TARGET ORTHO

Ilizarov Part 2

Dr Daivik T Shetty

Consultant Orthopedic Surgeon

Father Muller Medical College

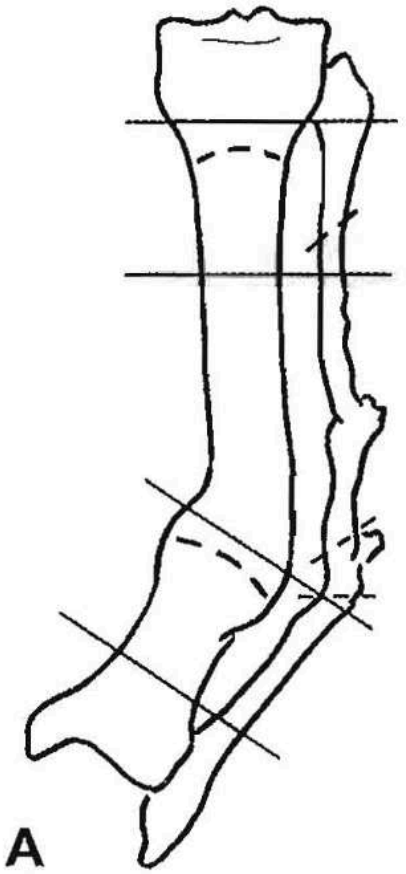
Mangalore

Assembling the frame

- General Considerations

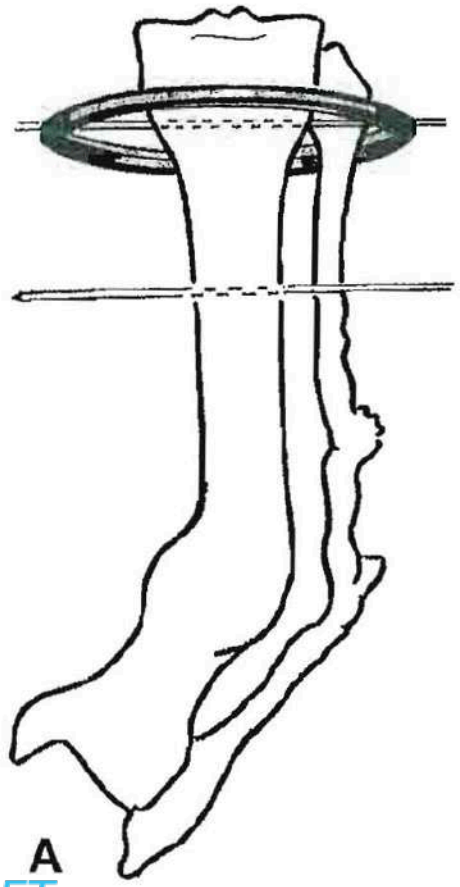
1. Stability of fixation of frame to the bone
2. Prevention of gross bone fragment motion
3. Ability to manipulate bone and to perform necessary fragment movements such as straightening, bending, distraction, compression, rotation and combination of these movements

Preassembled method of frame application



A

Assembling frame during surgery



Pre-assembled vs Intraoperatively assembled

- **Pre-assembled**

Saves time during surgical procedure

Gives surgeon the latitude to try some component variation

Requires adjustment during surgery, cannot foresee all necessary modifications

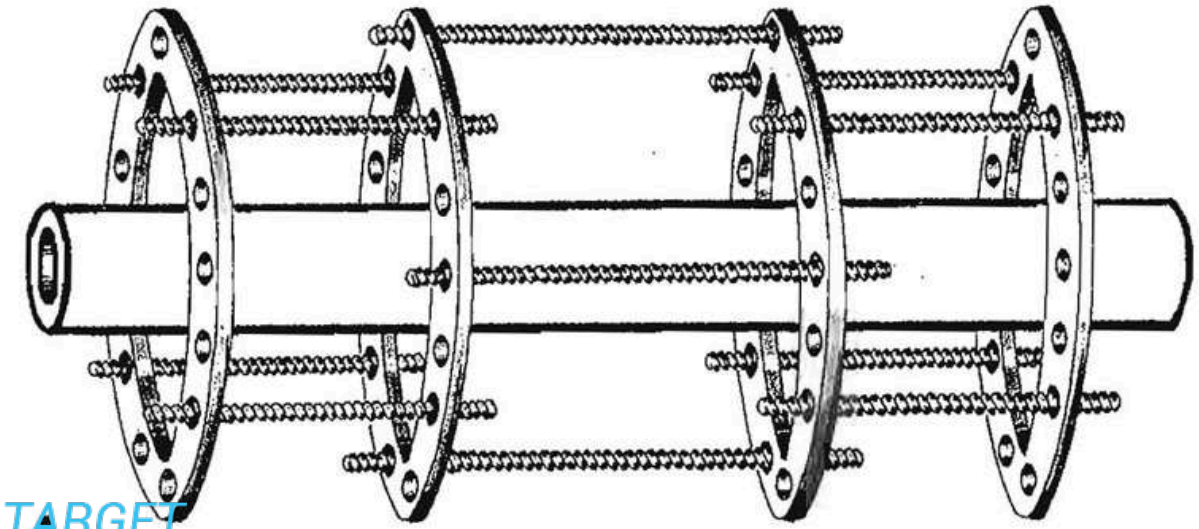
- **Intra-operatively assembled**

Affords surgeon greater experience in practical frame construction details

Avoids making correction during surgery

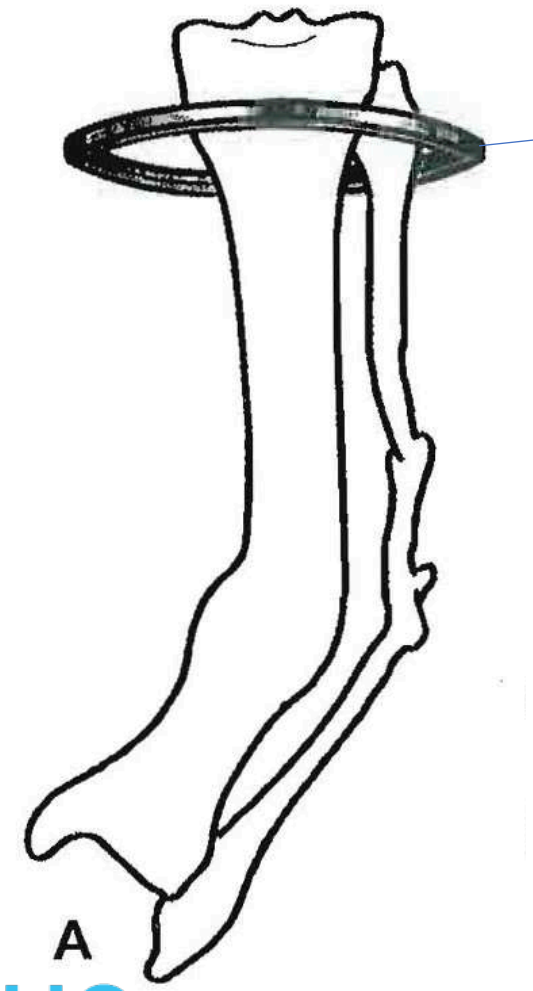
Increased surgical time in an already lengthy procedure

Rings are Chief component



- K-Wire support
- Frame formation
- Supplementary part support

Ring Positioning



MAIN PROXIMAL FRAME SUPPORTING RING

- Stationary
- Always located at the base of the frame
- Bears weight of the entire construction

