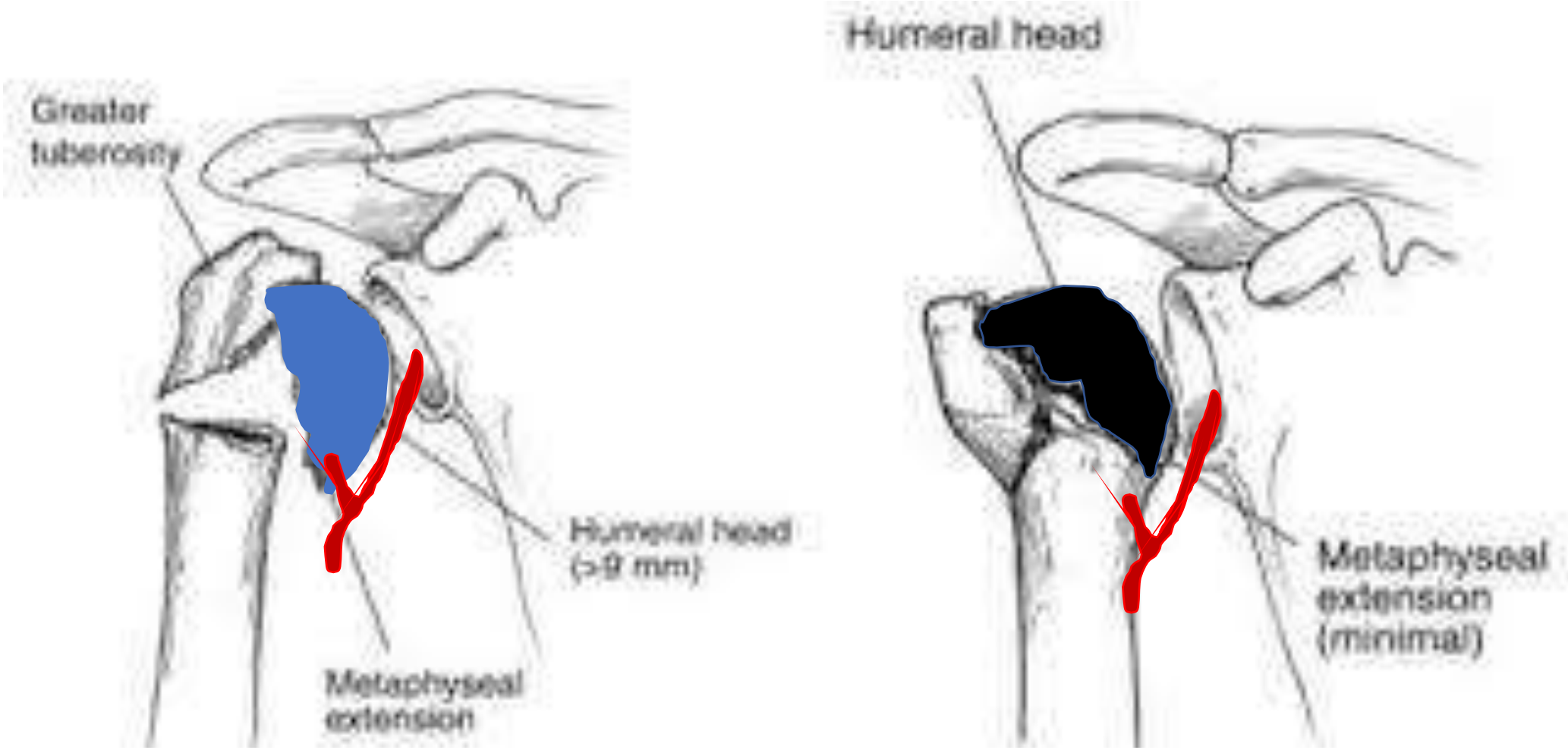
Risk of AVN

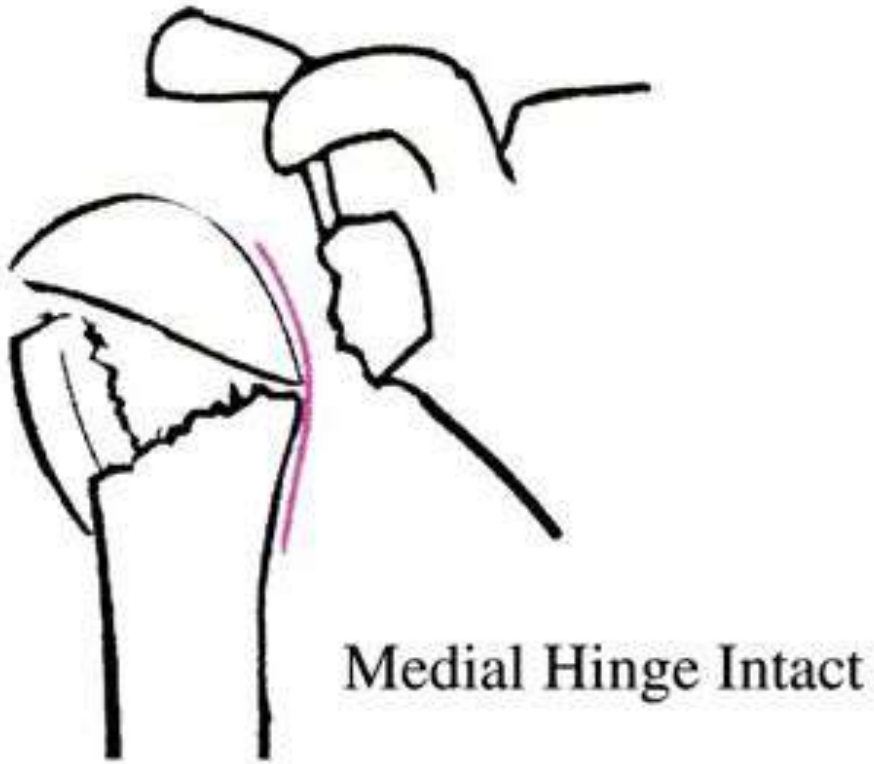
- Varus displacement of head
- Metaphyseal fracture extension of humeral head
- Medial displacement of humeral shaft in relation to humeral head

Hertel's criteria

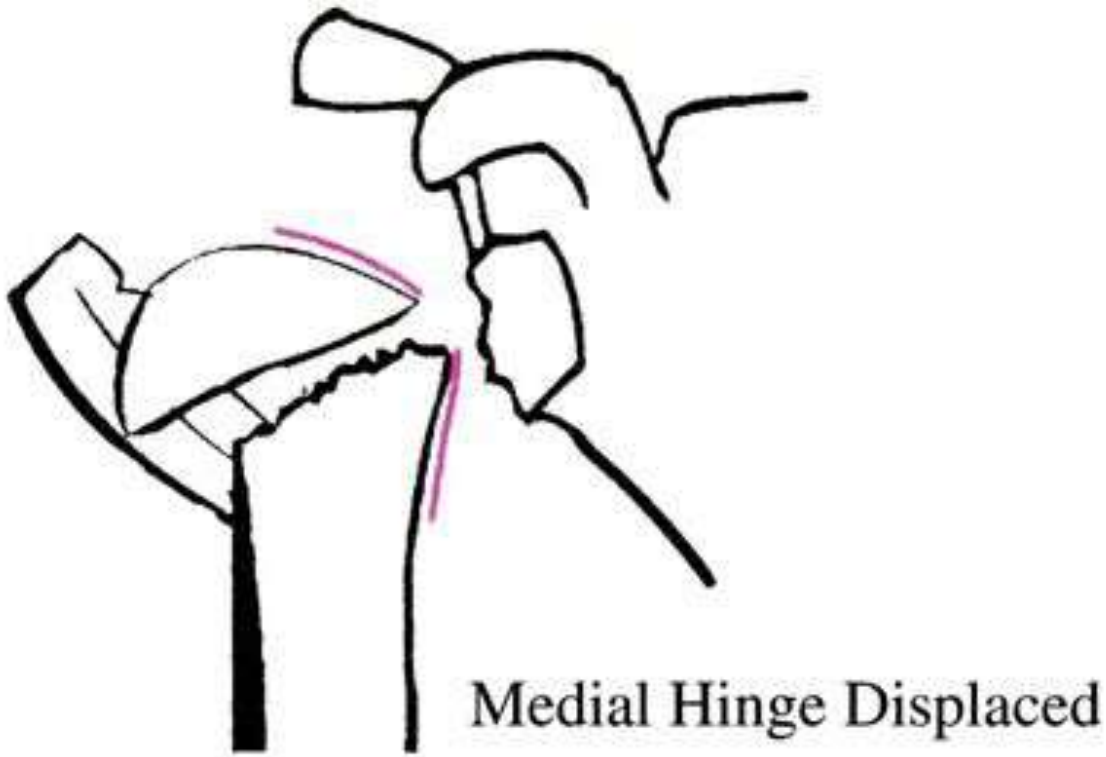
- Metaphyseal extension (with calcar) <8mm
- Loss of integrity of medial hinge (> 2mm)
- Fracture pattern - anatomical neck
- Comminution of medial metaphysis

97% Positive Predictive Value





Medial Hinge Intact



Medial Hinge Displaced

> 2mm displacement

Hertel's criteria

Recently called into question

Original study used intraoperative doppler flowmetry as well as visual bleeding from drill holes in the humeral head to determine vascular supply

A lack of return of bleeding from drill holes was associated with AVN

Campochiaro et al 2015

Series of patients assessed for AVN after proximal humerus fx

Hertel's criteria were less predictive of AVN, whereas poor reduction was highly predictive.

Proximal Humerus fracture

Epidemiology

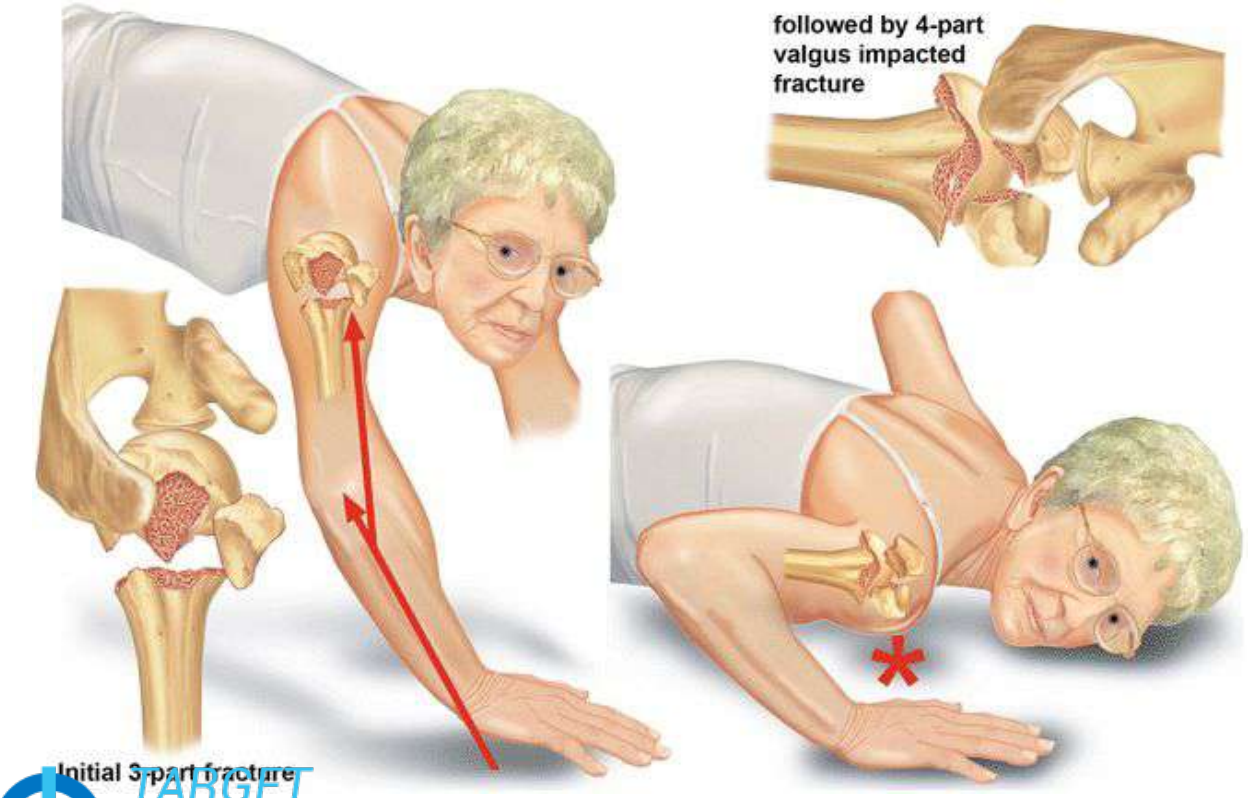
- Females > Males
- Bimodal distribution – young males, older females
- Incidence increases with age

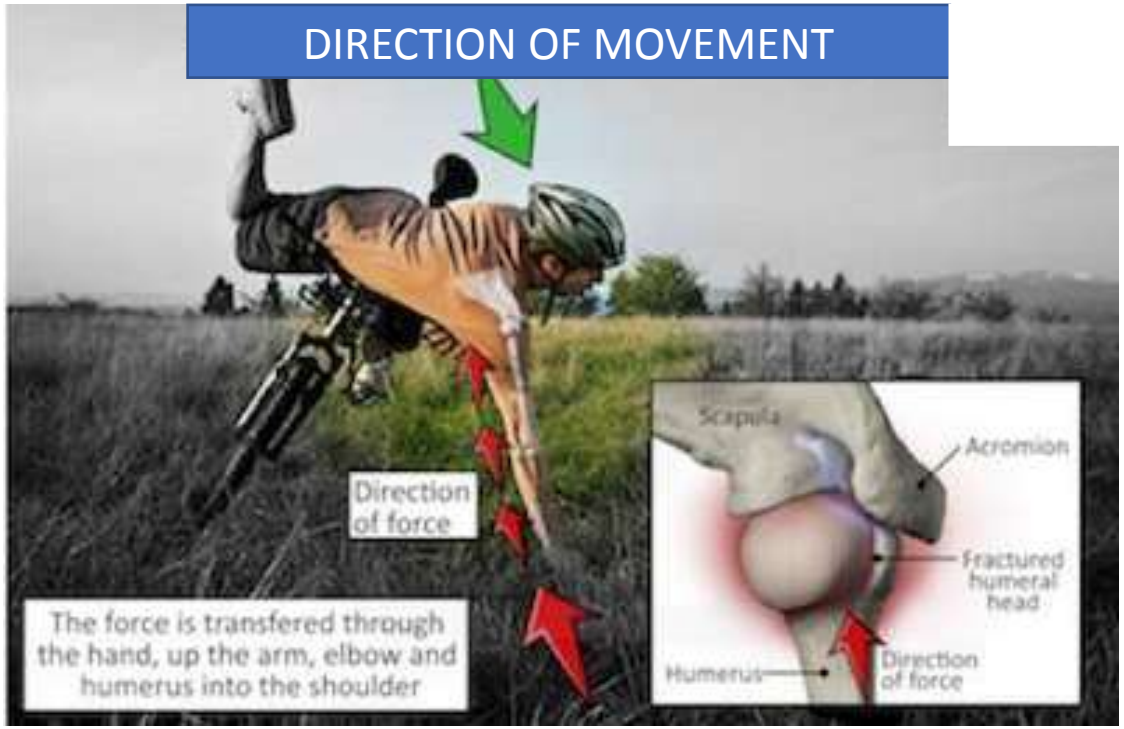
As population ages the incidence of proximal humerus fractures is expected to increase

- Osteoporosis related fracture

- 3rd most common nonvertebral osteoporotic fracture

Mechanism of Injury





Proximal Humerus
3 main leading modes

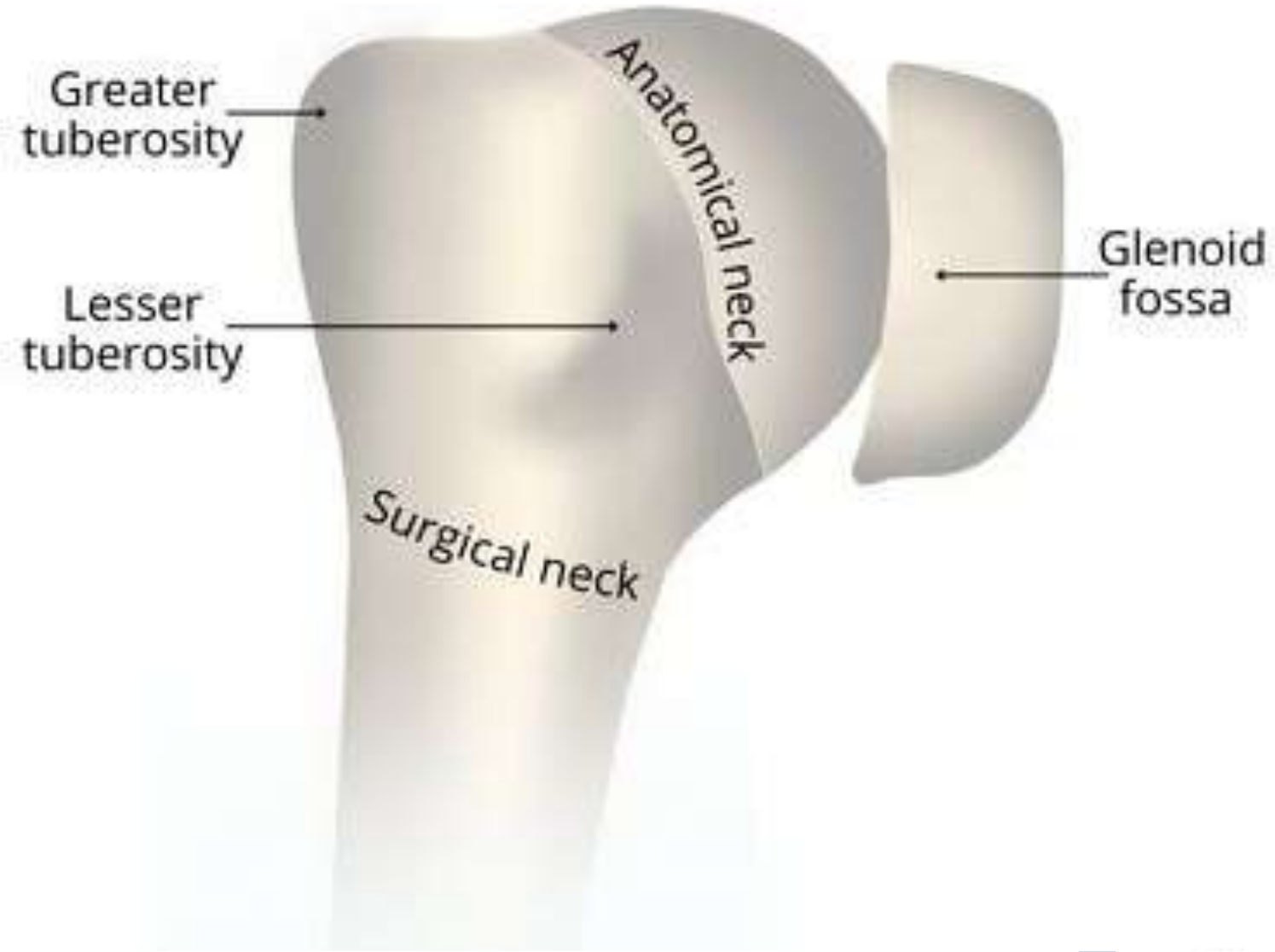
Compressive loading of Glenoid onto humeral head