What is the main proximal frame supporting ring used in Humeral frame ?

a) Italian arch

b) Omega Ring

c) 5/8th Ring

d) Half ring

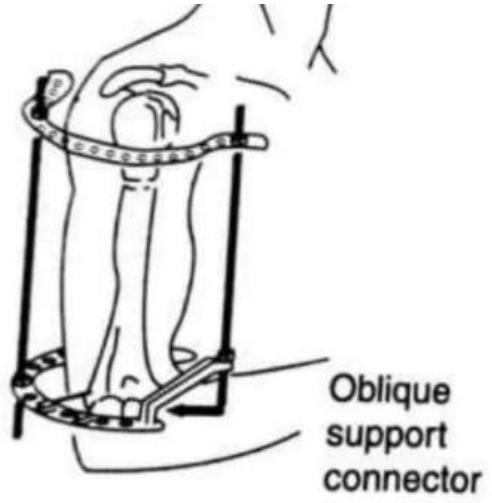
What is the main proximal frame supporting ring used in Humeral frame ?

a) Italian arch

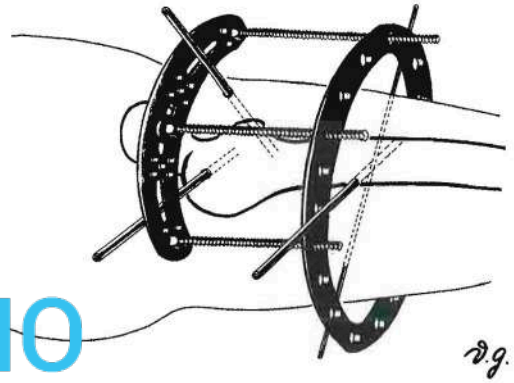
b) Omega Ring

c) 5/8th Ring

d) Half ring

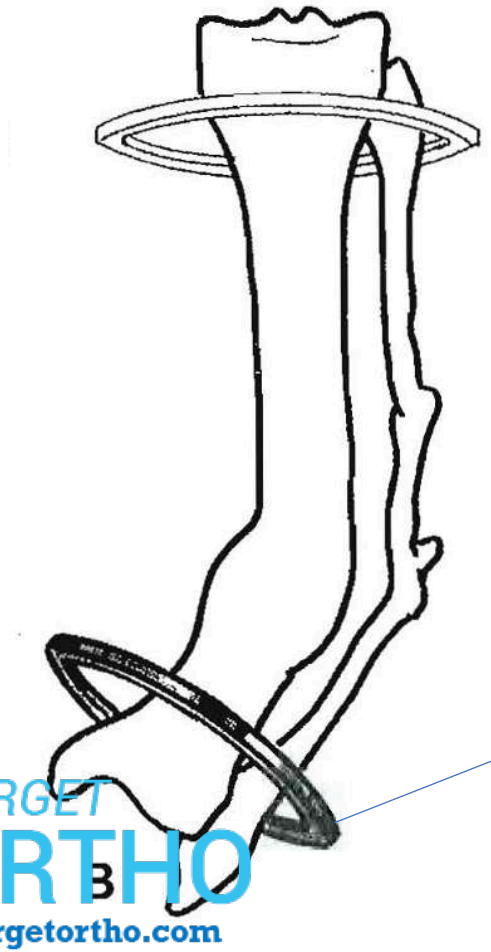


Omega Ring in Humeral frame



Supporting arch in Femoral frame

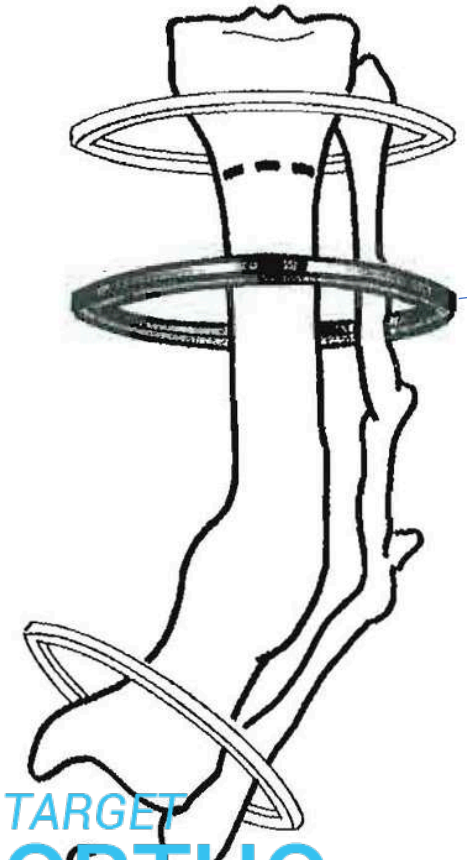
Ring Positioning



Always is located most distally
It can be stationary or movable depending on frame purpose

STABILIZING FRAME SUPPORTING RING

Ring Positioning



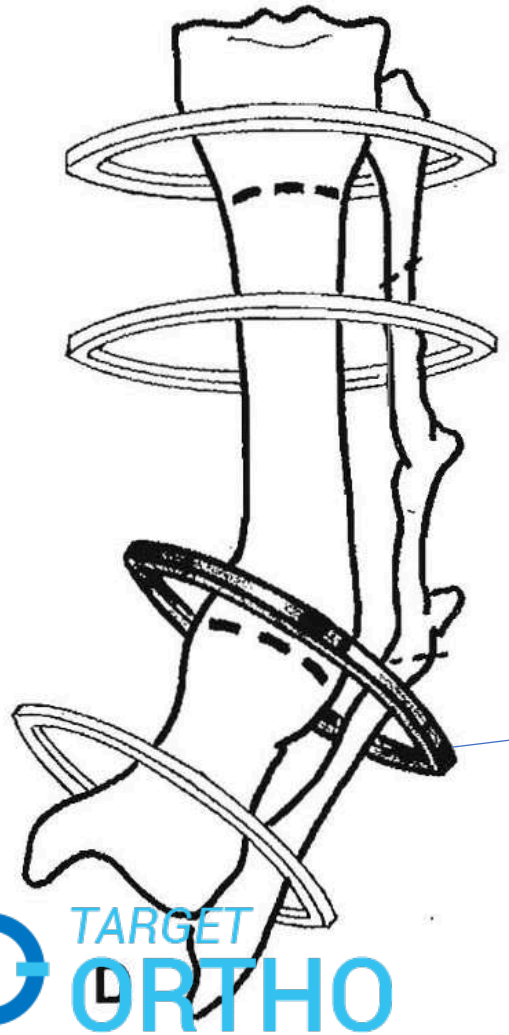
PUSHER PULLER RING

Movable ring used for application of distraction-compression forces

Located distal to fracture-osteotomy-nonunion site

Depending on frame size, there may be two puller-pusher rings acting simultaneously or in opposite directions

Ring Positioning



Medially located ring
Used as reference for the supporting rings or distraction-compression rings
Can be stationary or movable on location

REFERENCE RING

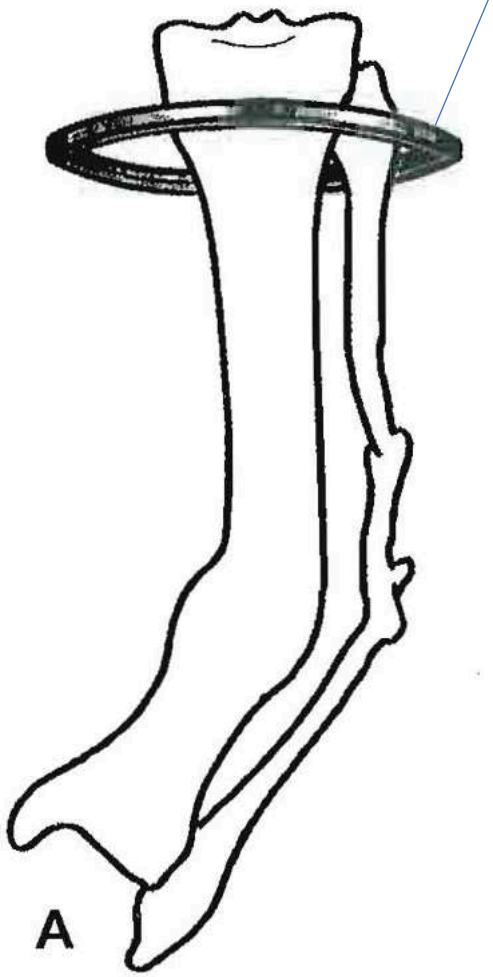
Ring Level

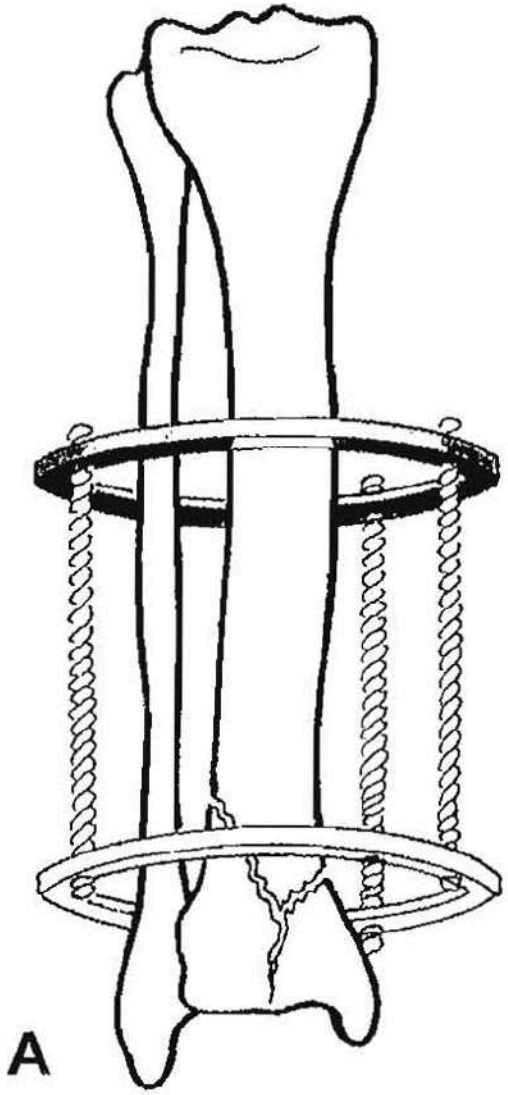
- Choice of Ring level determines distribution of the forces applied to the ring.

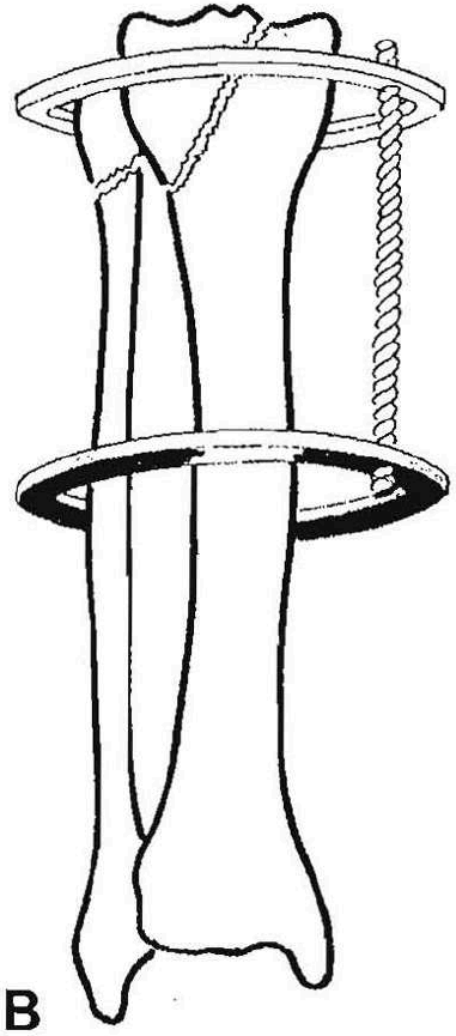
The motionless, main supporting ring supports the primary frame stabilization forces