Bending forces of surgical neck

Tension forces of rotator cuff of GT, LT

Associated Injuries

- Distal radius fracture
- Proximal femur fracture
- Humeral shaft comminution
- Glenoid rim fracture and avulsion fracture of coracoid

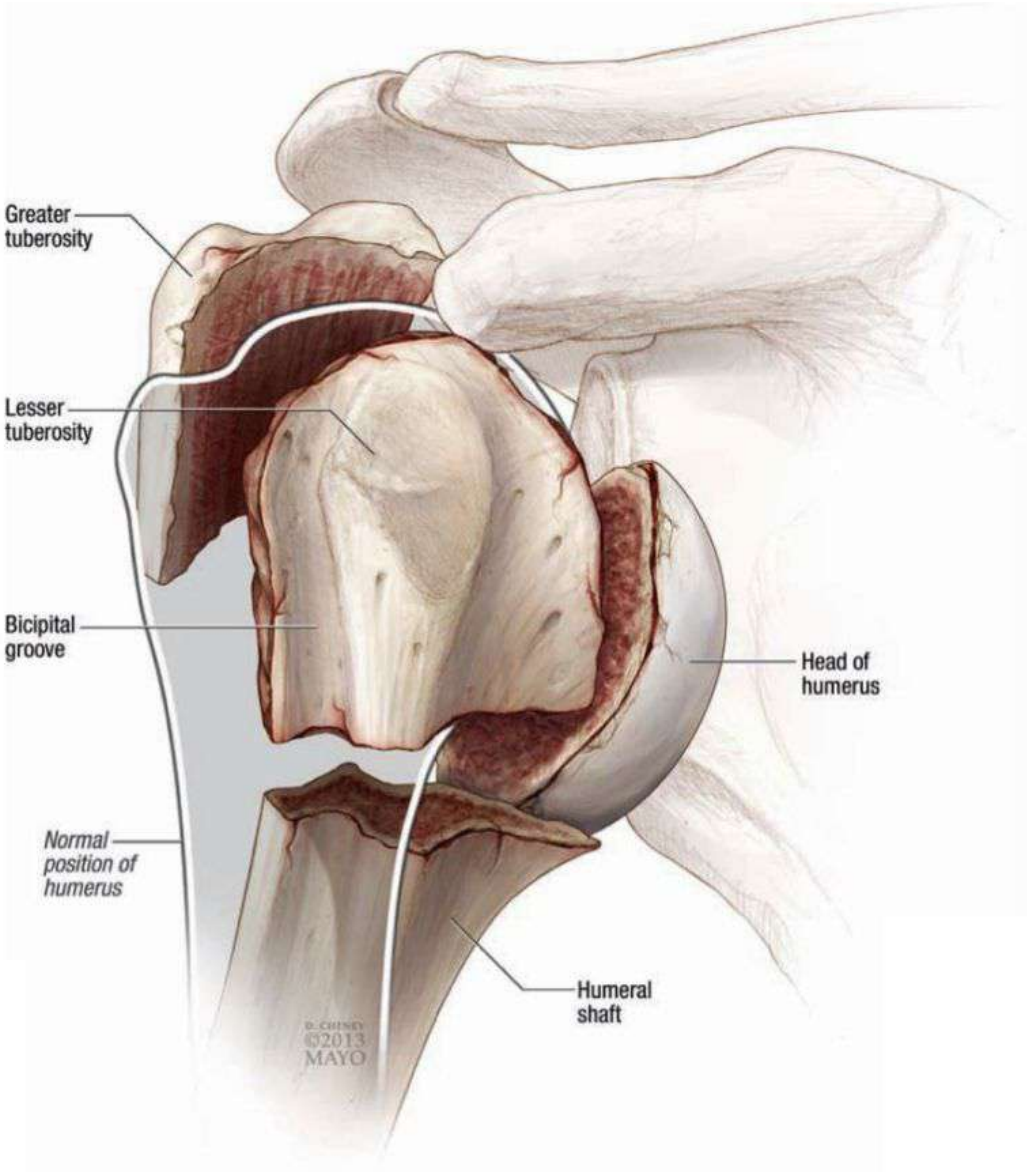


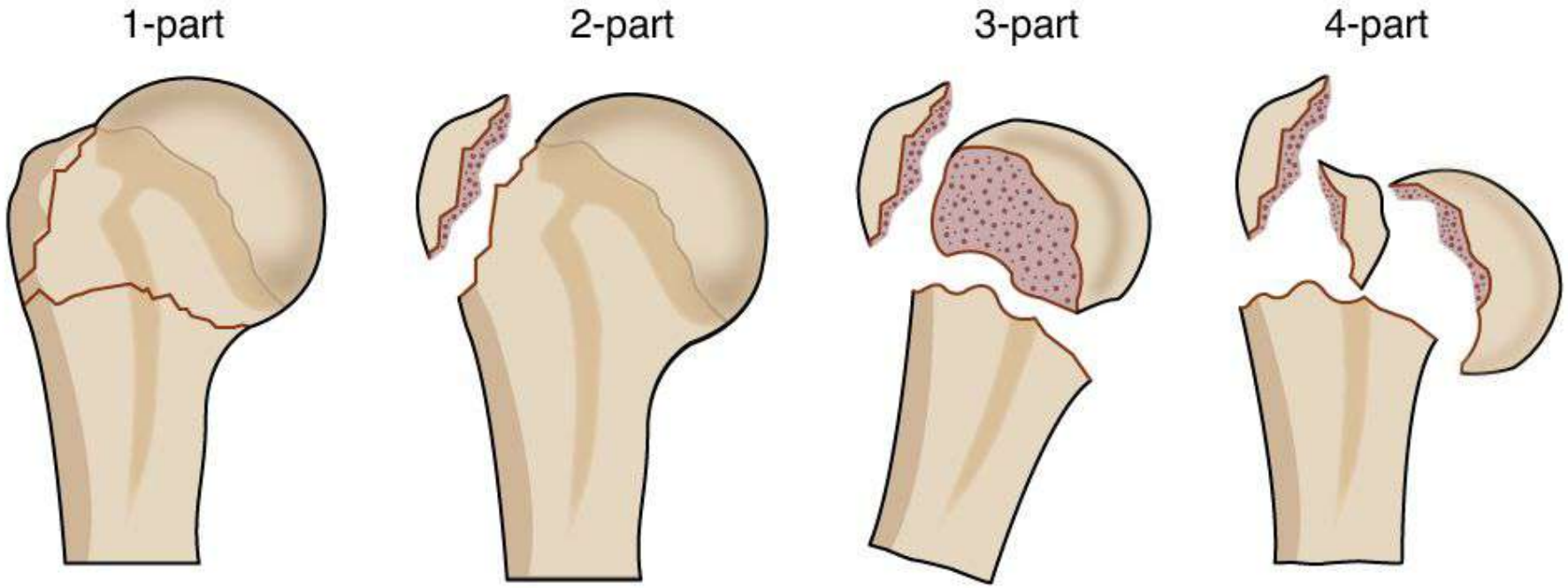
Classification

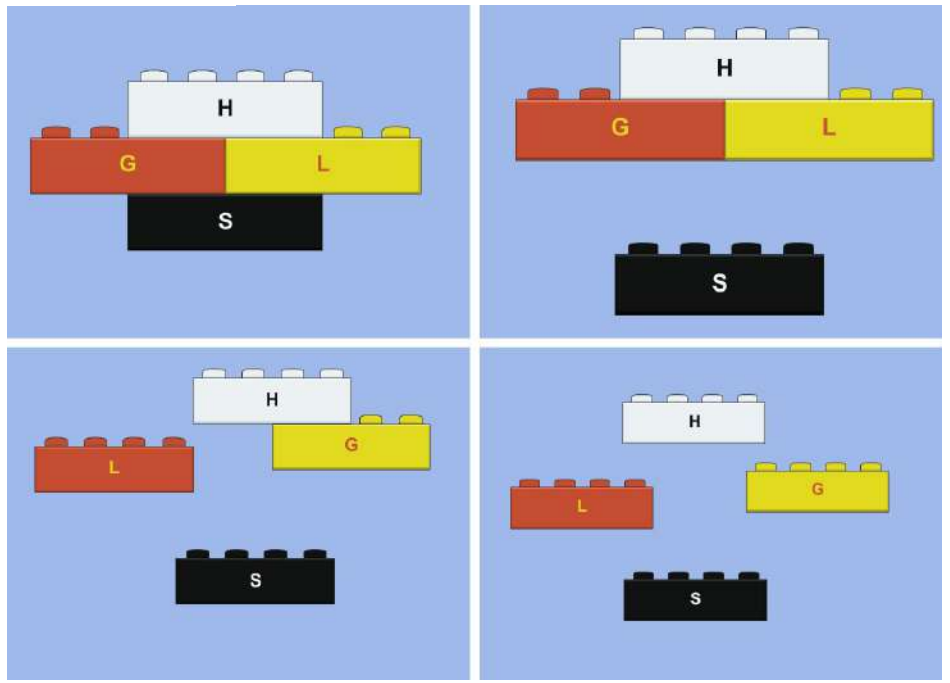
- **Codman** stated that fracture line of Proximal Humerus has 4 major fragments

- Humeral head
- Greater tuberosity
- Lesser tuberosity
- Humeral shaft proximal to insertion of pectoralis major tendon

NEER CLASSIFICATION







One Part

Fracture fragment is considered displaced if the segment is

- Translated by at least 1cm
- Angulated by minimum of 45 degrees

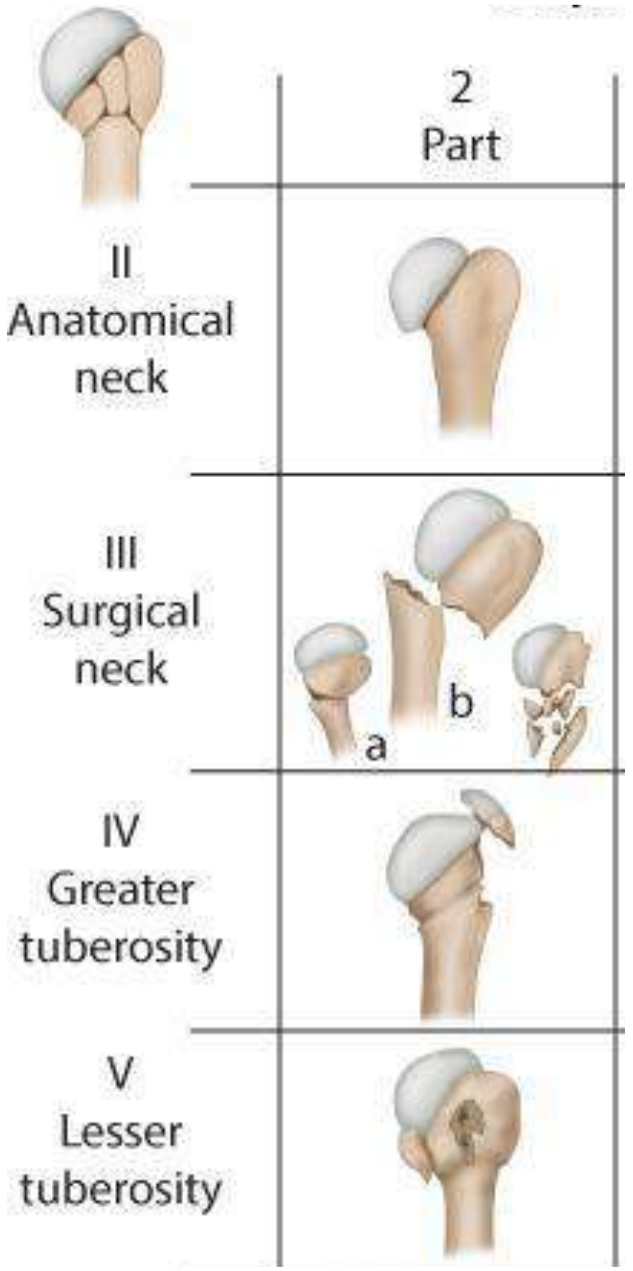
2-part fracture

Two-part GT

Two-part LT

Two-part Surgical neck

Two-part anatomical neck



3-part fracture

- Surgical neck + Greater trochanter = head segment is internally rotated by action of subscapularis

- Surgical neck + Lesser trochanter = head segment is externally rotated by supra and infraspinatus

3–part

4–part

GT+SN

Fracture Dislocation Proximal Humerus

Head split fracture – Articular surface fracture

AO/OTA classification

- Bone=1
- Segment = 1
- Pattern

A=Extraarticular unifocal

B=Extraarticular bifocal

C = Intraarticular

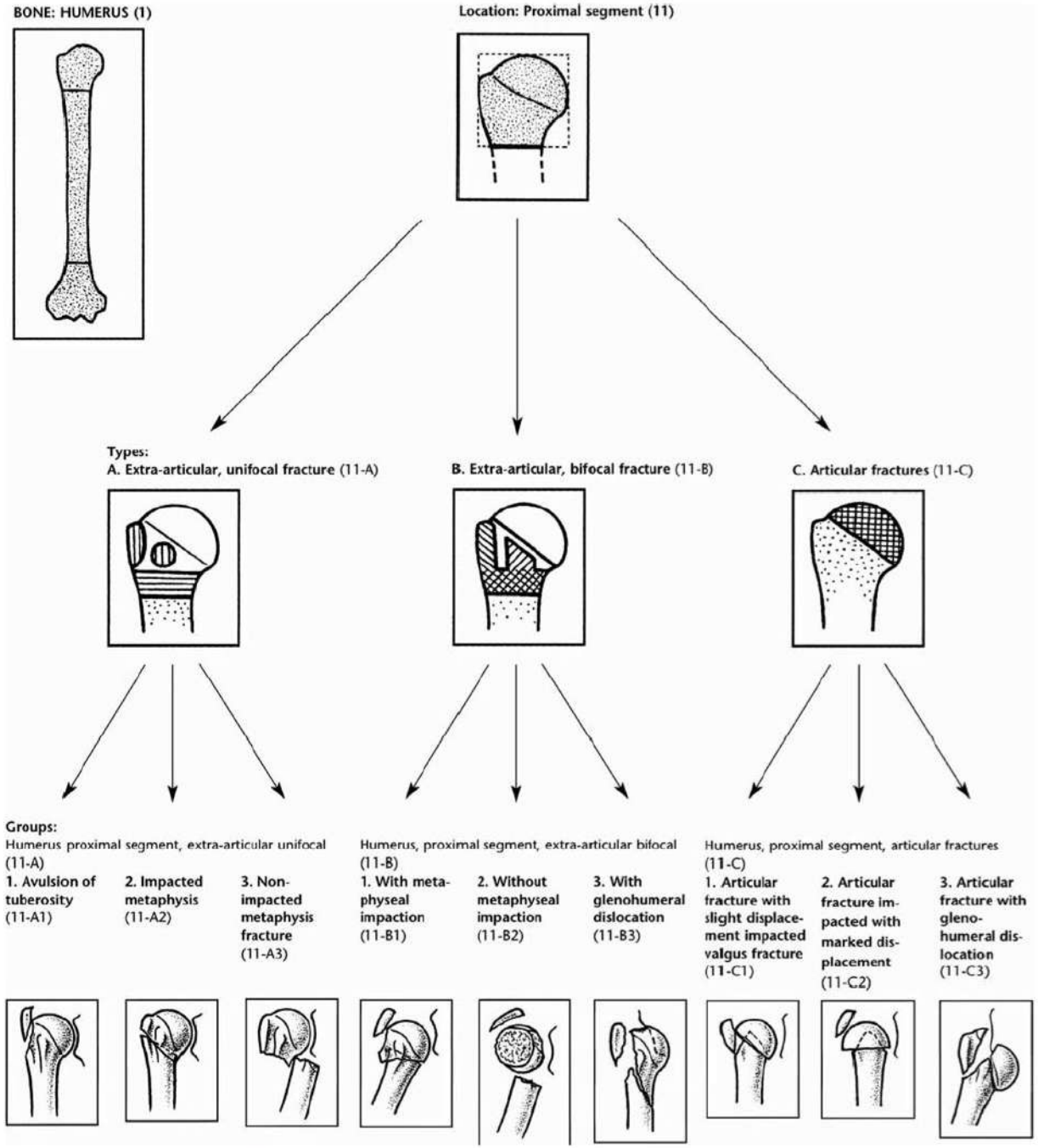


FIGURE 37-15 AO/OTA classification for proximal humerus fractures.[257,280]

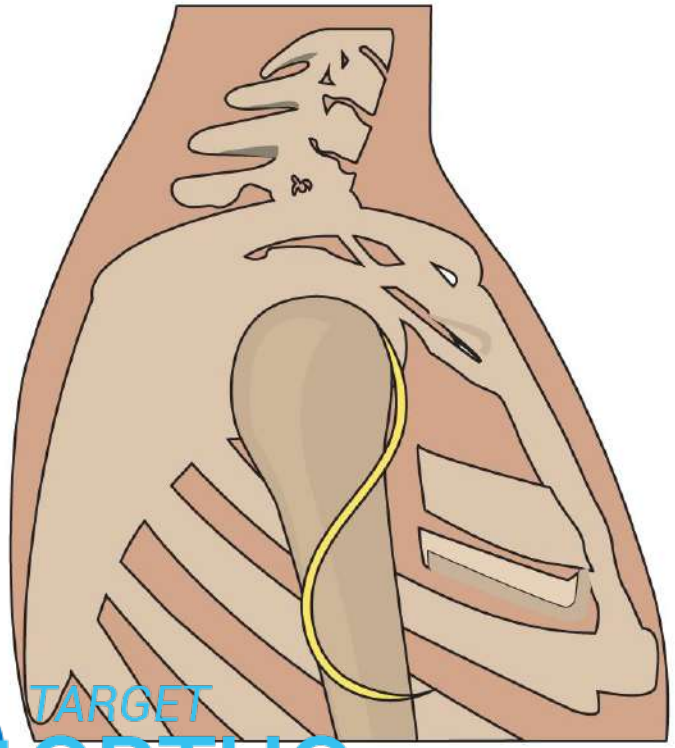
Clinical Presentation

- Shoulder pain worse with motion
- Immobility
- Ecchymosis
- Soft tissue swelling
- Open fractures may occur in axilla but are rare
- Usually occur at lateral aspect of axilla as pec major displaces shaft medially

“ Shoulder Terrible Triad Injury “

A	B	C
Abductor injury	Brachial plexus injury	Anterior glenoid injury
1. Rotator Cuff	1. Distal nerves	1. Capsulolabral
2. Greater tuberosity	2. Shoulder nerves	2. Bony Bankart

Nerve Injury



Motor -

Deltoid
Teres Minor

Sensory -

Vascular Injury

Axillary artery injury is RARE

Occurs due to

- Traumatic dissection due to kinking because of direct trauma by medially displaced shaft

- Avulsion of one of the circumflex arteries

Vascular Injury

Assess Radial pulse and Capillary filling of fingers – compare with contralateral side

Rich collateral circulation

Weak Asymmetric pulse - further investigation

X-Ray

- **Shoulder Trauma Series**

Shoulder AP View?