Located on the strongest and widest part of the bone

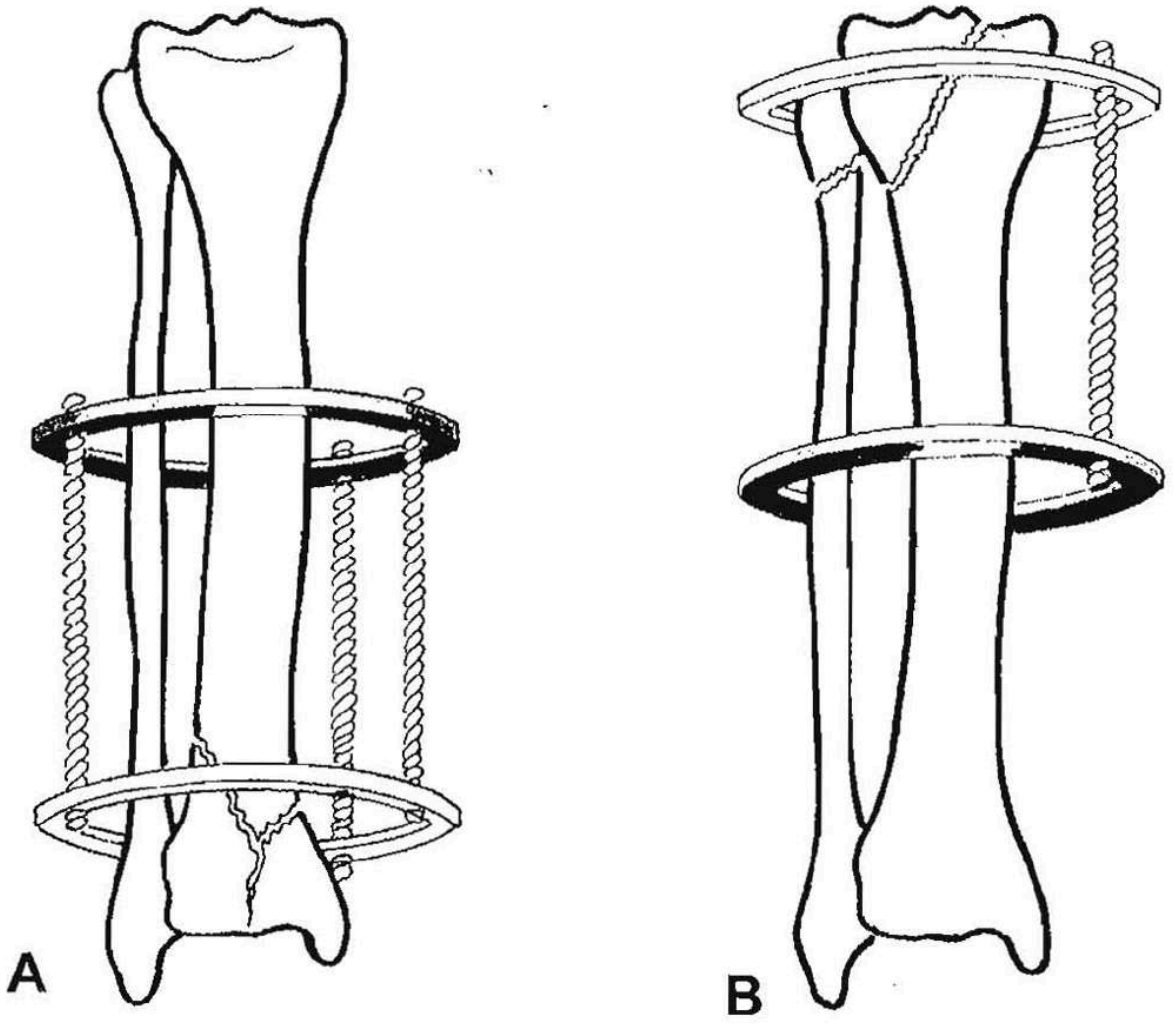
3-5cm distal to joint space







Main supporting ring 3-5 cm distal to joint space



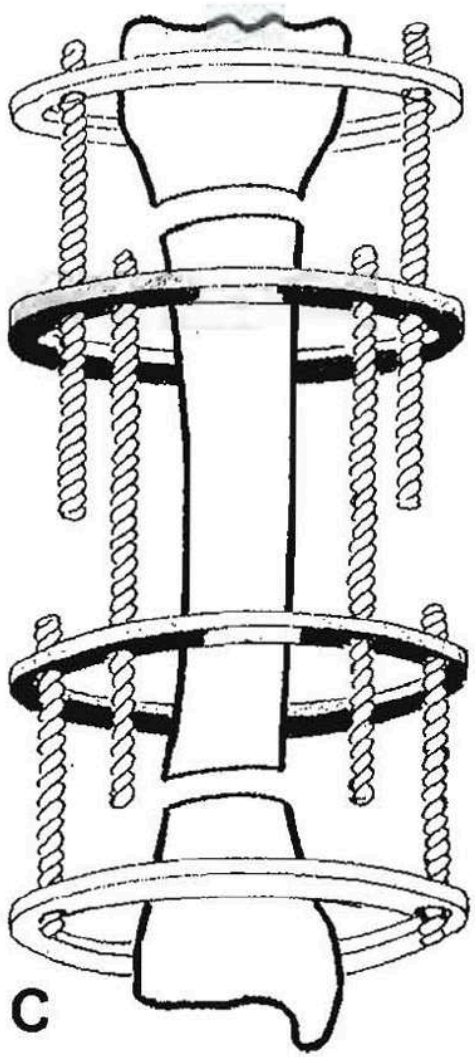
Stabilizing frame supporting ring

- Determines forces of stabilization
- Balances to the main supporting ring

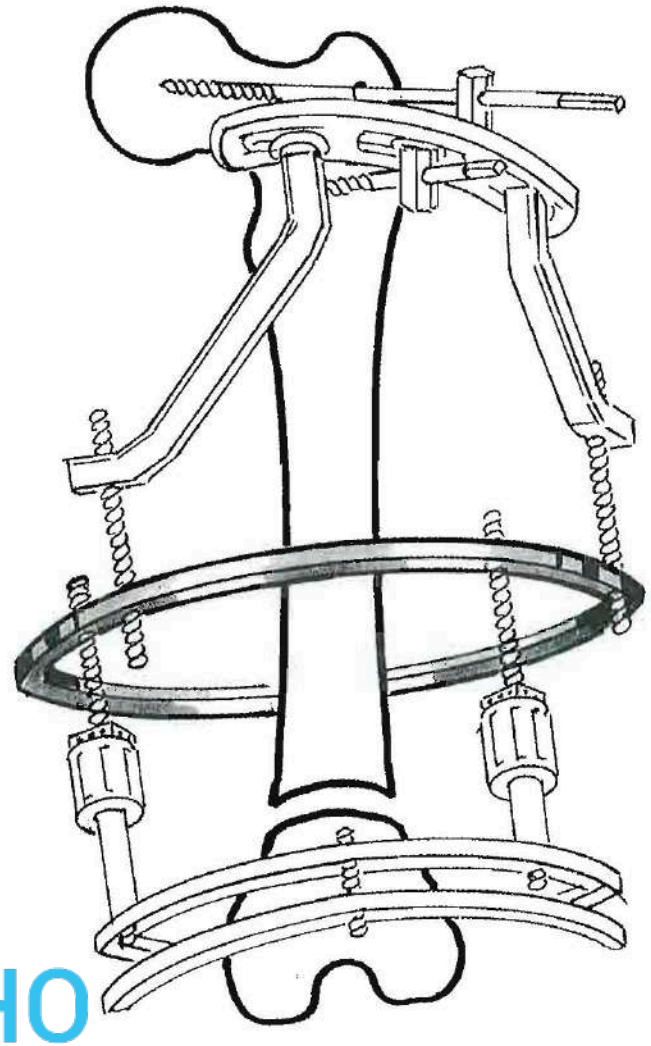
Pushing Pulling Ring

To act most effectively these forces must be applied close to the site of the osteotomy, fracture, nonunion.

Consideration of the general principle of preservation of bone fragments ends that is, a distance at least **3 to 5 cms** must remain



Reference Ring (Free Ring)



Determines the distribution of translational forces along the limb

Hence placed at the level of the intersection of these forces – corresponds to apex of bone angulation

Reference ring remains without any wire fixation

Ring Inclination

Choice of ring inclination = direction of forces applied to the ring

Each ring has to be set in a position of correct inclination with regard to bone axis

Ideal ring inclination ?

a) 90-degree angle

b) 100-degree angle

c) 80-degree angle

d) 45-degree angle

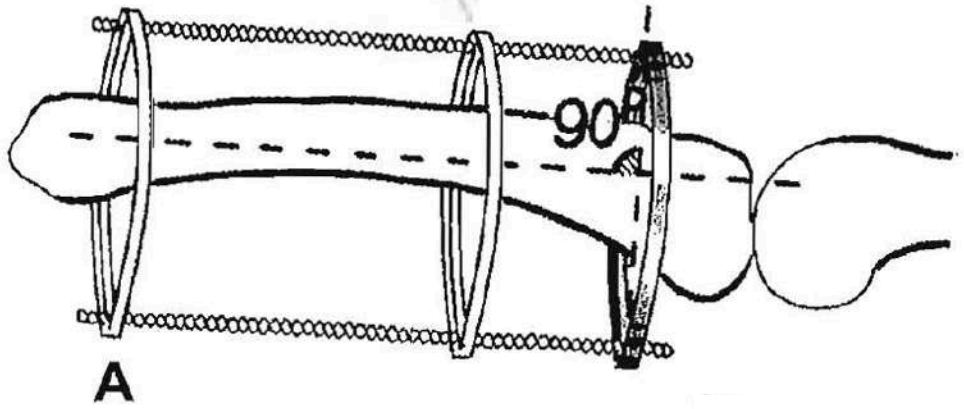
Ideal ring inclination ?

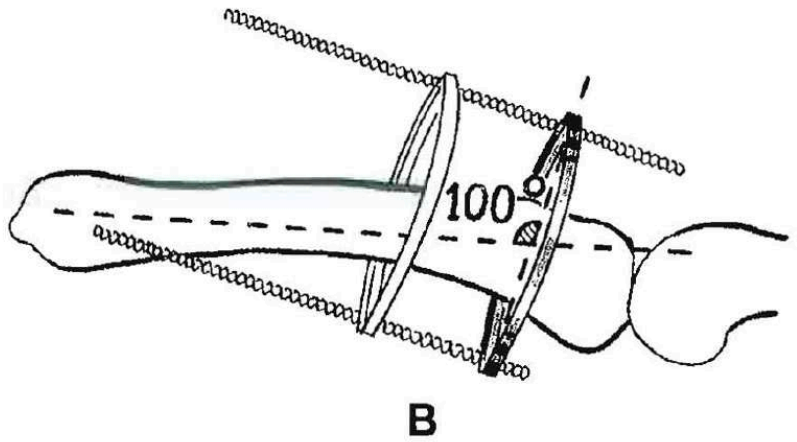
a) 90-degree angle

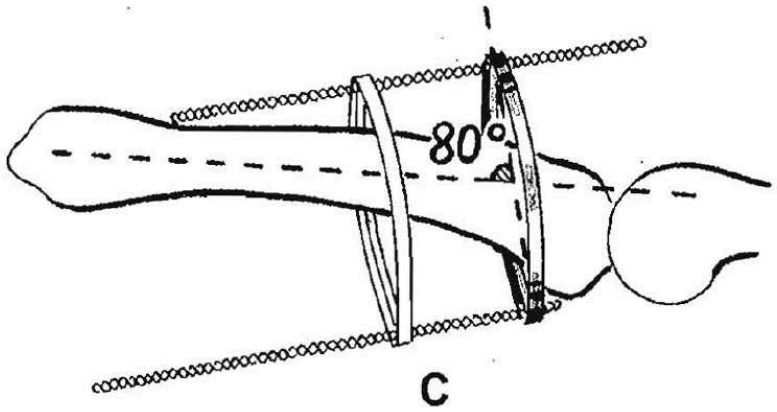
b) 100-degree angle

c) 80-degree angle

d) 45-degree angle



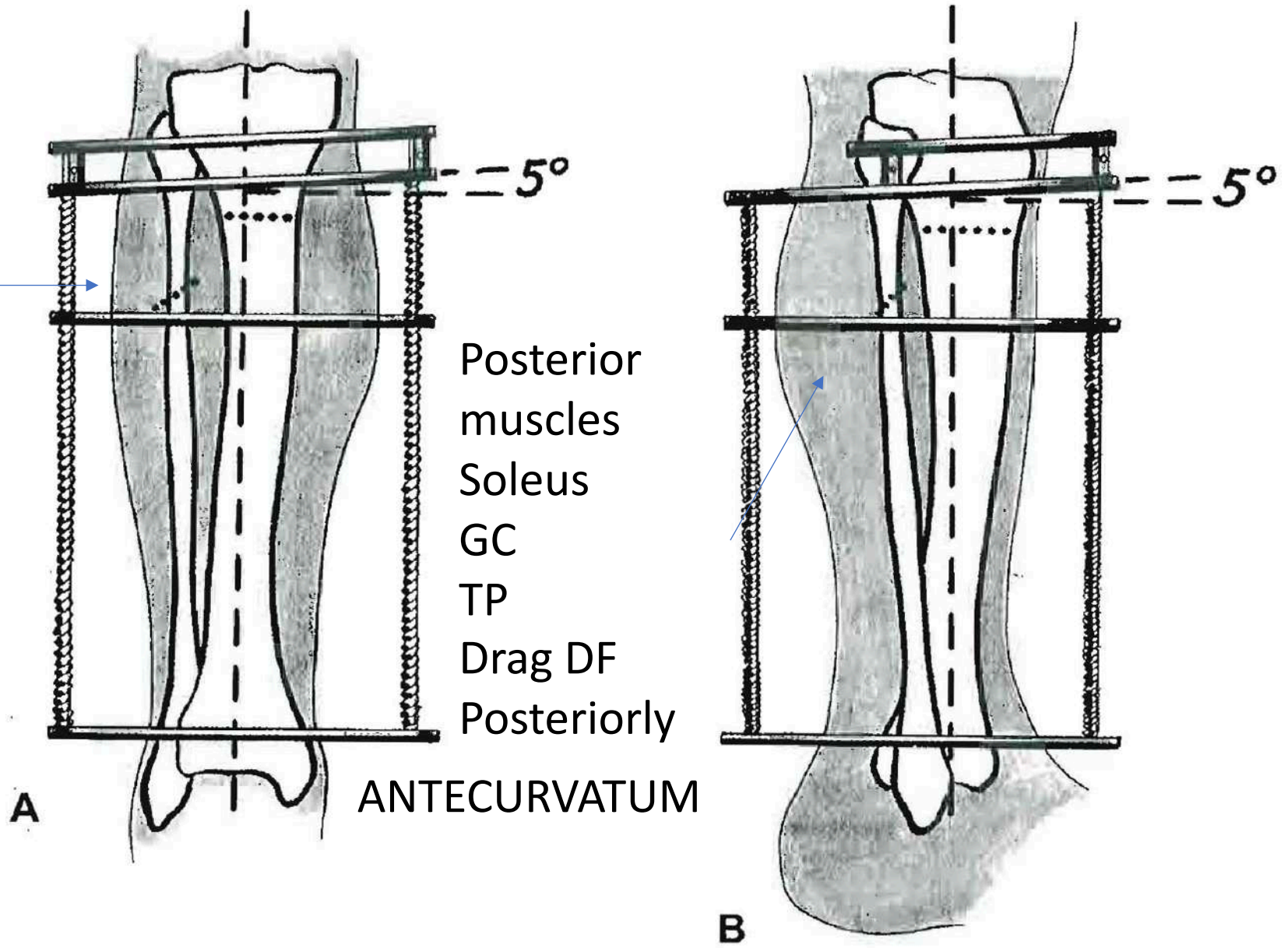




The ring is not positioned around the exact geometric center, but around the anatomic bony center of fixation

The only way to determine correct ring inclination is taking into consideration bone shape and position on anteroposterior and lateral radiographs