GRASHEY VIEW

30-40 DEGREE TILT

- To prevent glenoid and humeral head overlap
- Perpendicular to plane of scapula

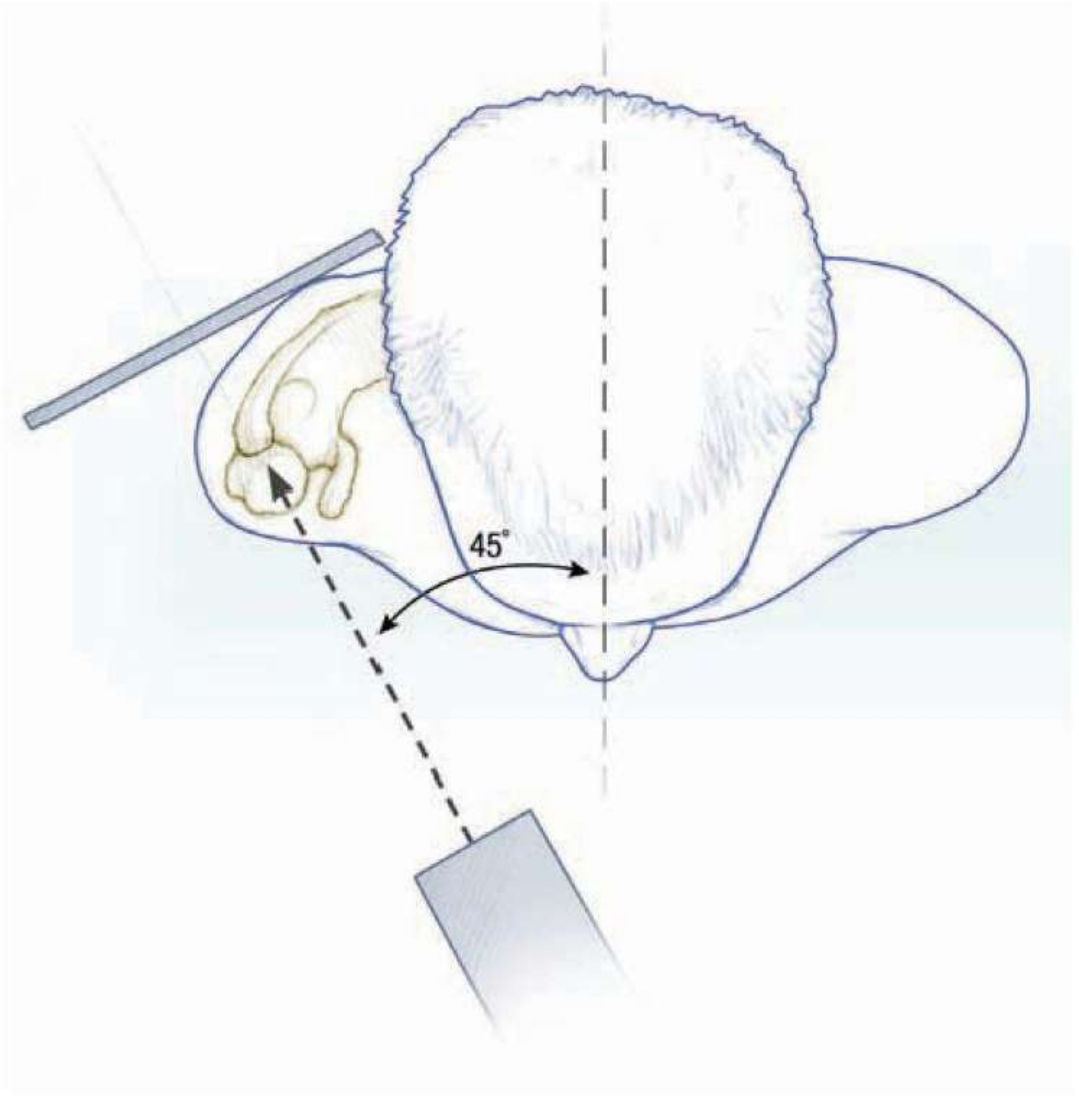
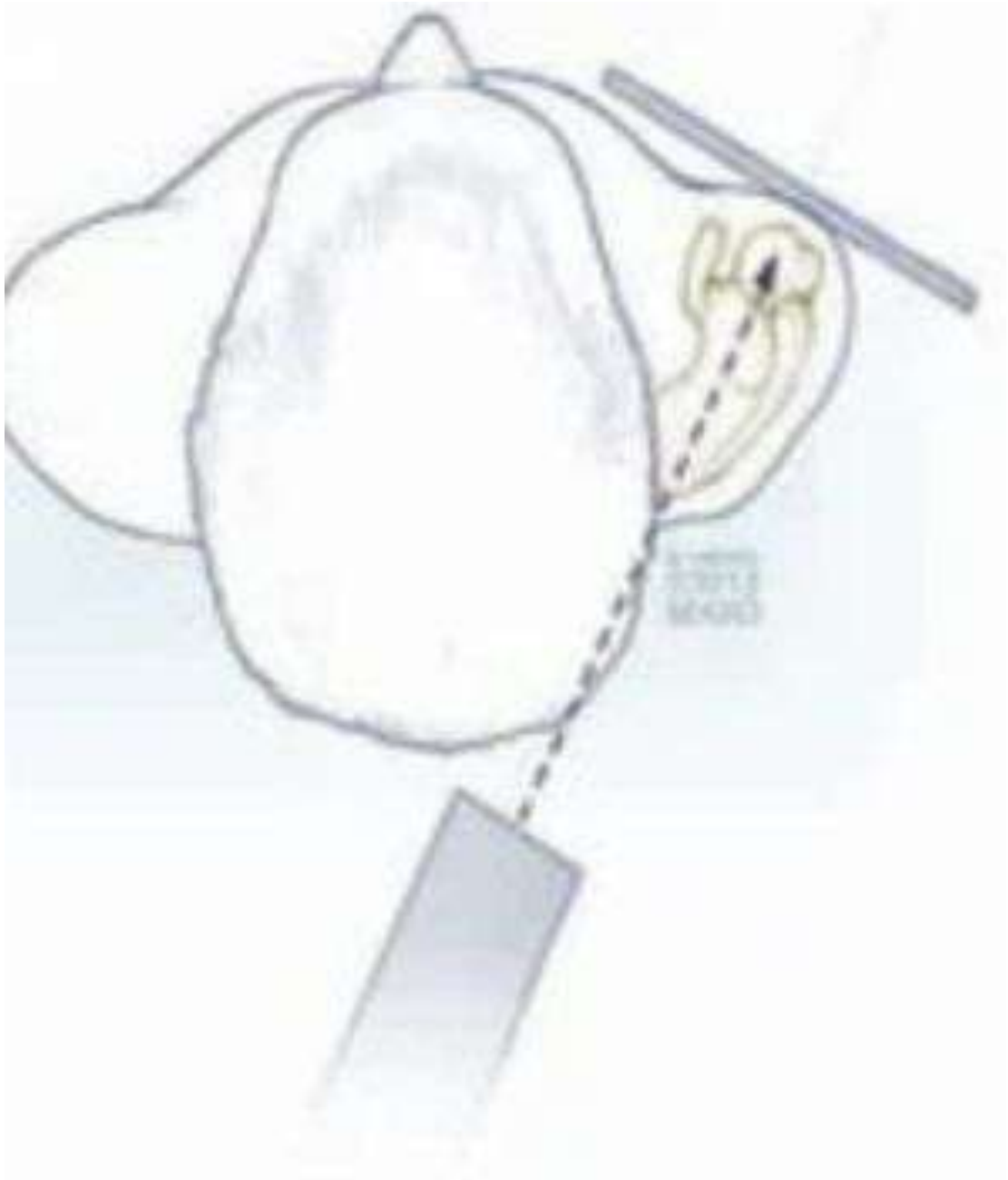


FIGURE 37-6 AP Grashey view of the shoulder. The patient's torso is rotated 30–45 degrees bringing the side opposite to the injured shoulder forward. The x-ray beam is thereby aimed perpendicular to the plane of the scapula, imaging the glenoid in profile and avoiding overlap between the glenoid and the humeral head.



NEER SCAPULAR Y VIEW

- Perpendicular to Grashey view

C

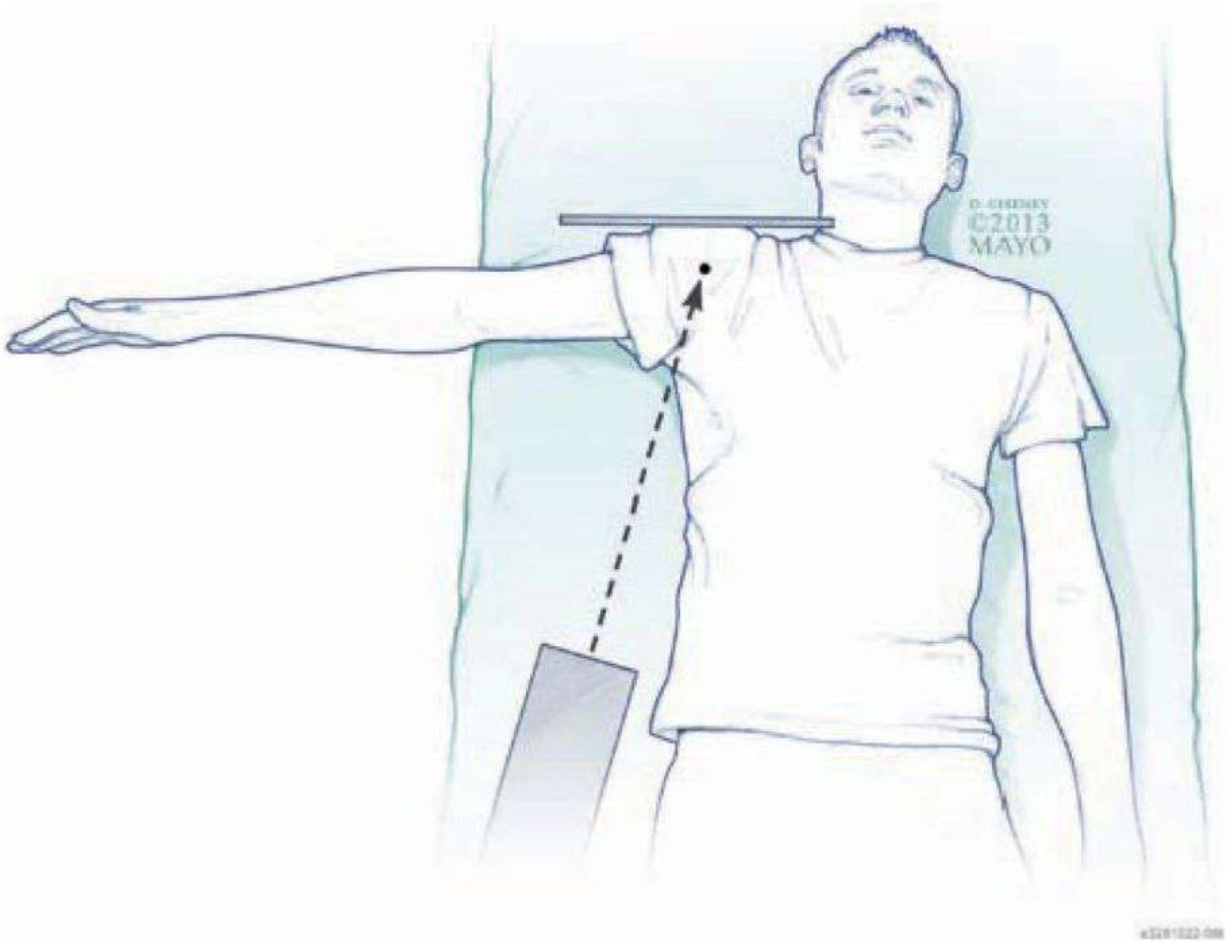


FIGURE 37-8 Axillary view of the shoulder. The arm is abducted as much as possible, with the patient supine and the x-ray beam projected from the axilla onto the cassette located on top of the shoulder.

Velpeau Axillary View

Upper limb in sling

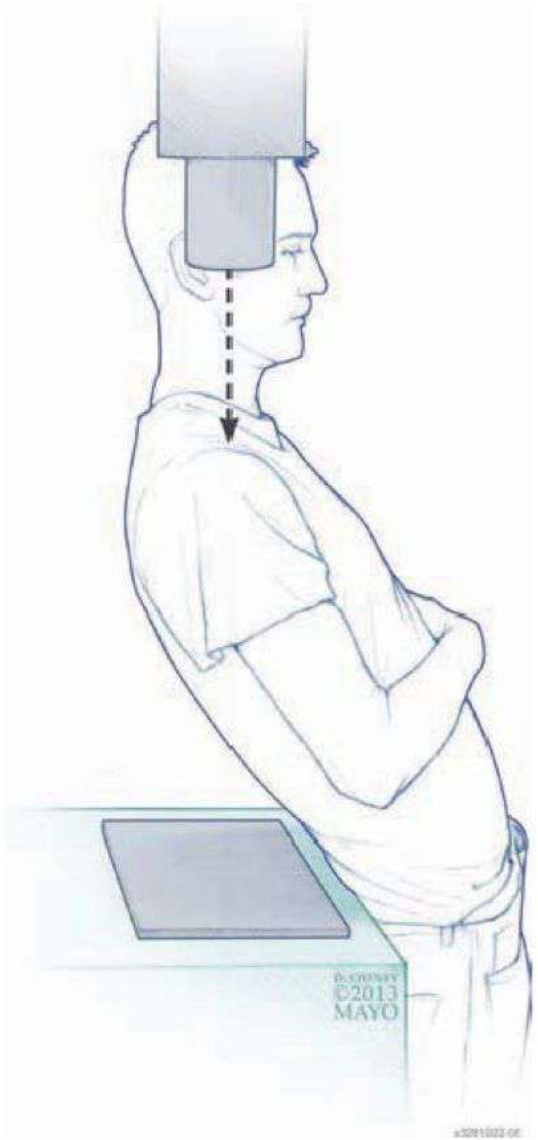
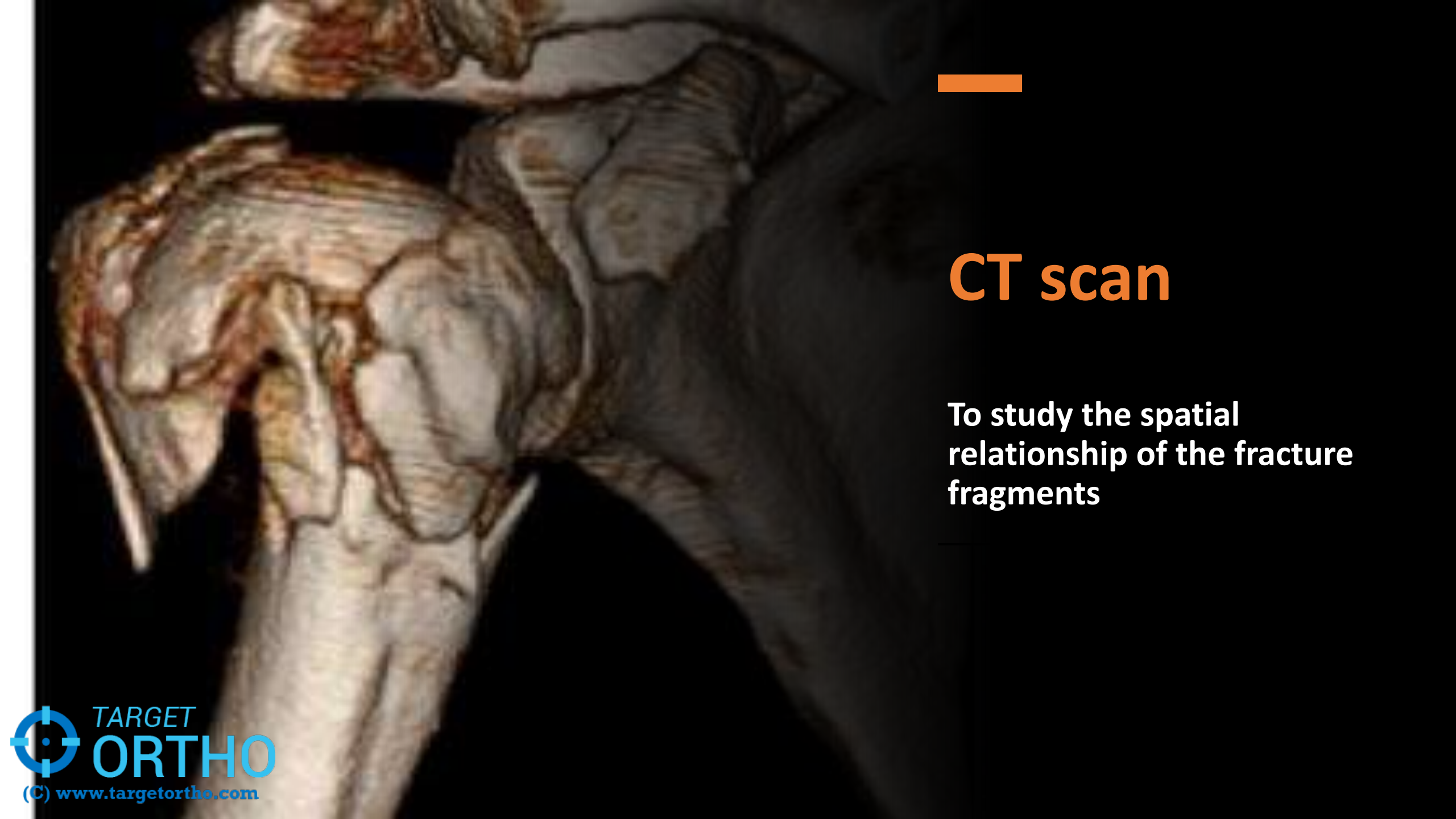


FIGURE 37-9 Velpeau axillary view of the shoulder. The x-ray beam is projected down perpendicularly onto a cassette. The patient is asked to lean back, to place the shoulder between the x-ray source and the cassette. This can be done with the upper extremity in a sling.