Lateral Leg Muscles
TA,EDL,EHL
Tend to drag a distal fragment laterally
VALGUS



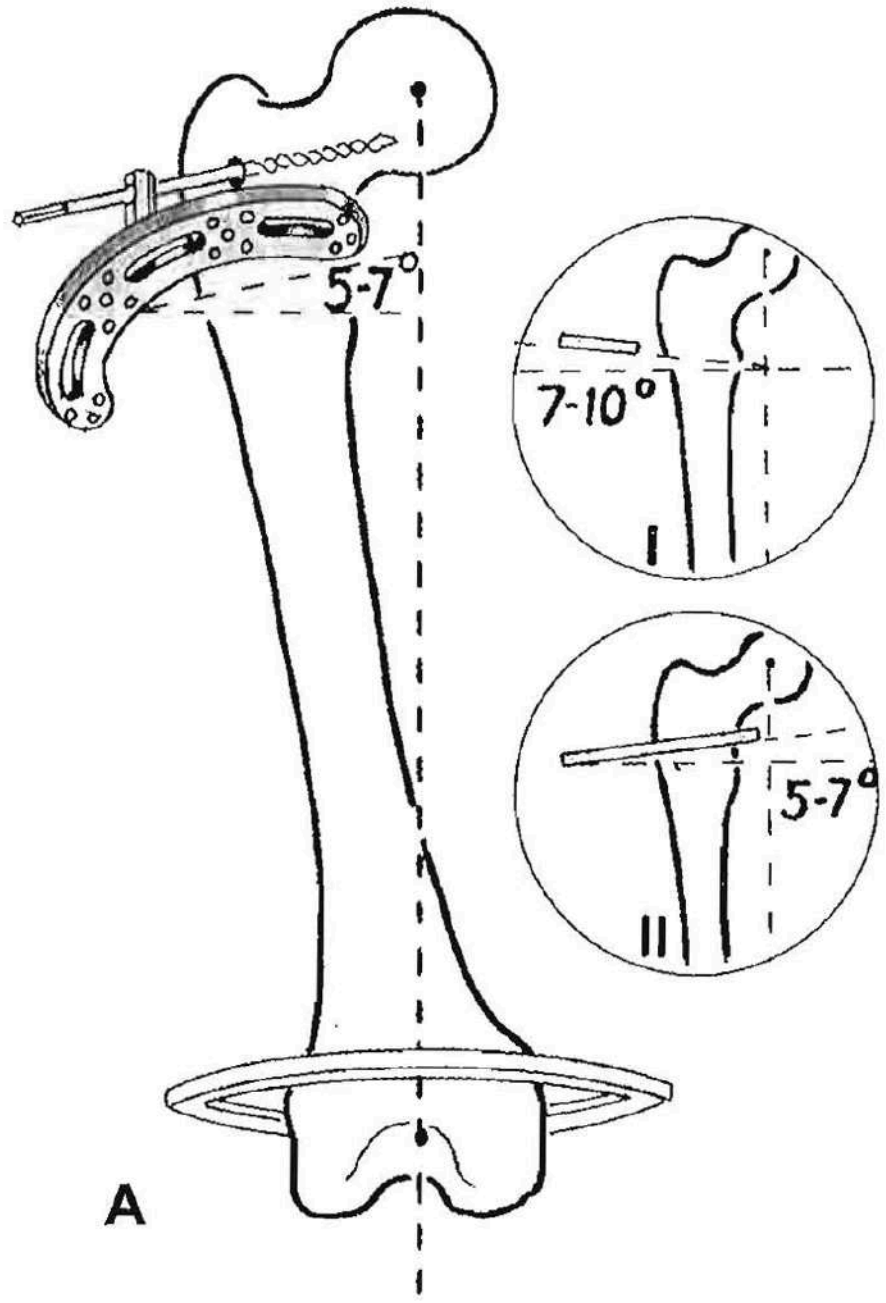
Posterior muscles
Soleus
GC
TP
Drag DF Posteriorly

ANTECURVATUM

PROXIMAL RING TITLTED 5 DEGREES (1CM)

ADDUCTOR GROUP
Tends to drag a distal fragment medially
VARUS

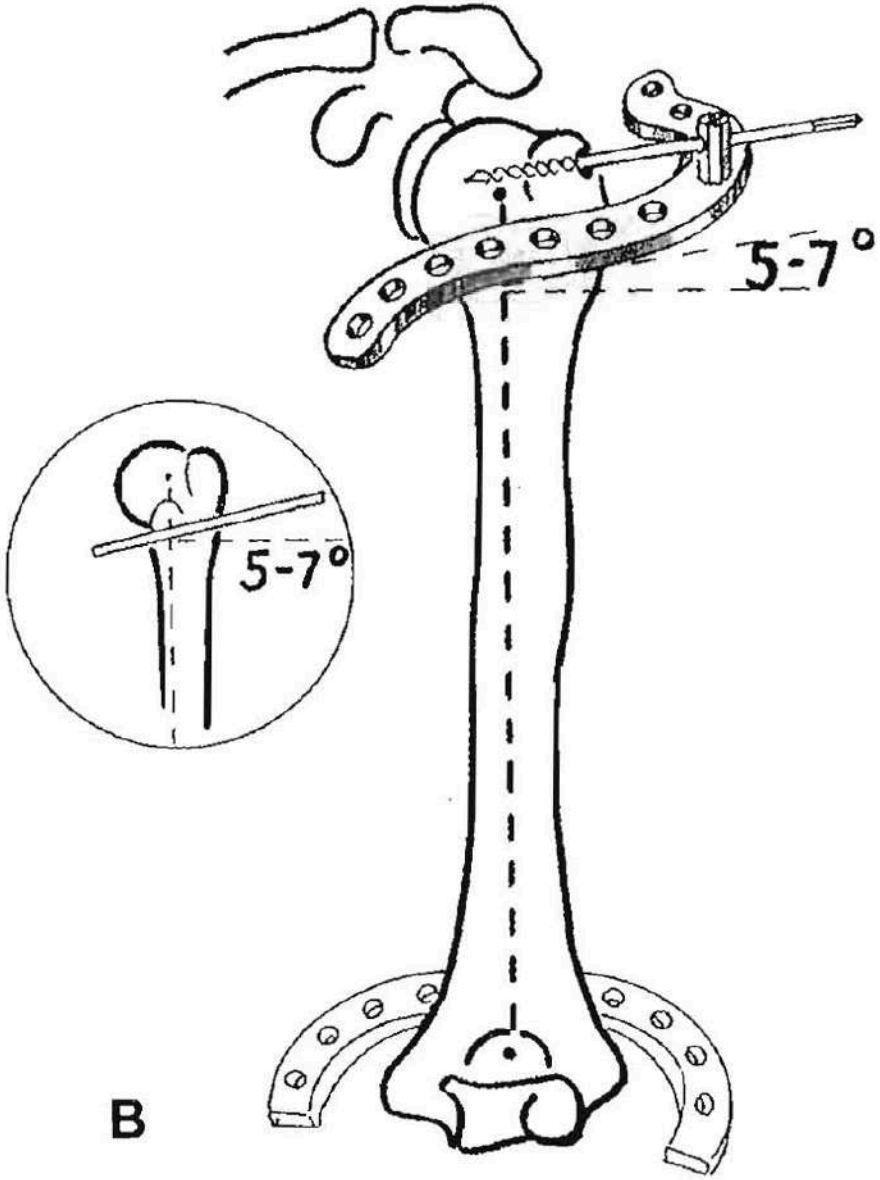
BICEPS FEMORIS
Tends to drag distal fragment posteriorly
POSTERIOR BENDING



7-10 DEGREES ABDUCTION

5-7 DEGREES ANTERIOR ELEVATION OF MAIN SUPPORTING ARCH

CORACOBRACHIALIS AND TRICEPS BRACHII GROUP
Tends to drag a distal fragment medially
VARUS

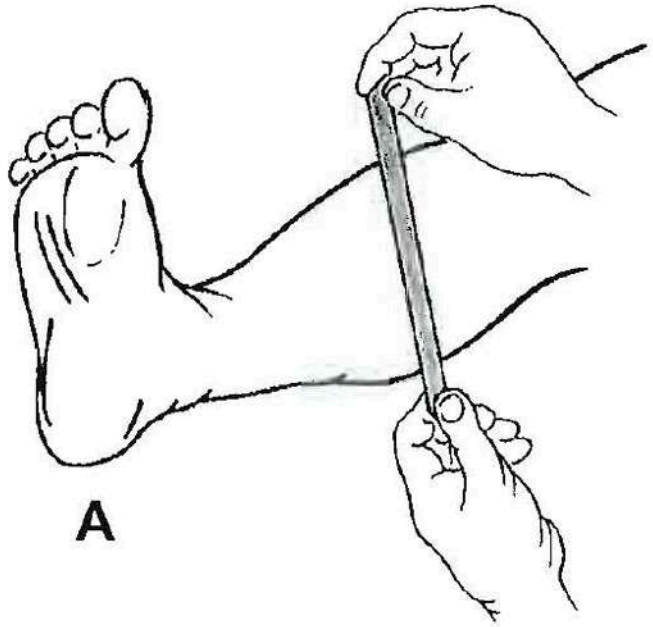


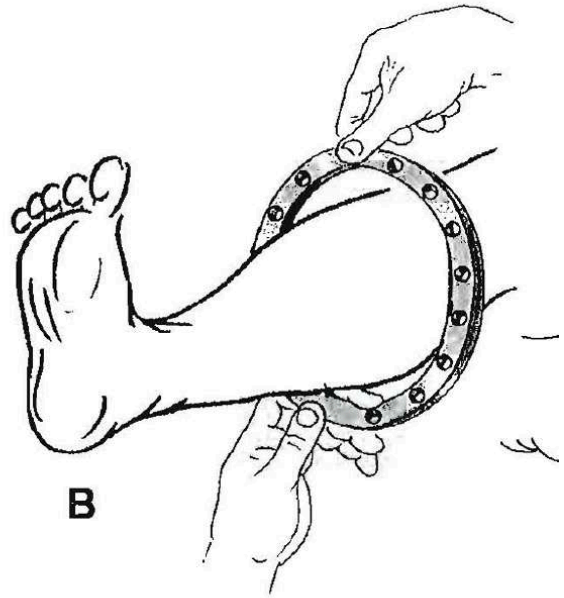
5-7 DEGREE ABDUCTION OF OMEGA RING ACHIEVES CORRECT POSITIONING OF DISTAL HUMERUS

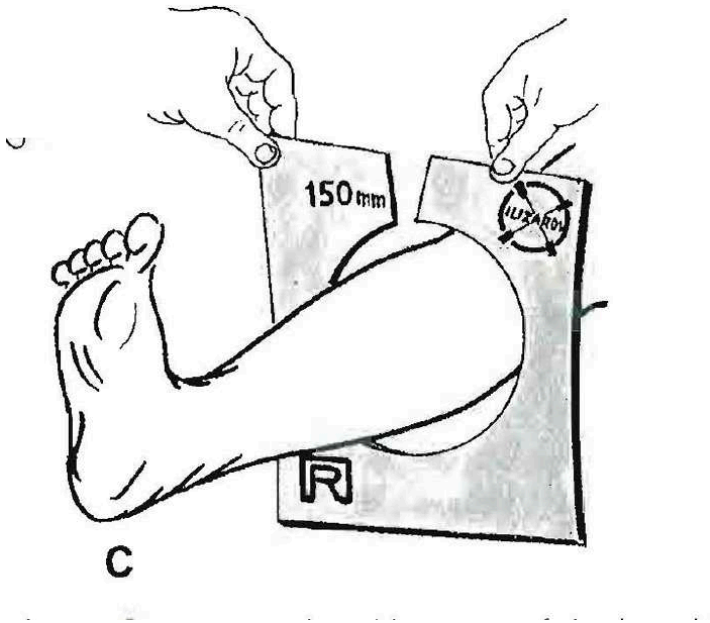
How to assess space between skin and ring?

How to assess space between skin and ring?

Independent of the level and angle of any rings, a space of **at least 3cm** should be maintained between inner curve of the ring and the skin.







Measurement performed in centimeters with a measuring tape before frame assembly

Taken in both frontal and sagittal planes

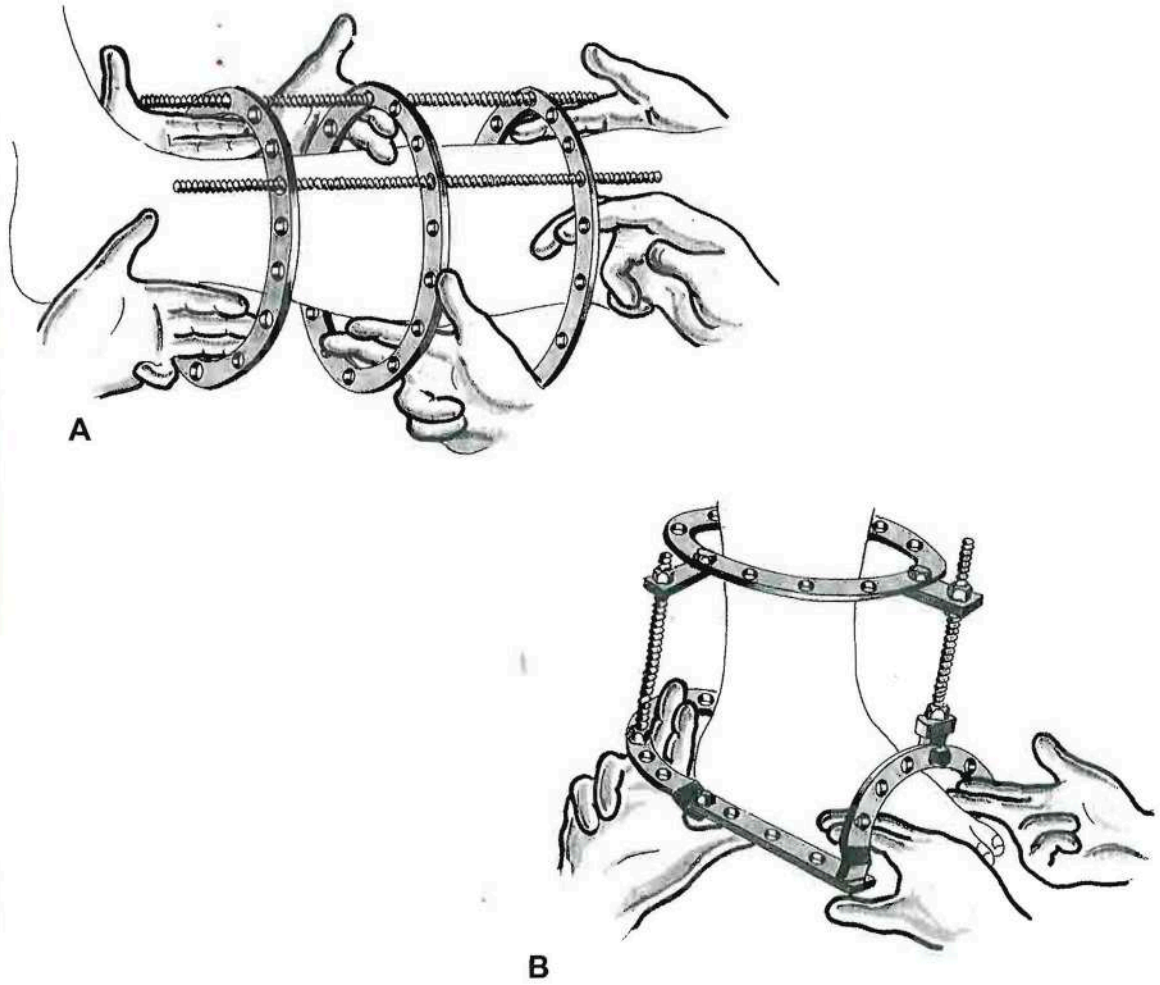
Largest figure taken and adding 6 cm to this provides internal ring diameter