CT scan

To study the spatial relationship of the fracture fragments

CT scan – 3D Reconstruction

- Coronal and Sagittal view

  - Alignment of humeral head
  - Comminution of calcar
  - Inferomedial hinge integrity
  - Metaphyseal extension
  - Osteopenia
  - Flexion / extension of fracture fragments
  - Head split fractures

MRI scans

- Confirms nondisplaced fractures
- Glenoid labrum
- Rotator cuff tear
- Glenoid rim fracture

Gadolinium enhanced – Humeral head perfusion

Treatment

Non operative

Operative

Non operative treatment

Undisplaced fractures – Stable fracture

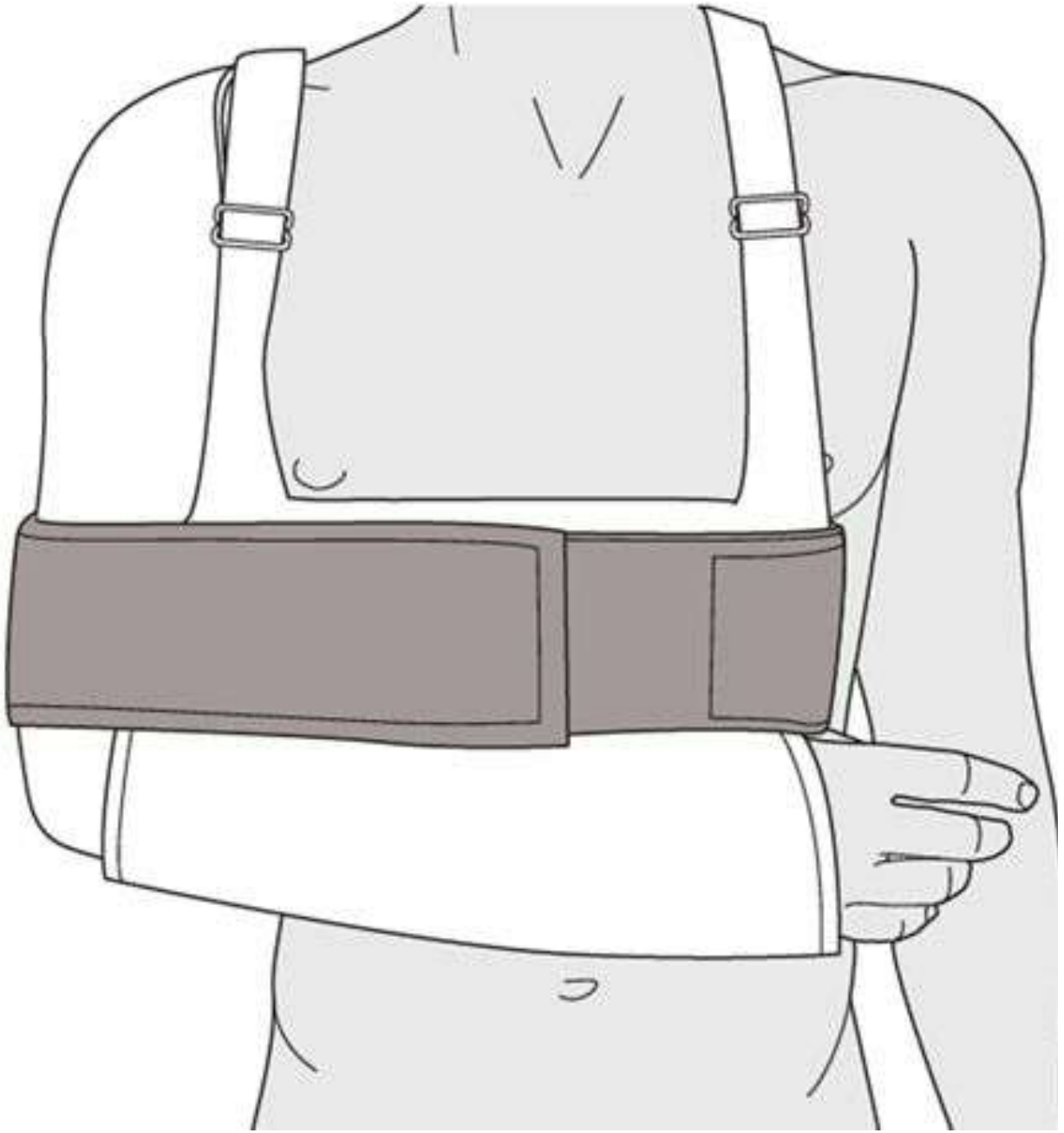
Displaced fractures

- High comorbidity – not fit for surgery
- Low demand – elderly patient
- Low compliance
- Poor bone quality

Greater Tuberosity Fractures

Greater tuberosity fragment surgical indications have evolved

- <3mm displacement in overhead athletes
- <5mm displacement in healthy adults



NEER PROTOCOL – Rehab

Phase 1	0-3 weeks	Pendulum exercises – as tolerated Avoid external rotation for 6 weeks
Phase 2	3-9 weeks	Orthopedic sling removed If evidence of healing on X-Ray 3-6 weeks – active assisted forward and side arm elevation Week 6 – active non assisted motion + isometric strength
Phase 3	> 9 weeks	Isometric strengthening Manual therapy

The PROFHER Randomized Clinical Trial

JAMA 2015

1250 patients with proximal humerus fractures

250 patients met surgical indications and were randomized to operative vs nonoperative treatment

No difference in outcomes at 2 years follow up

- Controversy regarding groups and treatment conversion
- 87 had “clear indication for surgery” and were not included in study
- 16/125 were randomized to surgery and did not receive surgery
- 66 surgeons involved

Regardless, supports nonoperative management in select patients

Operative options

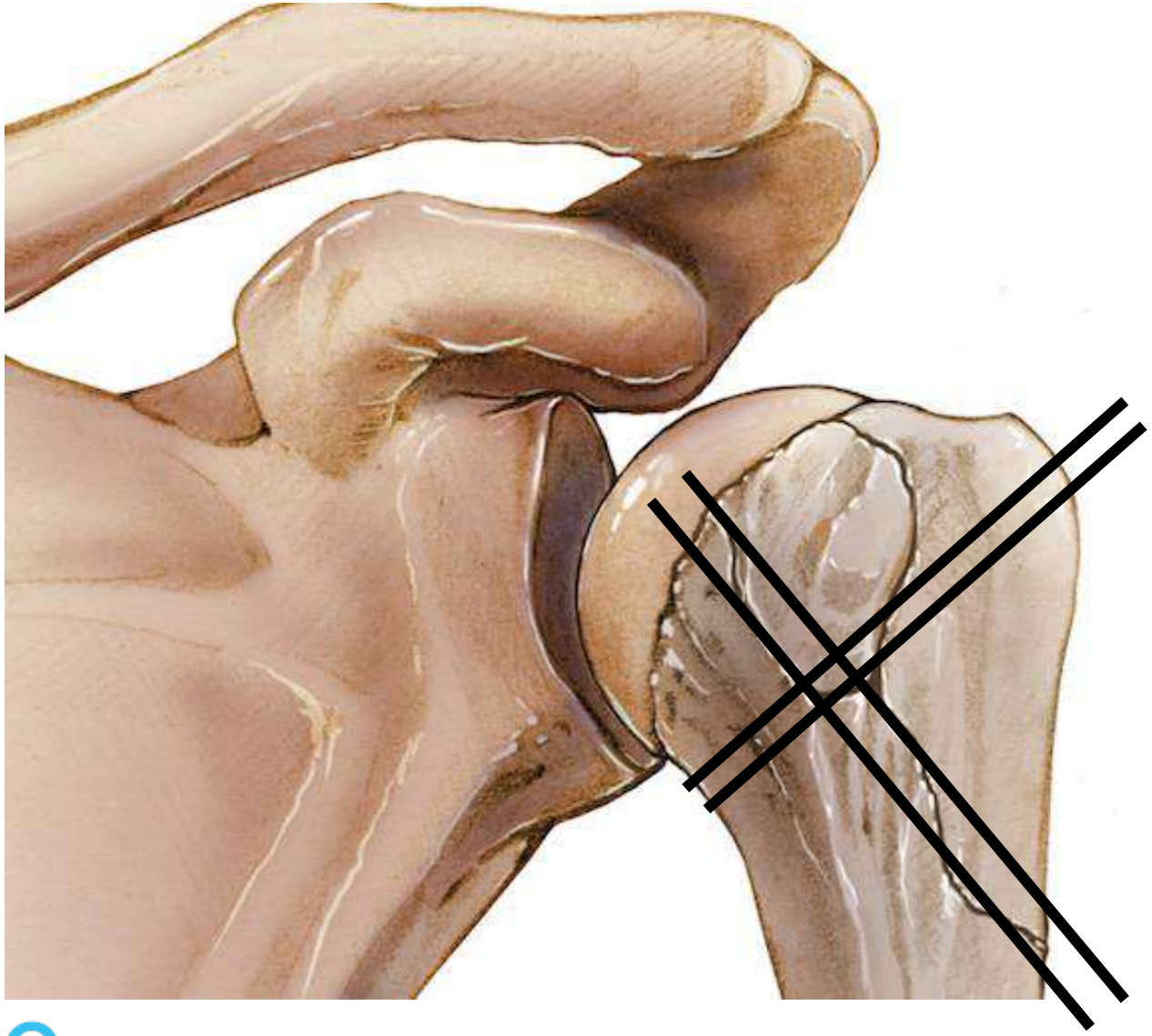
- Closed reduction + percutaneous fixation
- Trans osseous suture fixation
- Intramedullary nail
- ORIF with Plate
- Shoulder replacement

Closed reduction + percutaneous fixation

2-part fracture
3-part fracture

Should not be done when –

Calcar is insufficient
Lesser tuberosity fracture
Metaphyseal comminution



Incision should be limited to more than 5cm distal to acromion edge

Risk of axillary nerve injury

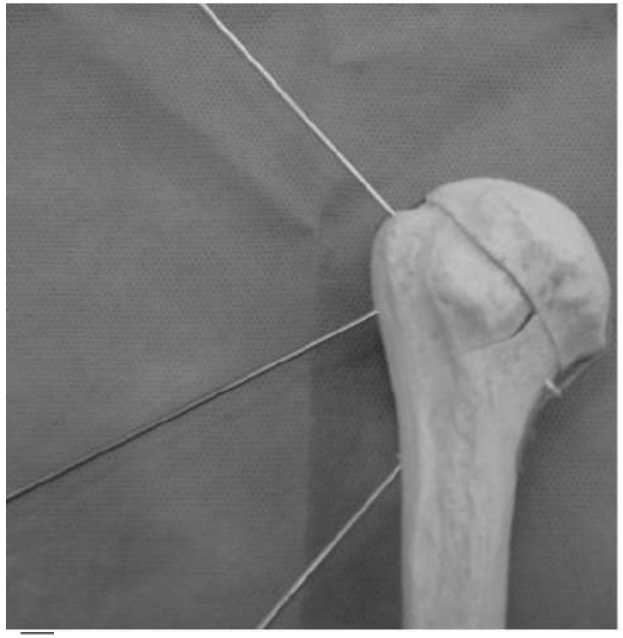
Closed reduction + percutaneous fixation

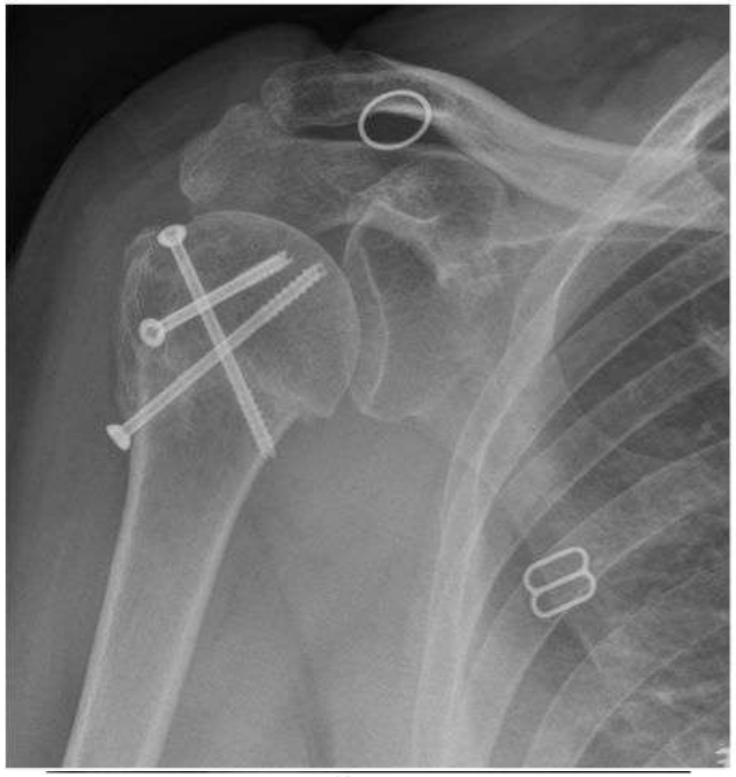
Threaded k wires

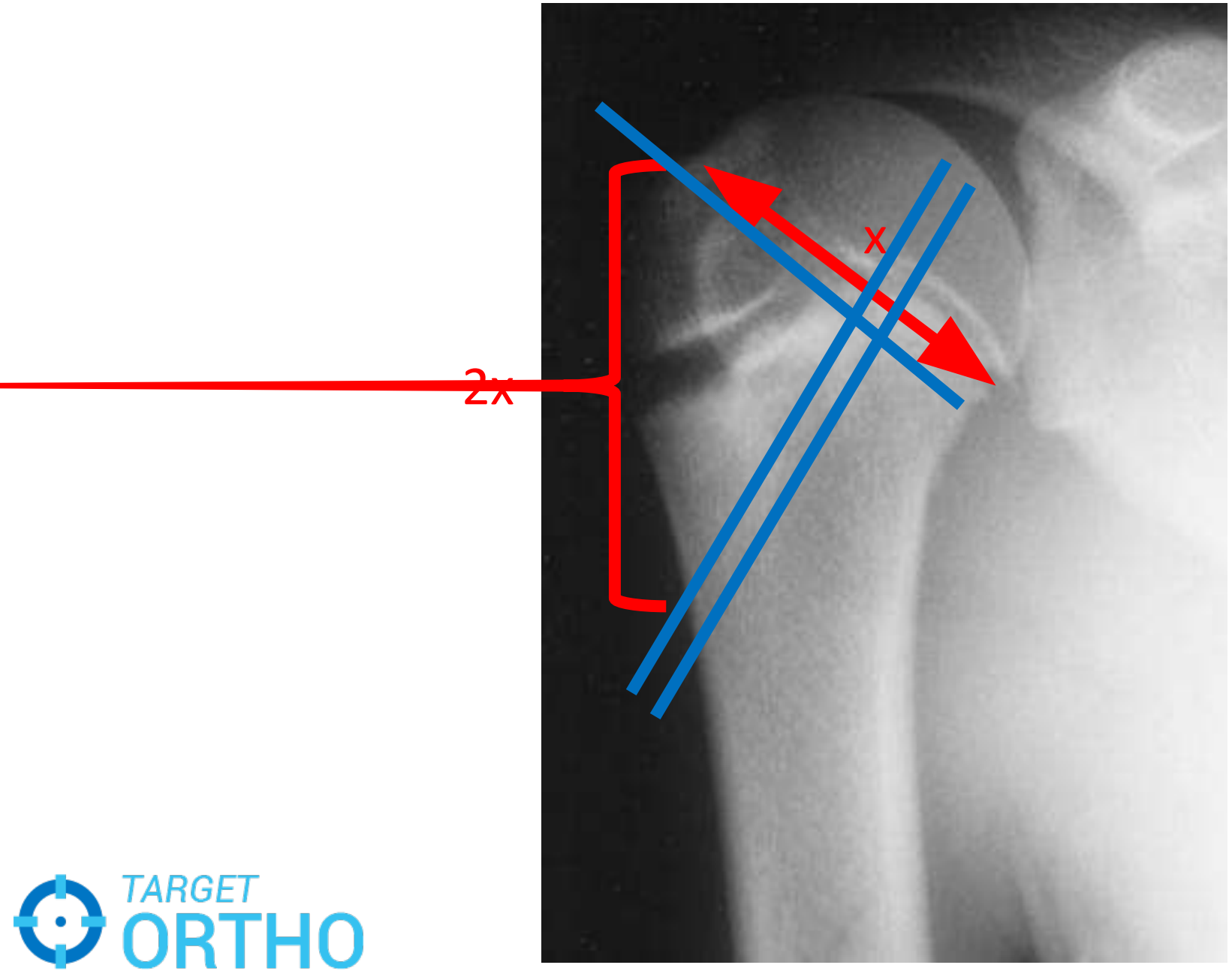
2.5mm K-wire used

Anterolateral to posteromedial direction – Retroversion of humerus

Modified Resch Technique







Open reduction and internal fixation with Plate

- Allows angular stability

- Indications

2 part, 3 part and 4 part fracture in young age

Articular surface fracture

Displaced GT

B

FIGURE 37-29 Patient positioning. Beach chair. **A:** A head holder is required to safely maintain control of the head during surgery. Intraoperative imaging can be obtained with a mini-C-arm (as seen) or a standard C-arm. **B and C:** If iliac crest bone graft is required as in this surgical neck nonunion, the contralateral iliac crest is prepared and draped. Intraoperative imaging can be obtained with a mini-C-arm (as seen) or a standard C-arm.

Position

- Beach chair

Beware of blood pressure cuff on gravity dependent leg that will give incorrect indication of perfusion elsewhere (i.e. brain)

- Semi Supine

FIGURE 36-18 Positioning the patient for antegrade nailing.

A 46-year-old male is involved in a motor vehicle accident and suffers a proximal humerus fracture. Operative treatment is recommended, and plate fixation is performed through an extended anterolateral acromial approach. Which of the following structures is at increased risk of injury using this surgical exposure compared to the deltopectoral approach?

1) Musculocutaneous nerve
2) Axillary nerve
3) Anterior humeral circumflex artery
4) Posterior humeral circumflex artery
5) Cephalic vein

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Deltopectoral “Workhorse of reconstructive shoulder surgery”

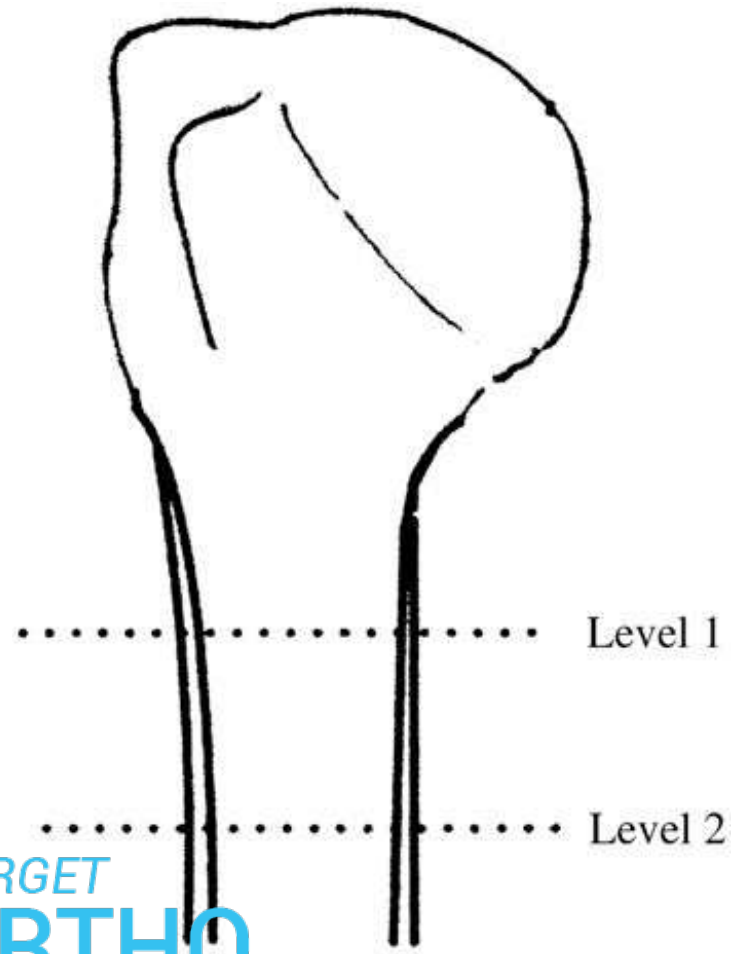
- Can visualize the joint for head split fractures with lesser tuberosity peel vs osteotomy
- Extensile

Deltoid Splitting

- Easier plate placement laterally
- Axillary nerve protection (5-7 cm inferior to acromion) • Less retraction and positioning needed for lateral plate placement

- Can be extensile if you dissect and protect axillary nerve

Combined Average Cortical Thickness Criteria



Line 1 = proximal level of the humeral diaphysis where the endosteal borders of the lateral and medial cortices become parallel
Line 2 = 20mm below Line 1

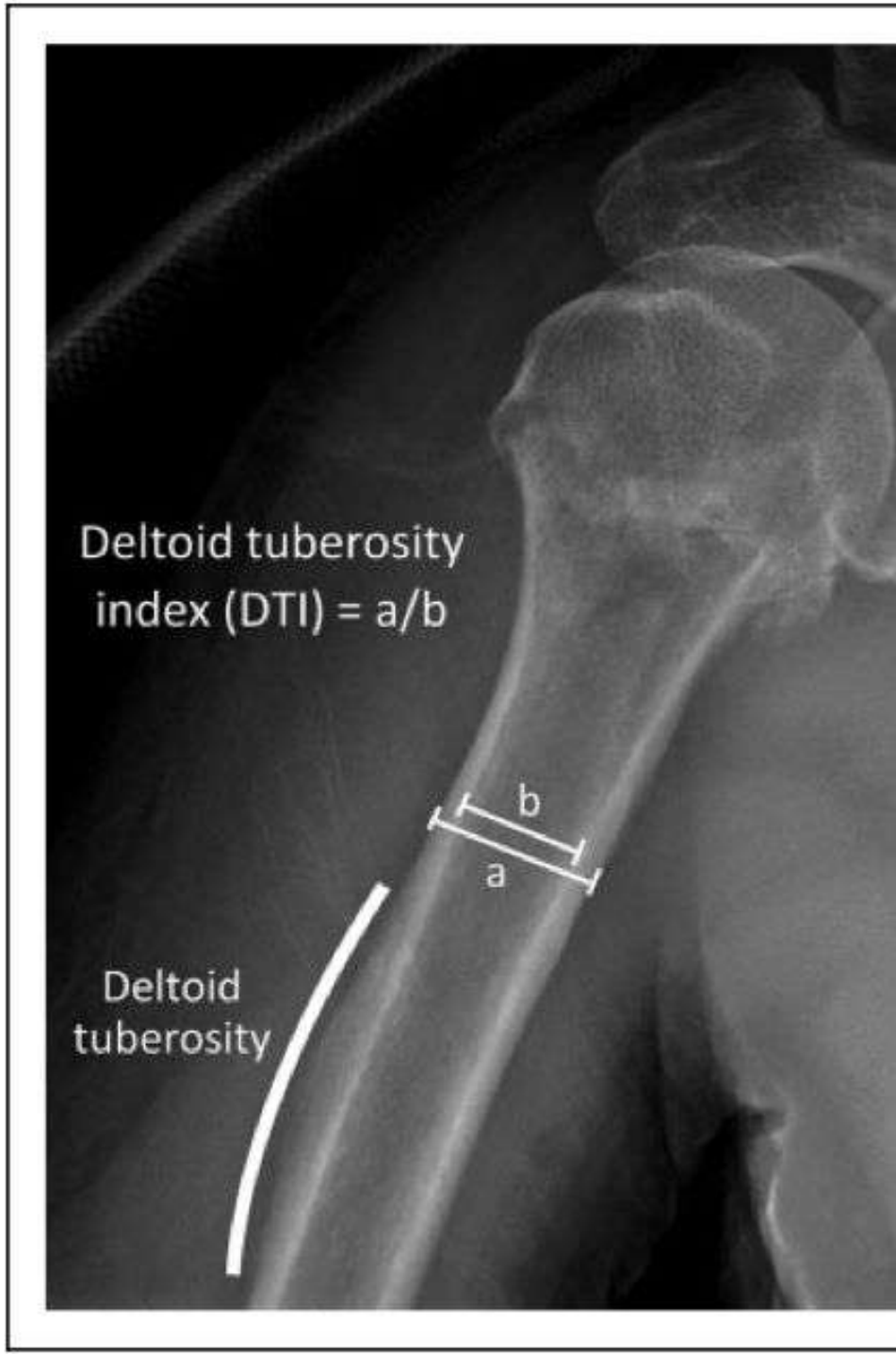
(a+b+c+d) / 2

>4mm = ORIF
<4MM = ORIF will fail

Deltoid tuberosity index

- Deltoid tuberosity index showed significantly high intraclass correlation coefficient and a strong correlation with the T score of BMD. Therefore, DTI may be useful for screening osteoporosis in PHF patients.

- Min Kim et al (2020)



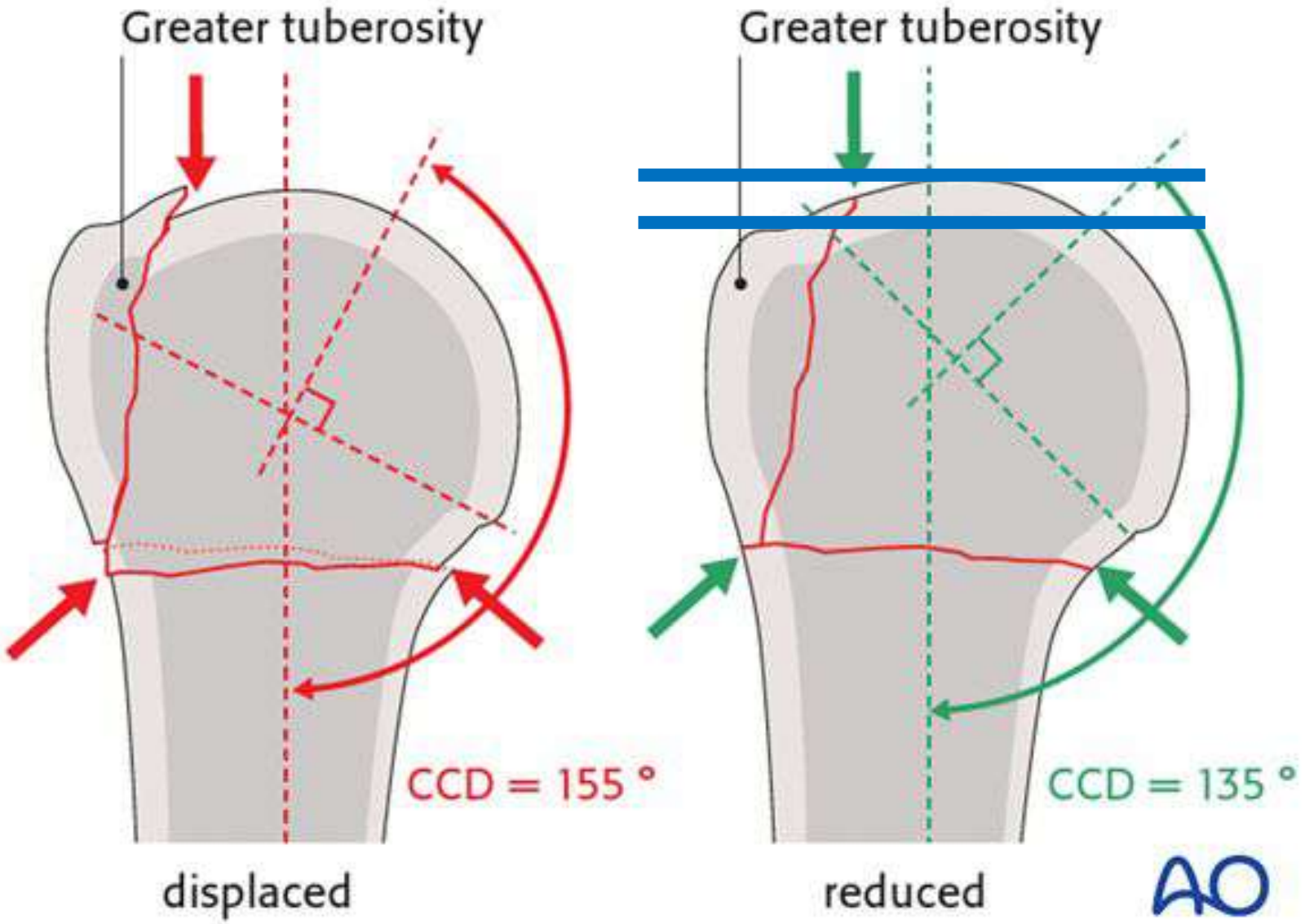
PHILOS plate

Proximal Humerus Inter Locking System

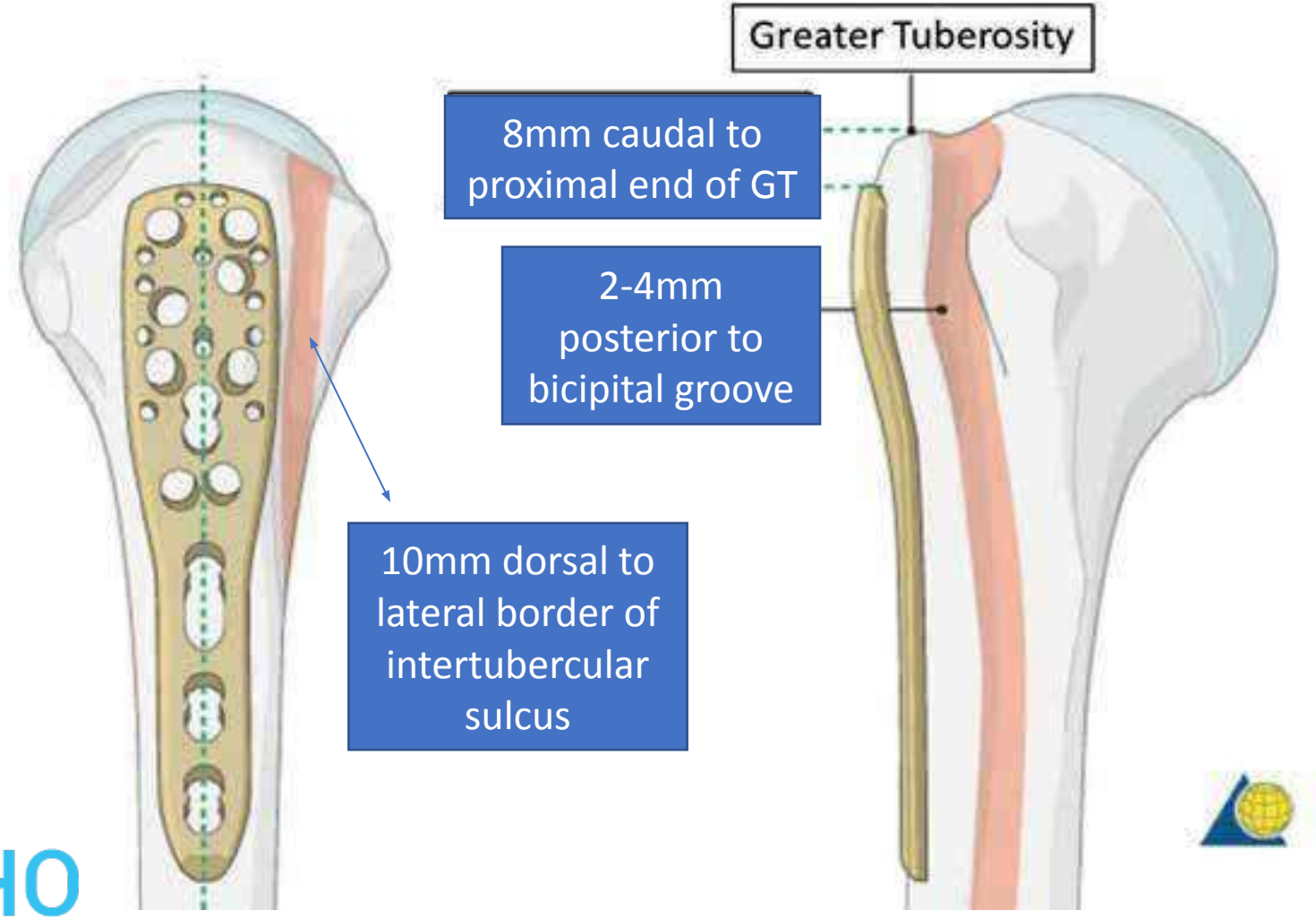
HTD distance

Head to tuberosity distance

8-10mm



Concept of reduction



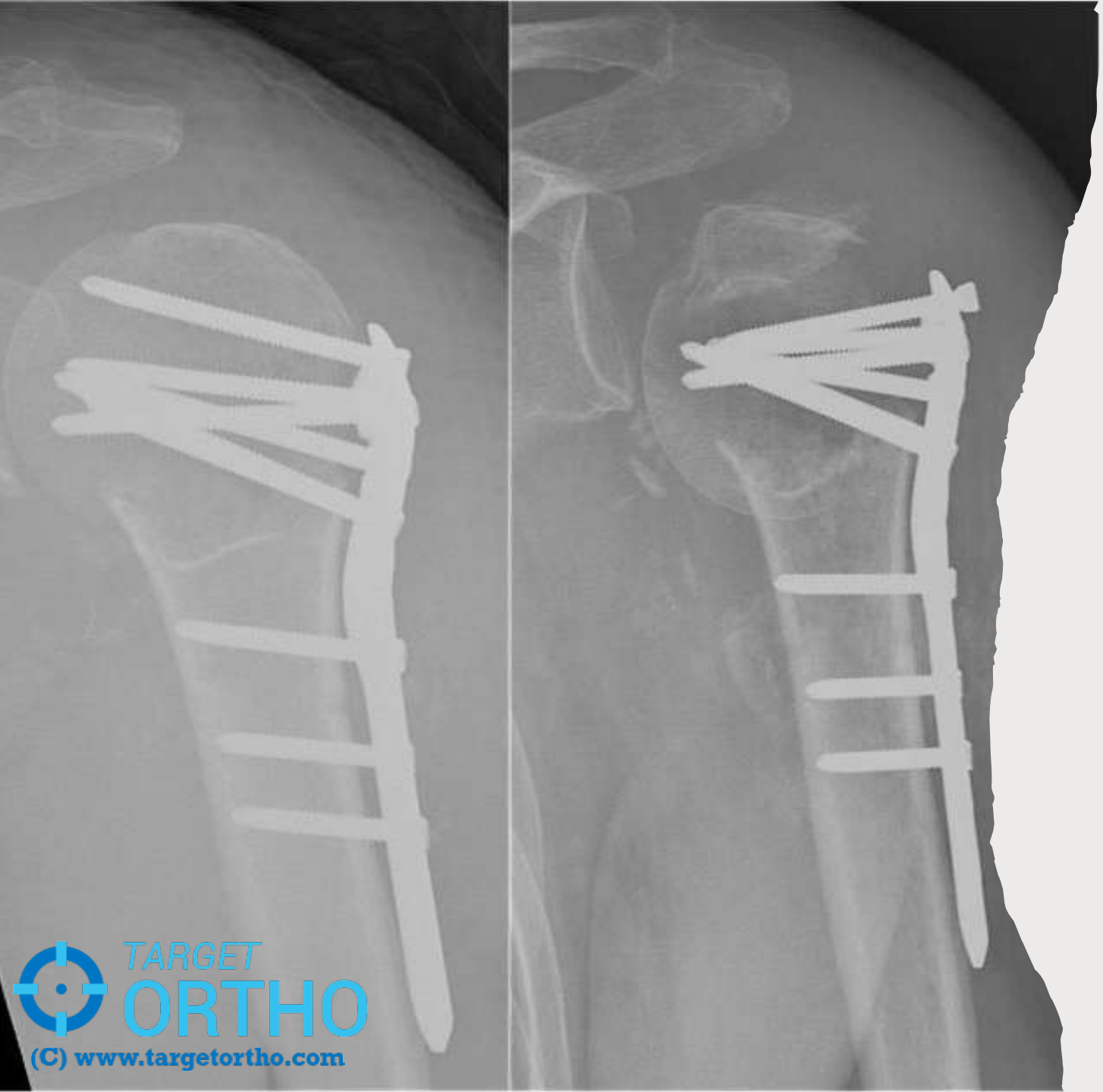
Screws to be placed

At least 4-6 screws to be placed to the humeral head

At least 3 screws to be placed into the distal shaft segment

2 screws into inferomedial aspect of humeral head

The proximal part of PHILOS plate has 10 suture holes of 2mm diameter



68-year-old female

Varus collapse !

Second generation locked plating for complex proximal humerus fractures in very elderly patients (2016)

Ashok S. Gavaskar, MS Ortho, Consultant Trauma Surgeon[a,*],
Bhupesh Karthik B., MS Ortho, Assistant professor[b],

7 locking head screws

Including 2 calcar screws

Augmented with traction sutures

Comminuted medial calcar – endosteal fibular strut

Subchondral metaphyseal bone – filled with injectable calcium phosphate cement

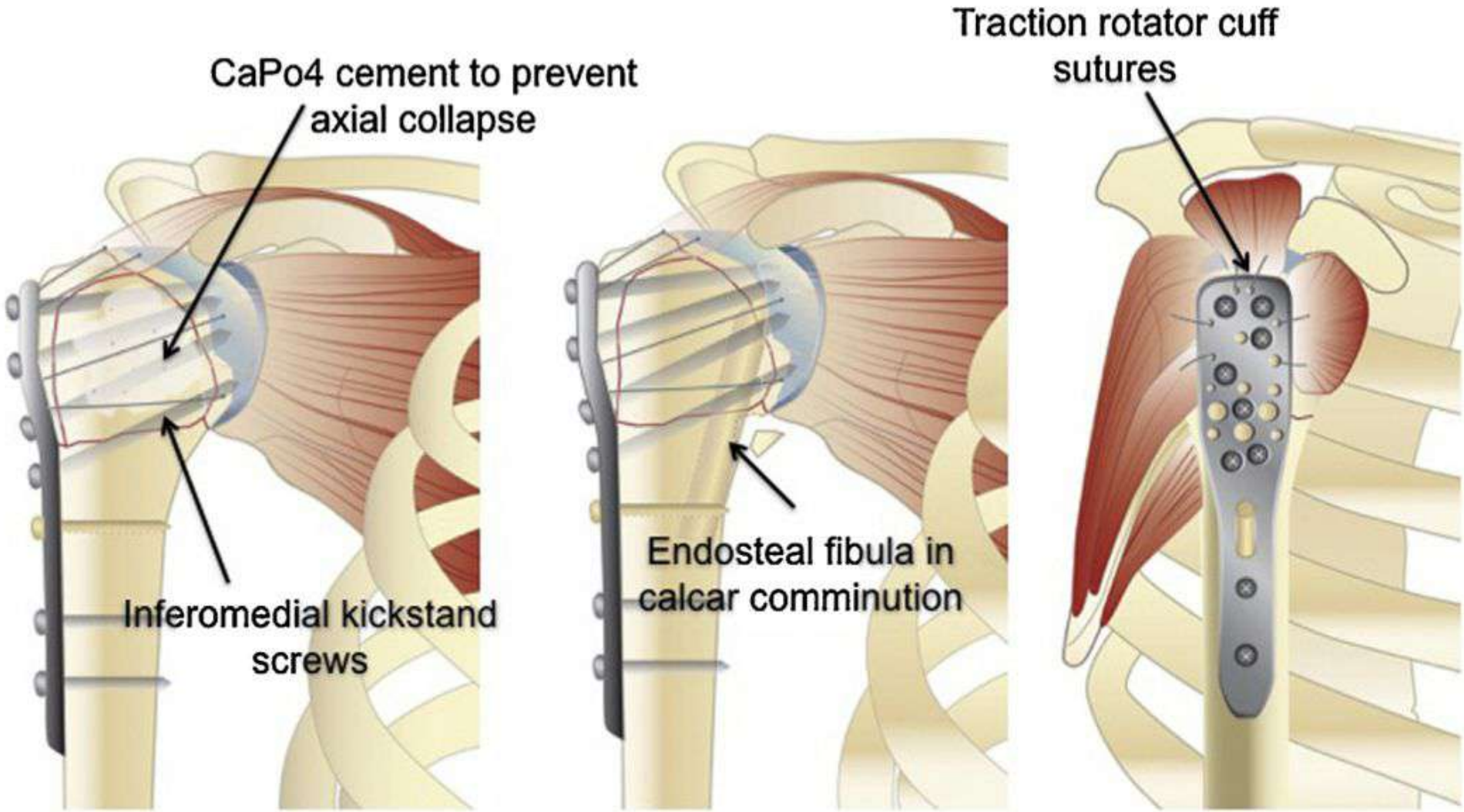


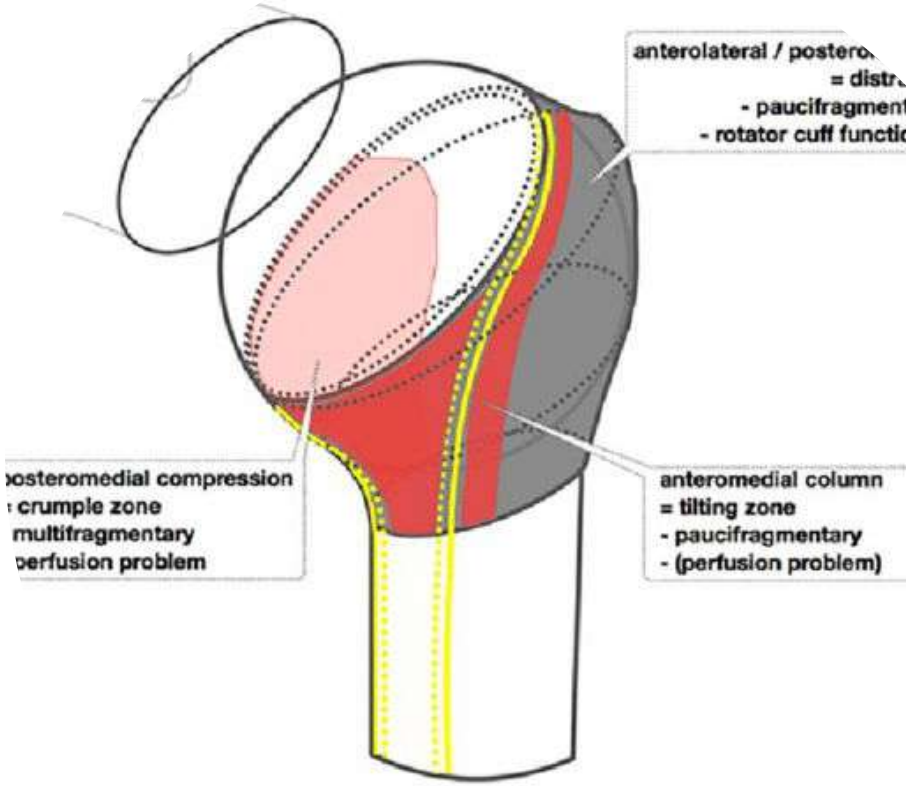
Fig. 1. Summary of surgical techniques used in second generation locked plating of proximal humerus fractures.

The Torus Concept

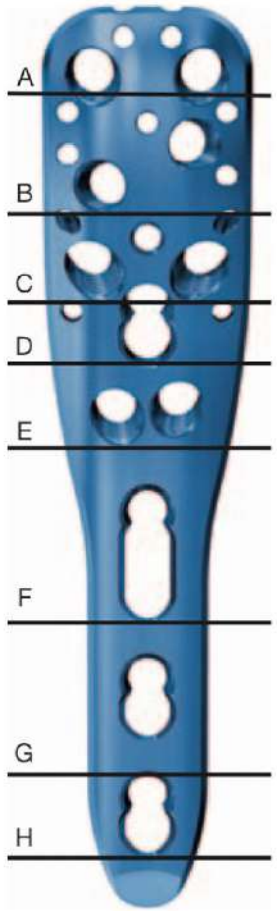
Head of humerus is supported by a three-legged stool

Aim of reduction

Reconstitute the three-legged stool

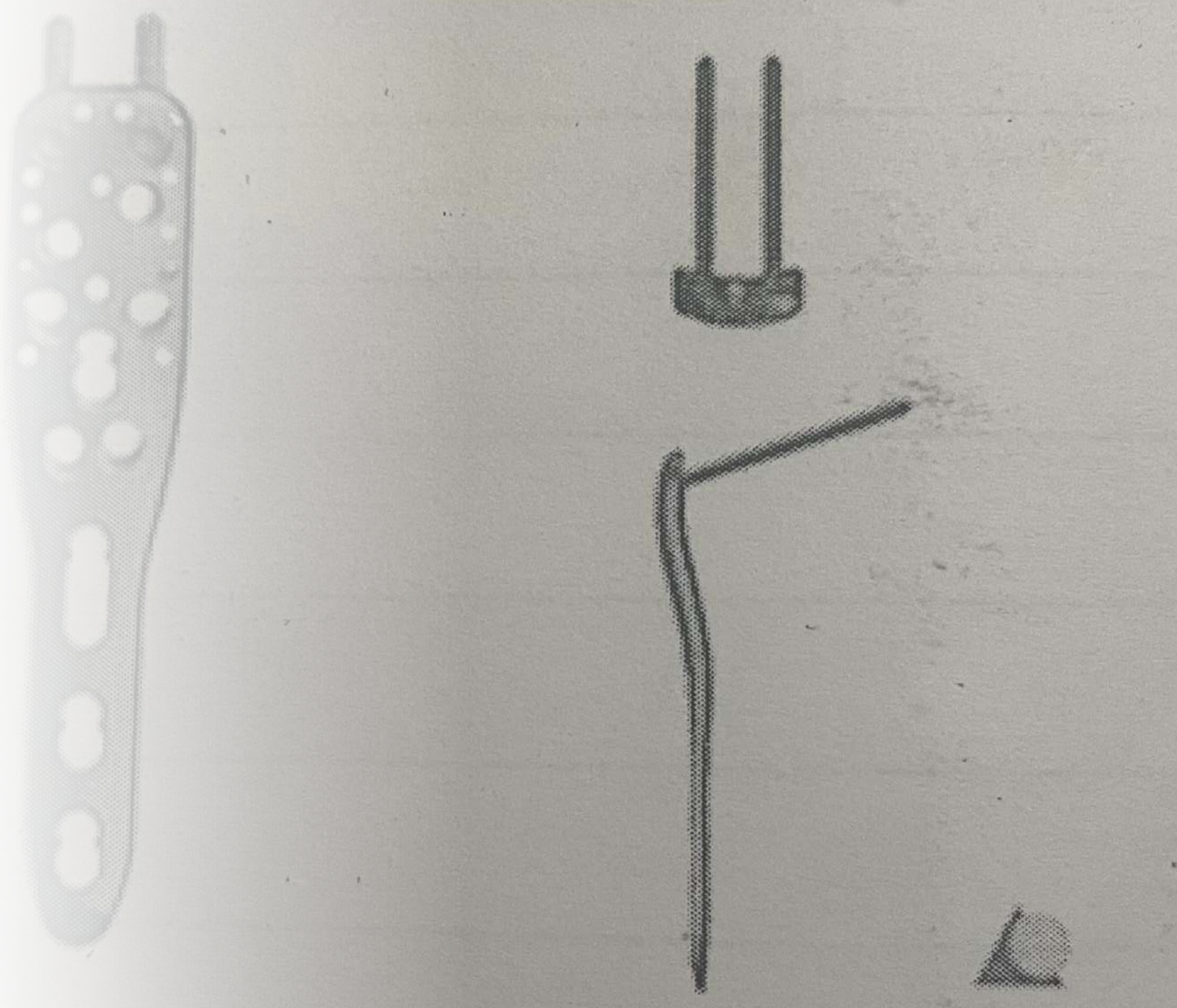


Levels of plate hole



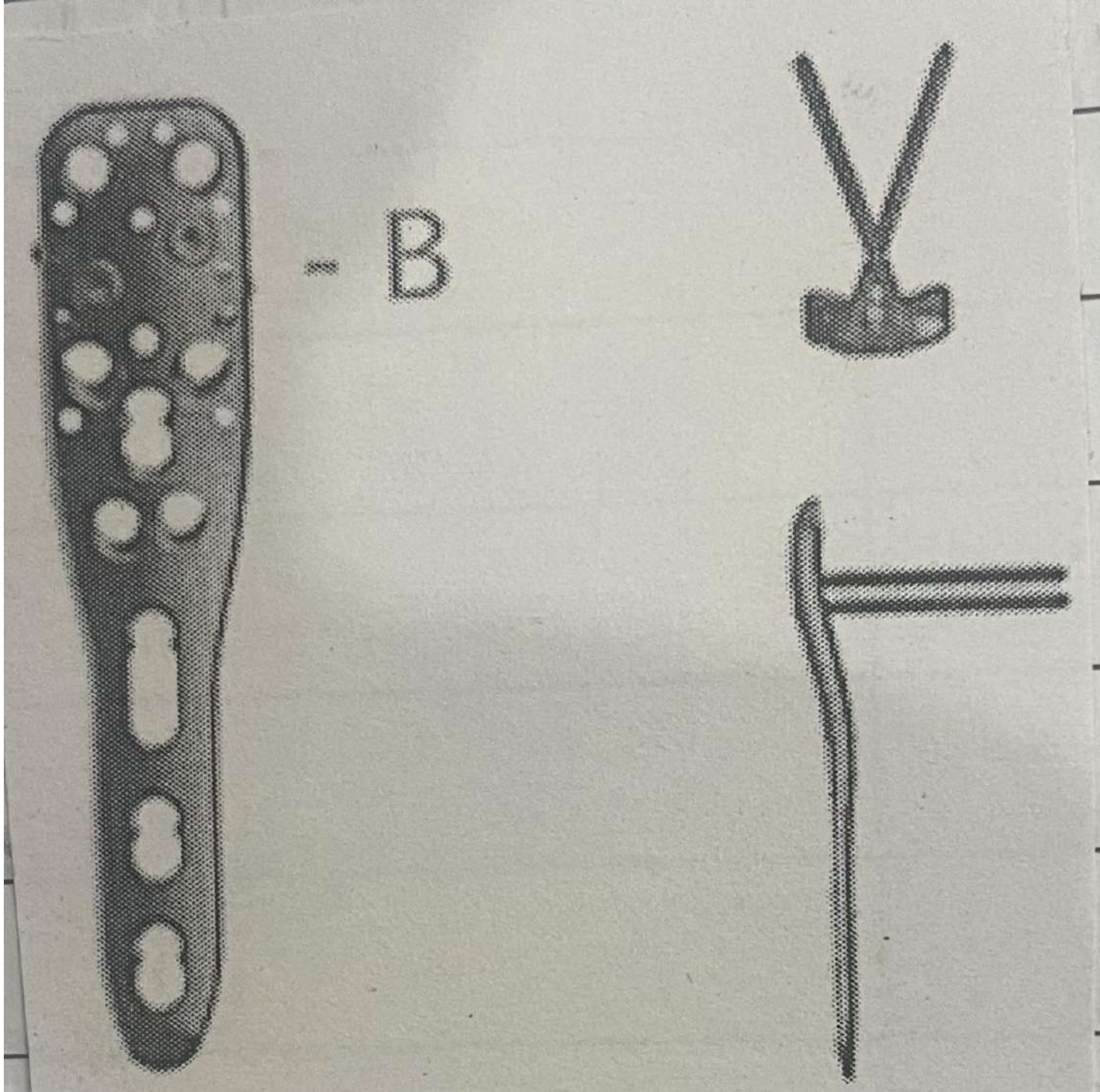
Level A

- Parallel holes angled slightly upwards



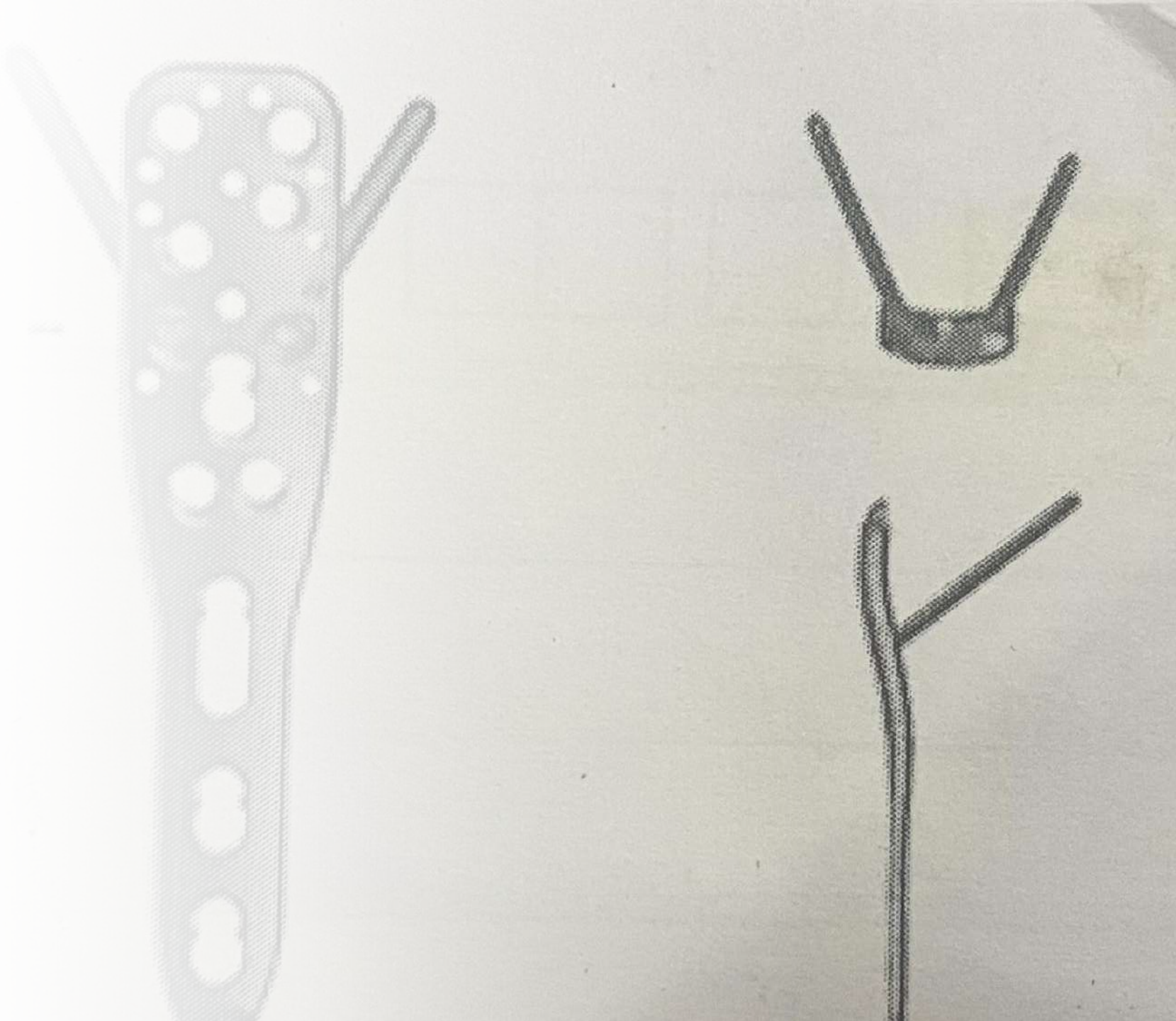
Level B

- Staggered holes
- Screws converge in head of humerus



Level C

- Holes are inclined upwards
- Screws diverge at head of humerus

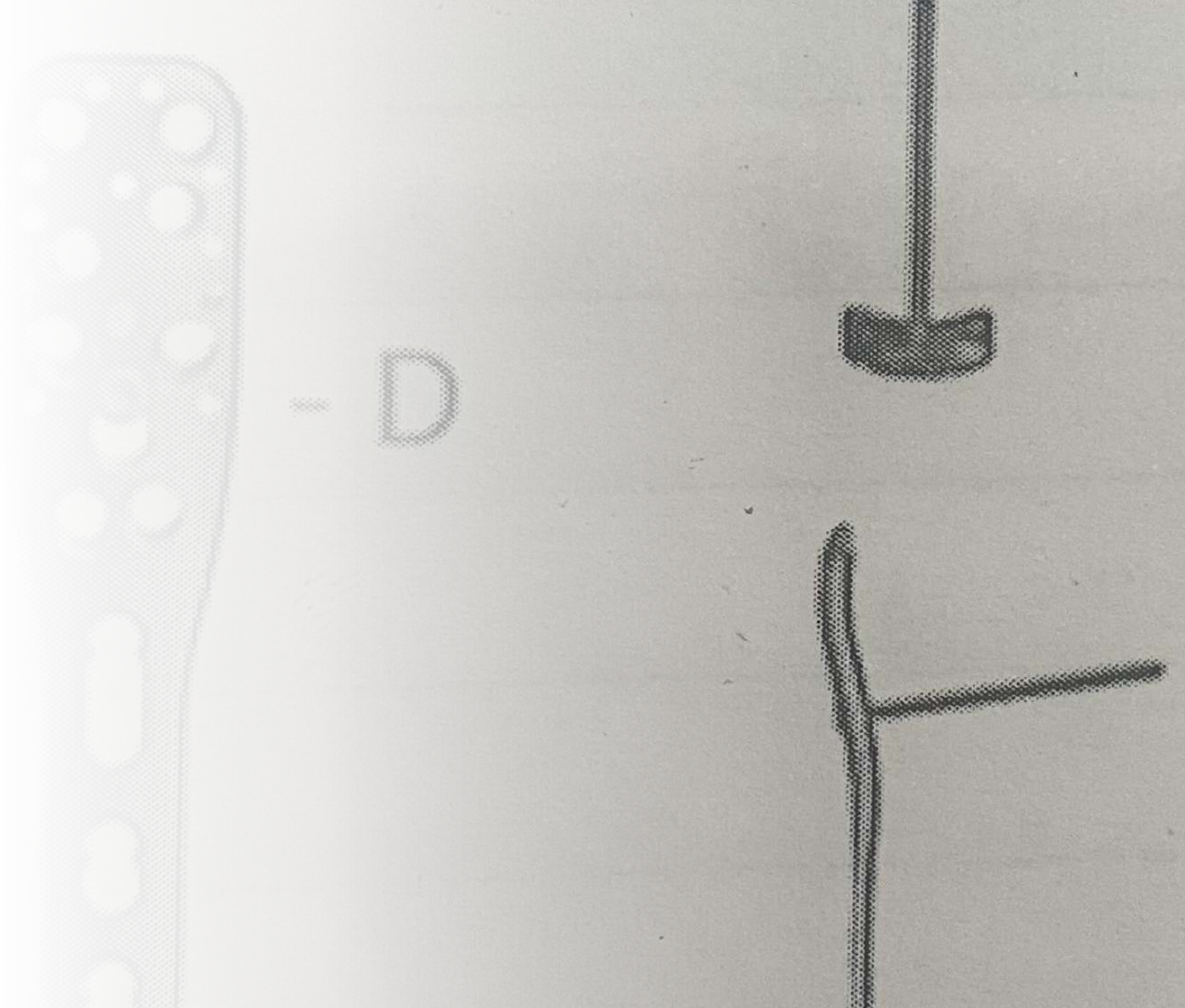


Level D

- One screw – LCP
- Combination hole

- Inclined slightly upwards

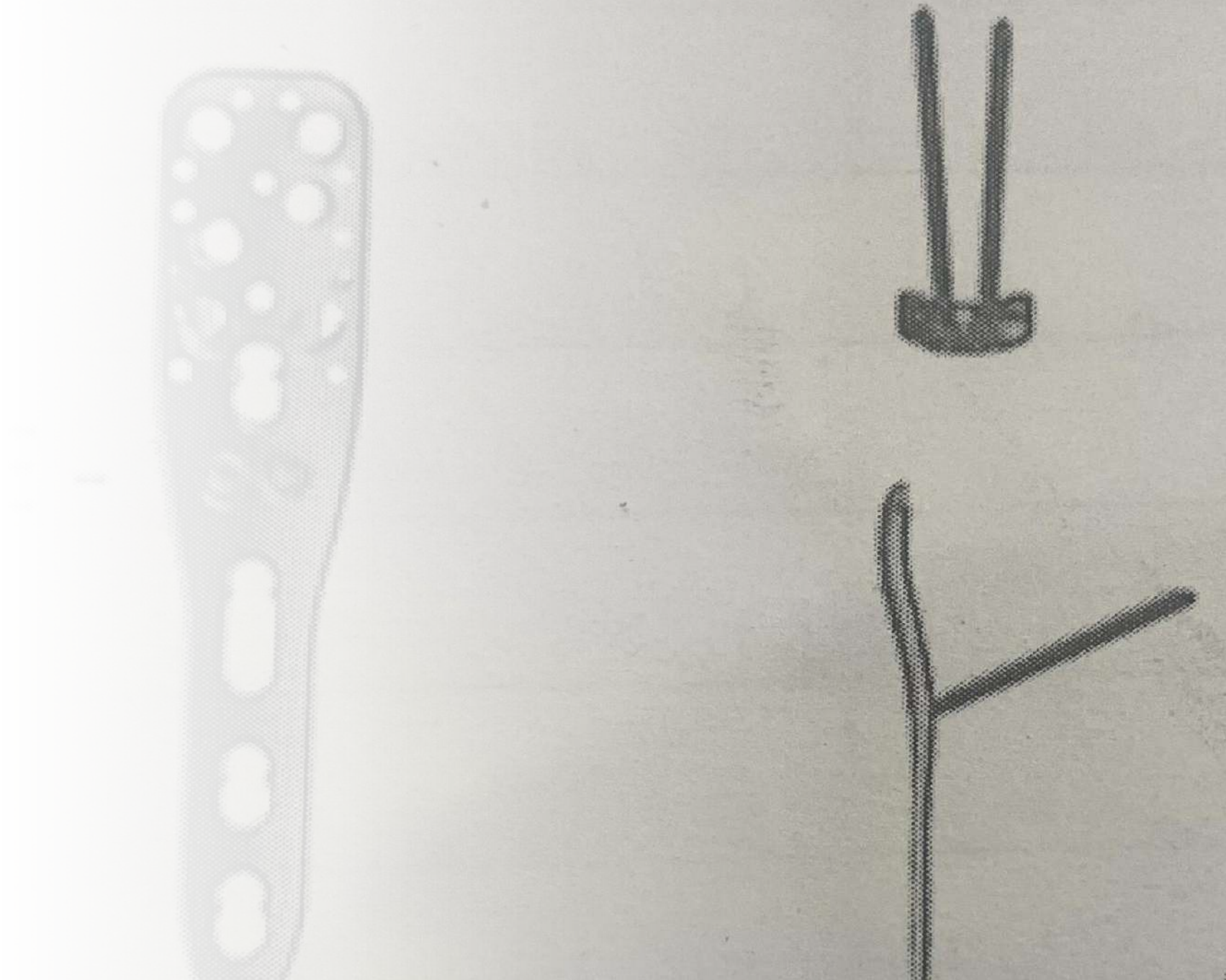
- Directs it to the head of the humerus



Level E

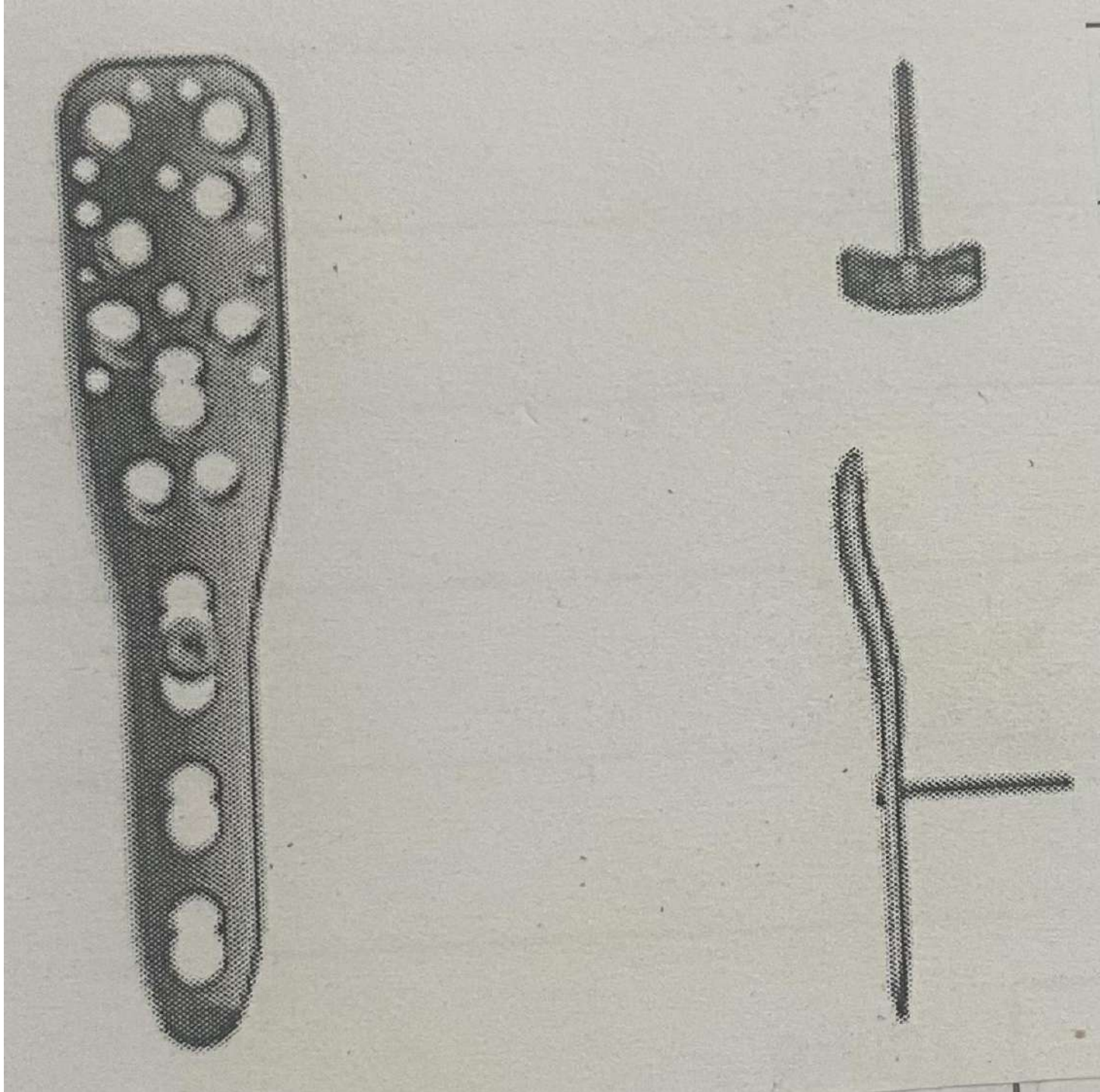
•Holes diverge slightly , inclined upwards

•Provide purchase to the calcar region



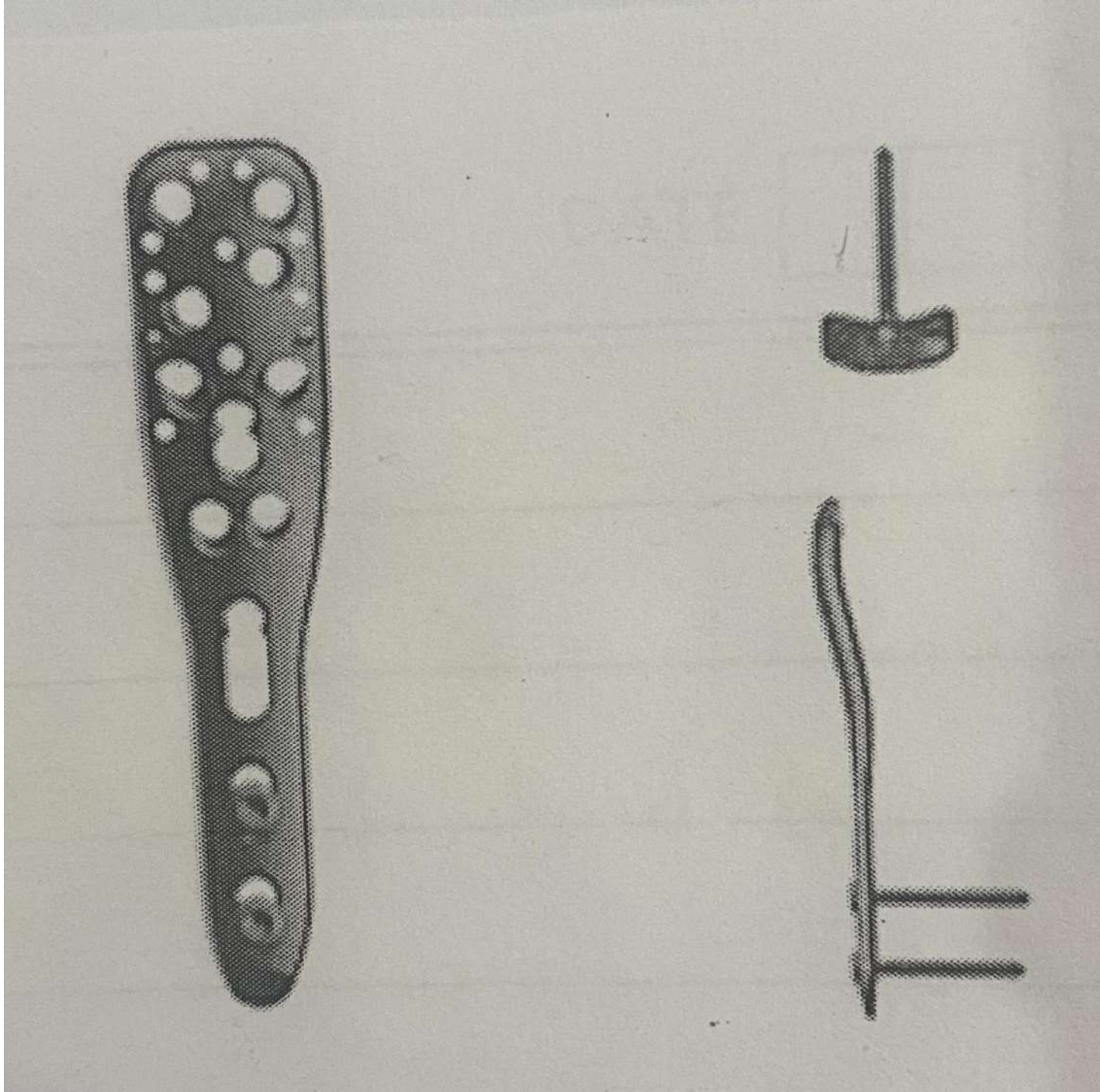
Level F

- Proximal screw in the shaft
- 3.5mm conventional screw or locking head screw
- Can be used to adjust the plate vertically



Level G and H

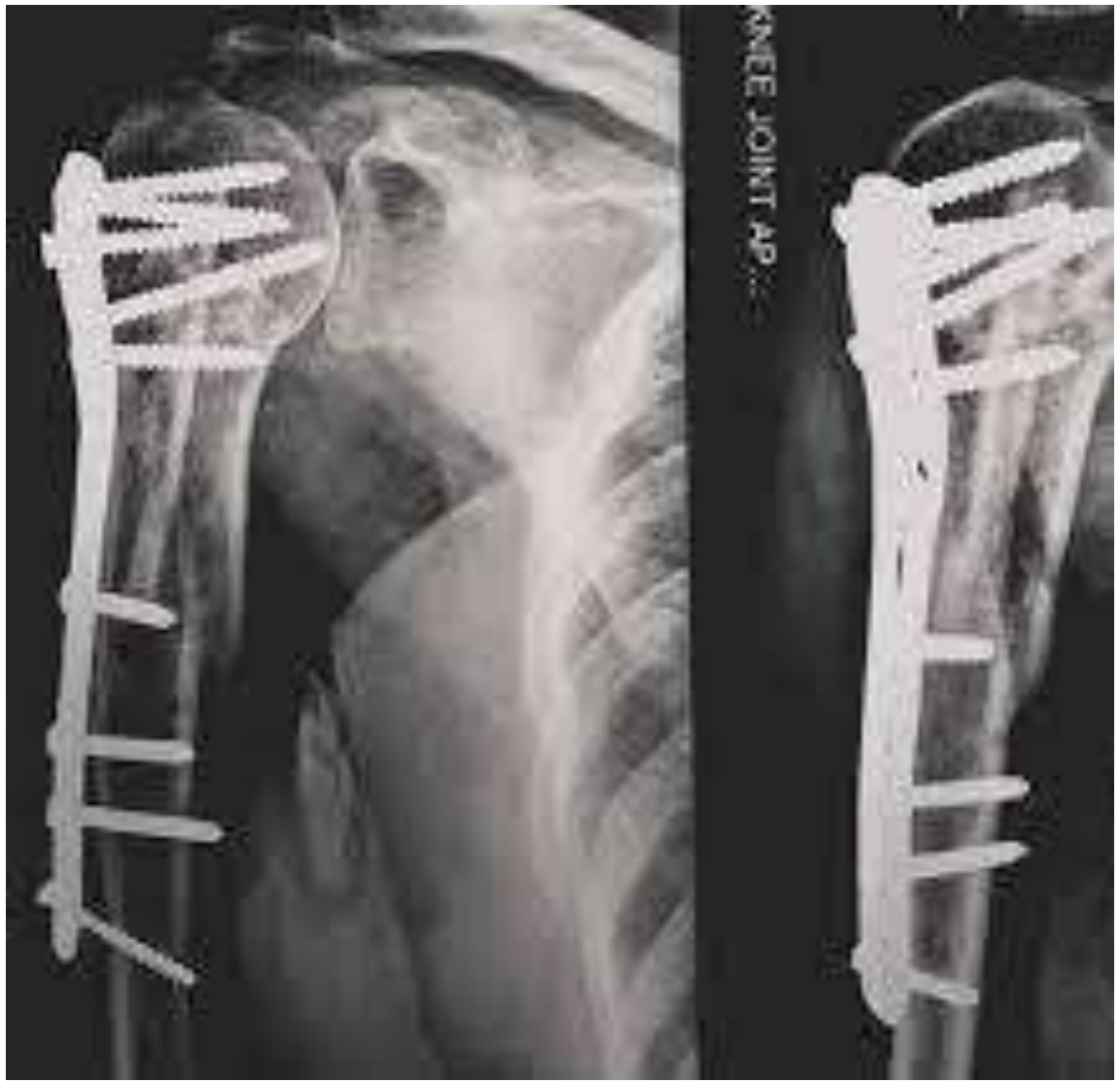
- LCP combination type screw



Varus Collapse

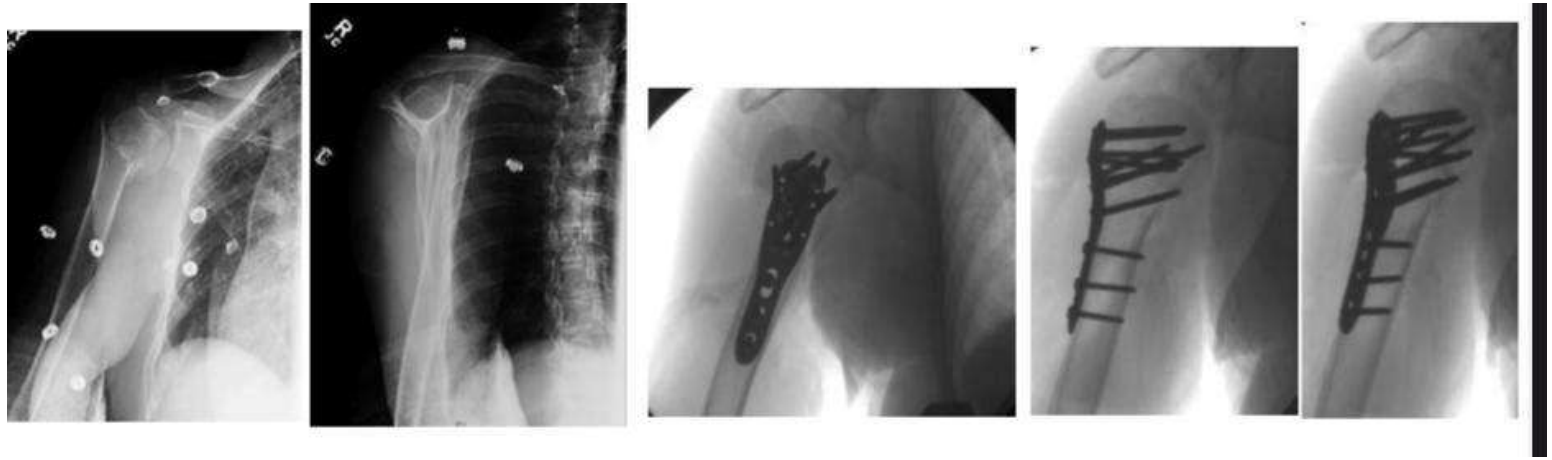
Intramedullary fibular strut graft –

In varus impacted fracture when medial calcar cannot be reconstructed



A 64-year-old woman is thrown off a horse, sustaining the injury shown in Figures A and B. She undergoes surgical fixation as seen in Figures C through E. What is the most reported complication of this procedure?

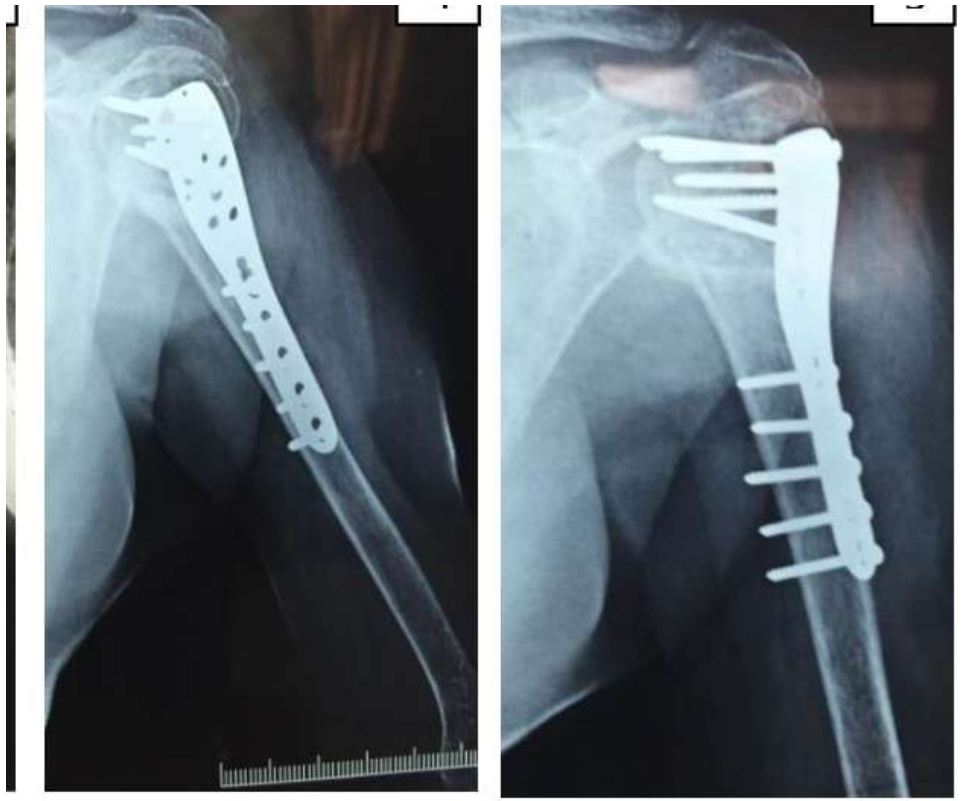
1. Axillary nerve injury
2. Valgus migration of the fracture
3. Non-union
4. Screw penetration



A B C D E

Most common reported complication of PHILOS plating

Screw perforation through humeral head



Intramedullary nailing

- **Indications :**

Two-part surgical neck displaced fracture

Three-part Greater tuberosity fracture

Pathological fracture

Segmental – proximal humerus with shaft fracture

Intramedullary nailing

M/C Complication

Rotator Cuff Dysfunction – Shoulder Pain

8-12mm proximal diameter nail

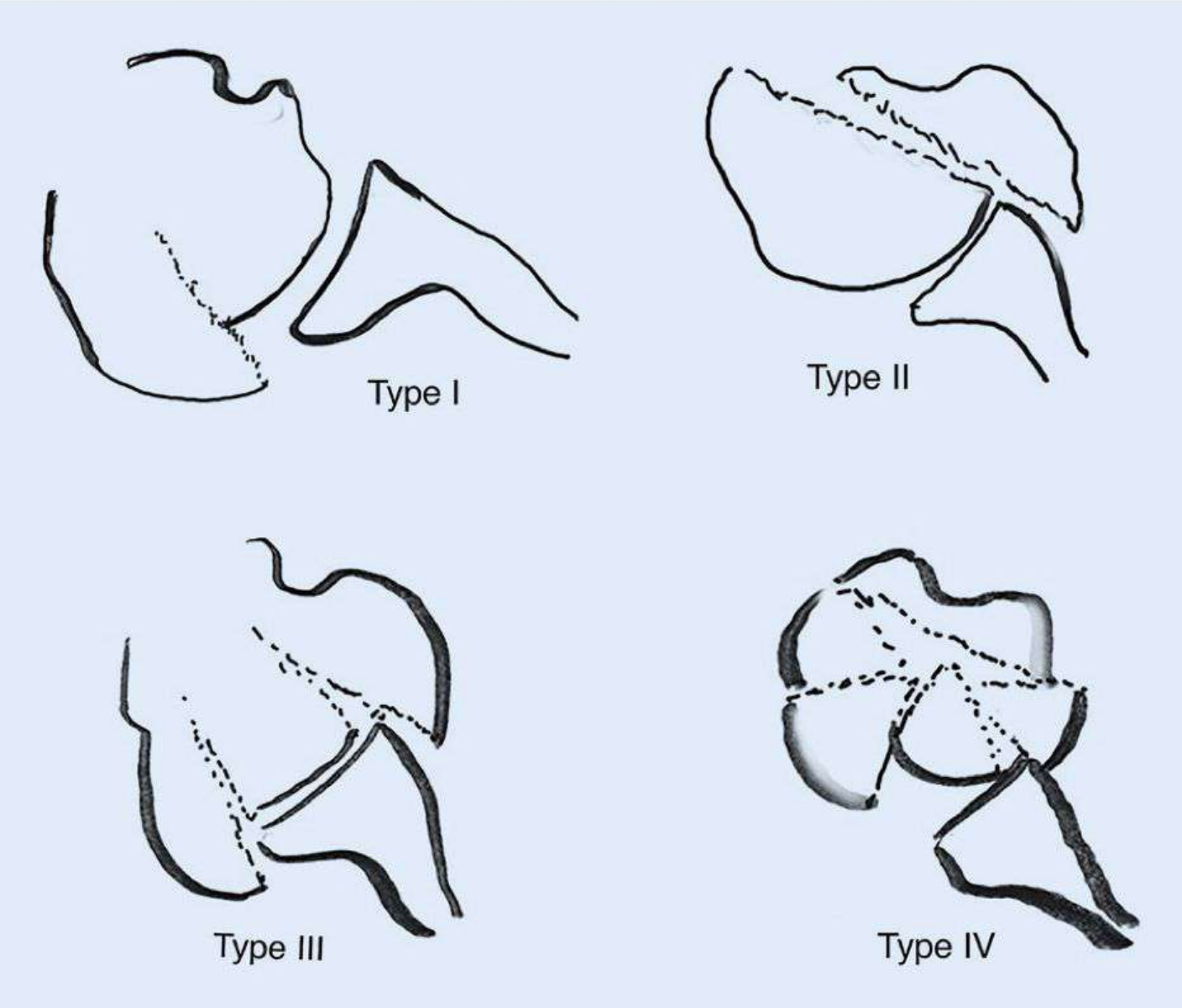
Entry point – 3cm incision to anterolateral corner to acromion

Type of nail	Entry point
Nails with proximal lateral bend	Closer to footprint of rotator cuff
Straight nails	Enter humeral head via split in musculotendinous junction of RC into articular surface of Humeral head

MULTILOC 2nd Generation Straight Nail

Head Split fractures

Schneibel et al 2019



Shoulder hemiarthroplasty

Done in

- Comminuted head split fractures
- Head depression fractures > 40 % articular surface
- Predictors of head ischemia
- Three- or four-part fracture severe comminution non reconstructable

When utilizing the pectoralis major tendon as a reference for restoring humeral height during shoulder hemiarthroplasty, at what level cephalad to the proximal edge of the tendon should the top of the prosthesis sit?

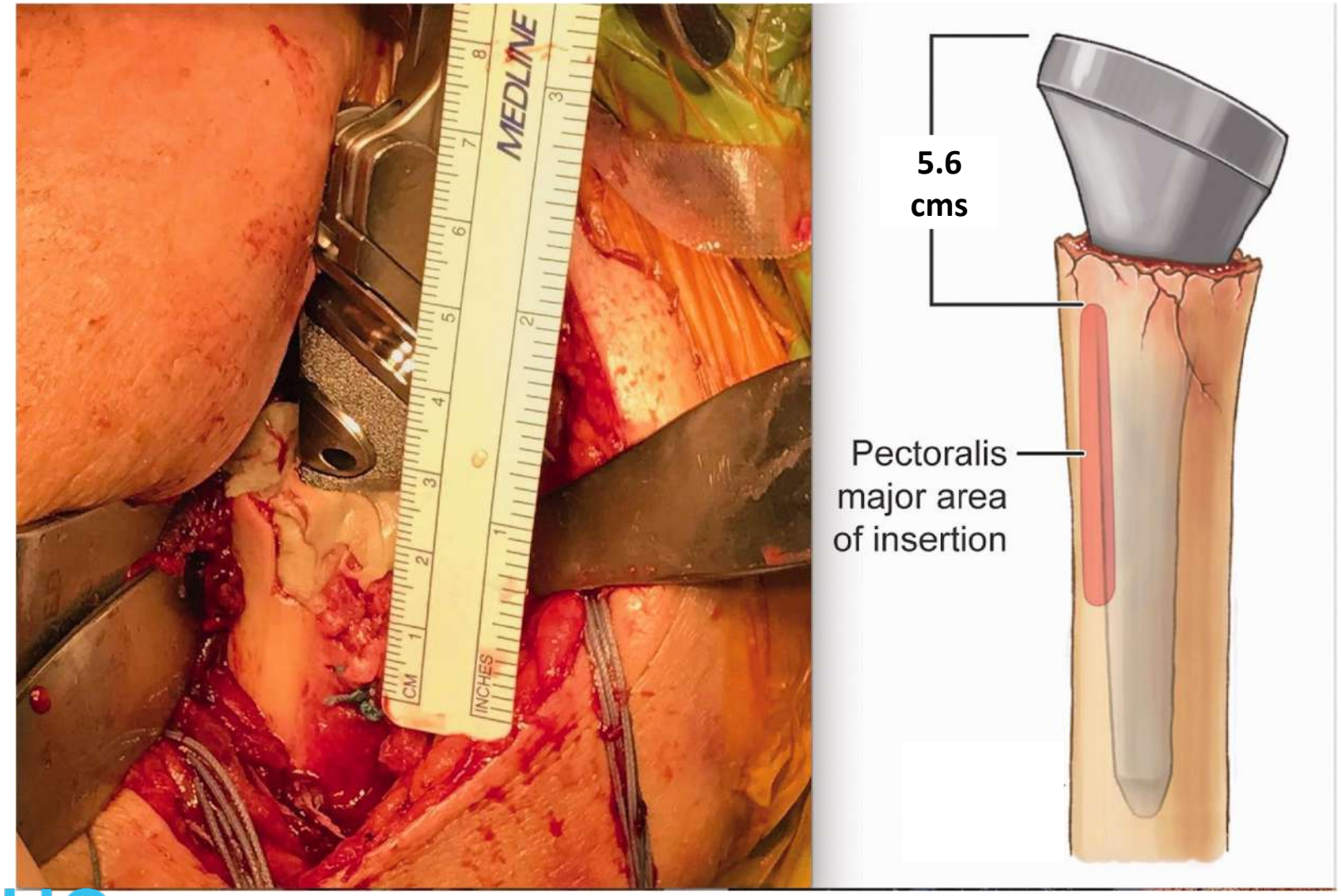
a) 1.0 cm

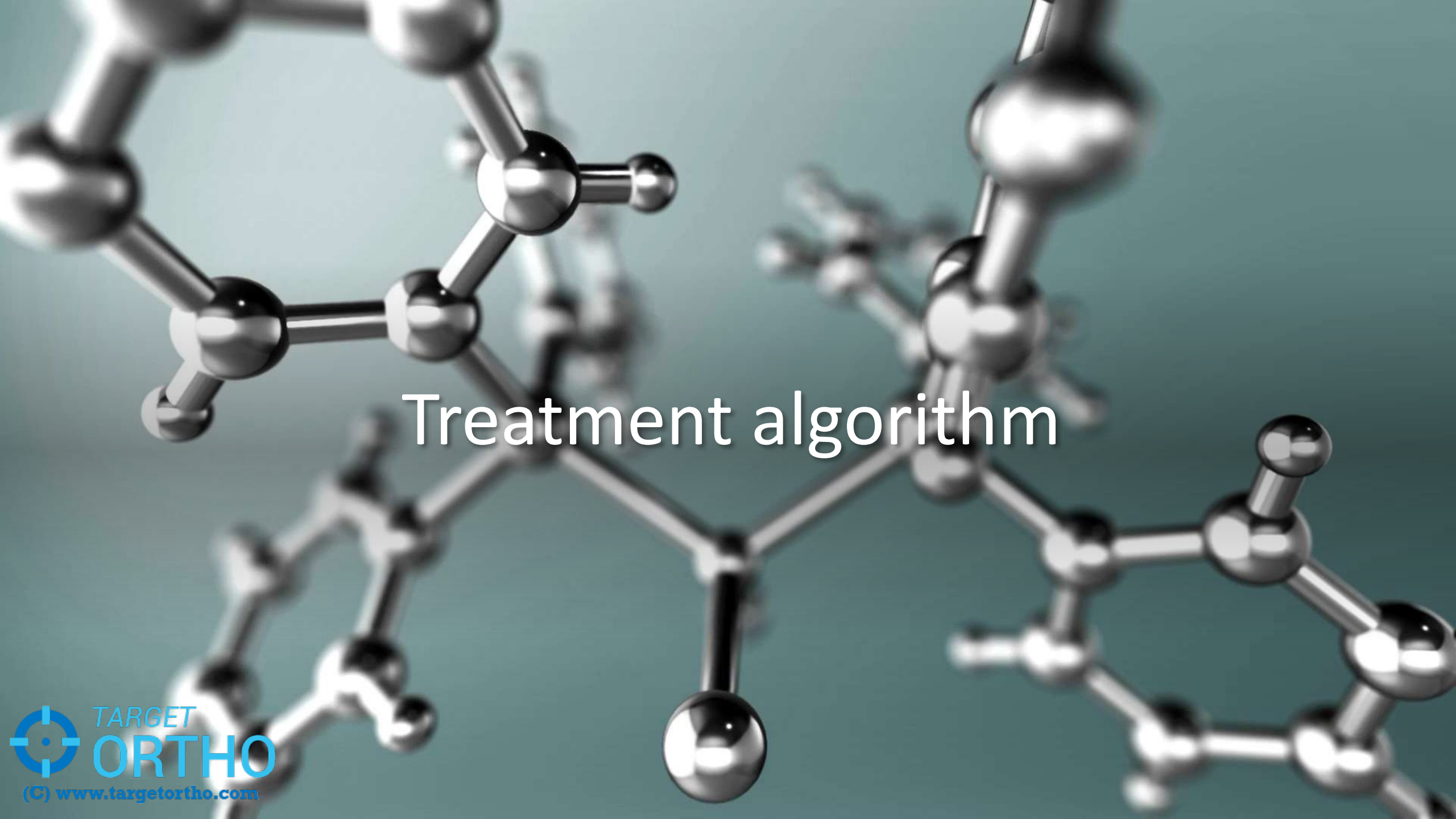
b) 3.8 cm

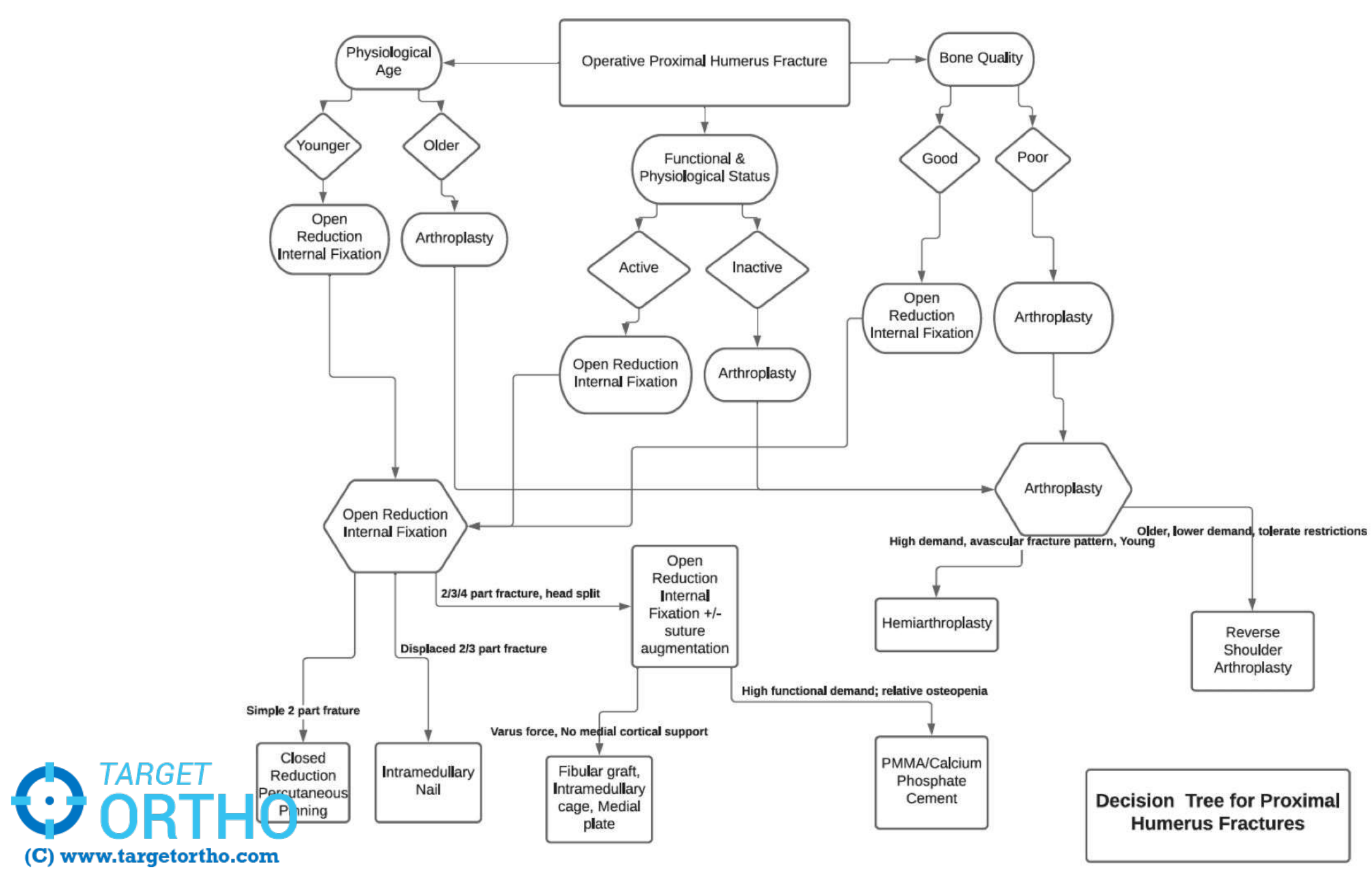
c) 6.5 cm

d) 2.4 cm

e) 5.6 cm







One part		Non operative
Two-part anatomic neck #	Young	Screw fixation
	Old	Hemiarthroplasty > ORIF
Two-part surgical neck #		ORIF with plate Nail >> Percut pinning

Two-part GT#

Displacement <5 / <3

Fragment size > 2.5cm ORIF with screw

Displacement >5 / >3

Fragment size < 2.5cm Suture anchor

Two-part LT#

Fragment size > 2.5cm ORIF with screw

Fragment size < 2.5cm Suture anchor /
Trans-osseous suture fixation

Young age

Head preservation >> hemi

Three and four part #

Old age

Hemi >> Head preservation

Complications

- **AVN**
- **Impingement**
- **Screw cut out**
- **Loss of reduction**

Medial support , calcar screw placement

Combined cortical thickness
Deltoid tuberosity index

- **Non-union**

Risk factors: Smoking, Alcohol abuse ,Osteoporosis , Inflammatory arthropathy

- **Malunion**

Tuberosity malunion can cause symptoms of rotator cuff weakness or impingement

- **Stiffness**
- **Infection**