Attach the ring of anticipated size over the limb where surgeon expects to attach it

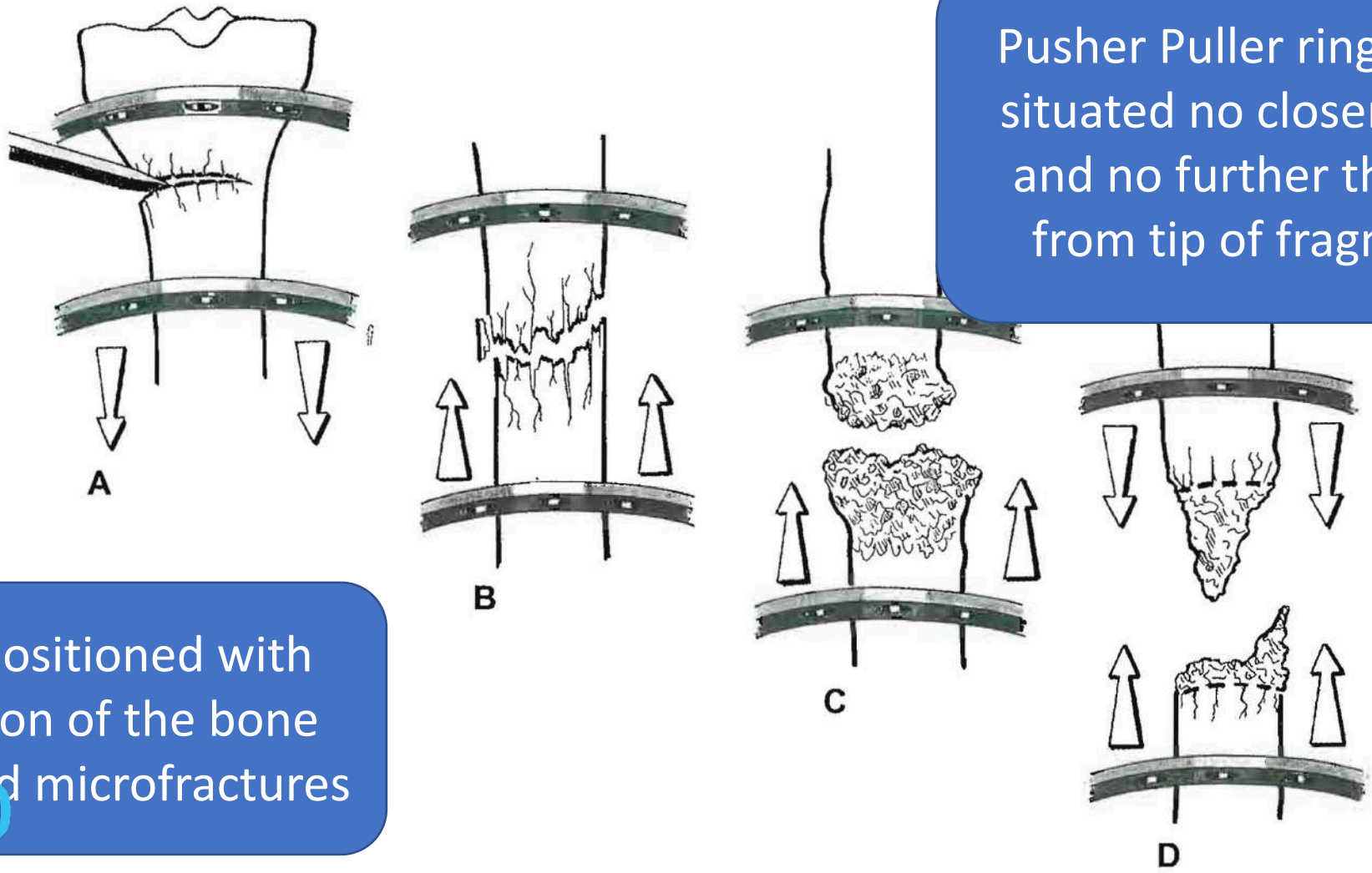
Ensure minimum 3cm gap at its narrowest section

Standard plastic templates over the limb at the presumed ring levels

“Two Finger Breadth Rule”



Ring positioning at Osteotomy/ Corticotomy / Nonunion and/or fracture sites

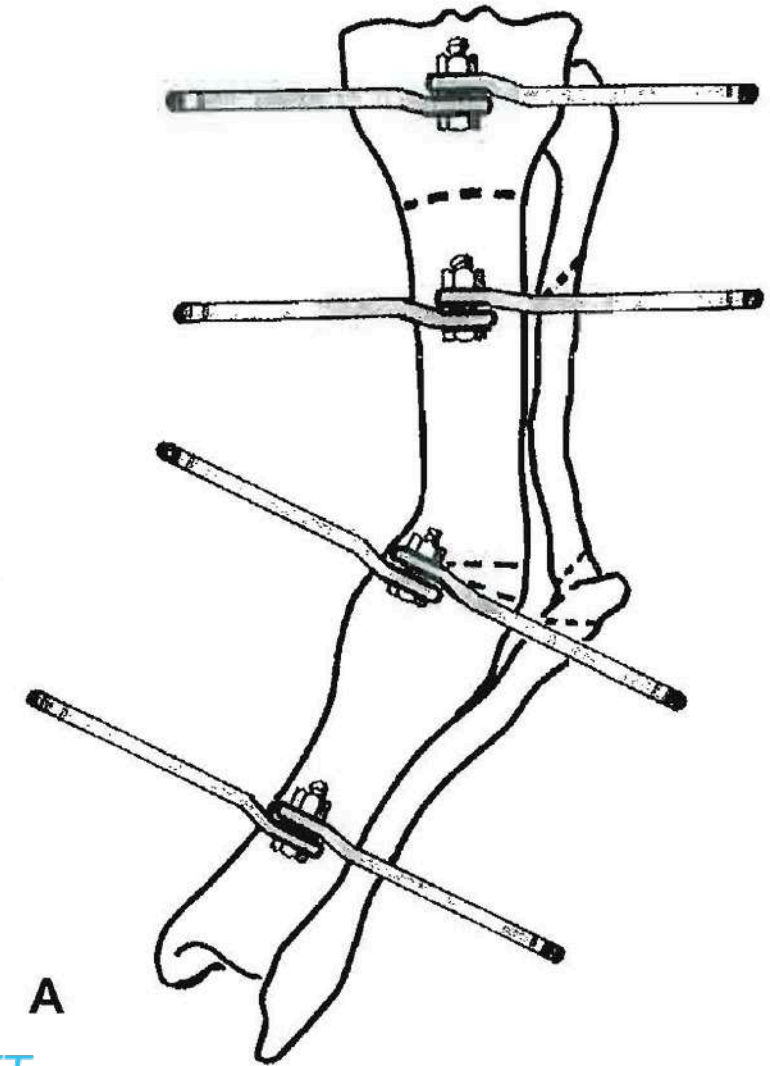


Pusher Puller ring should be situated no closer than 2cm and no further than 4-5cm from tip of fragment end

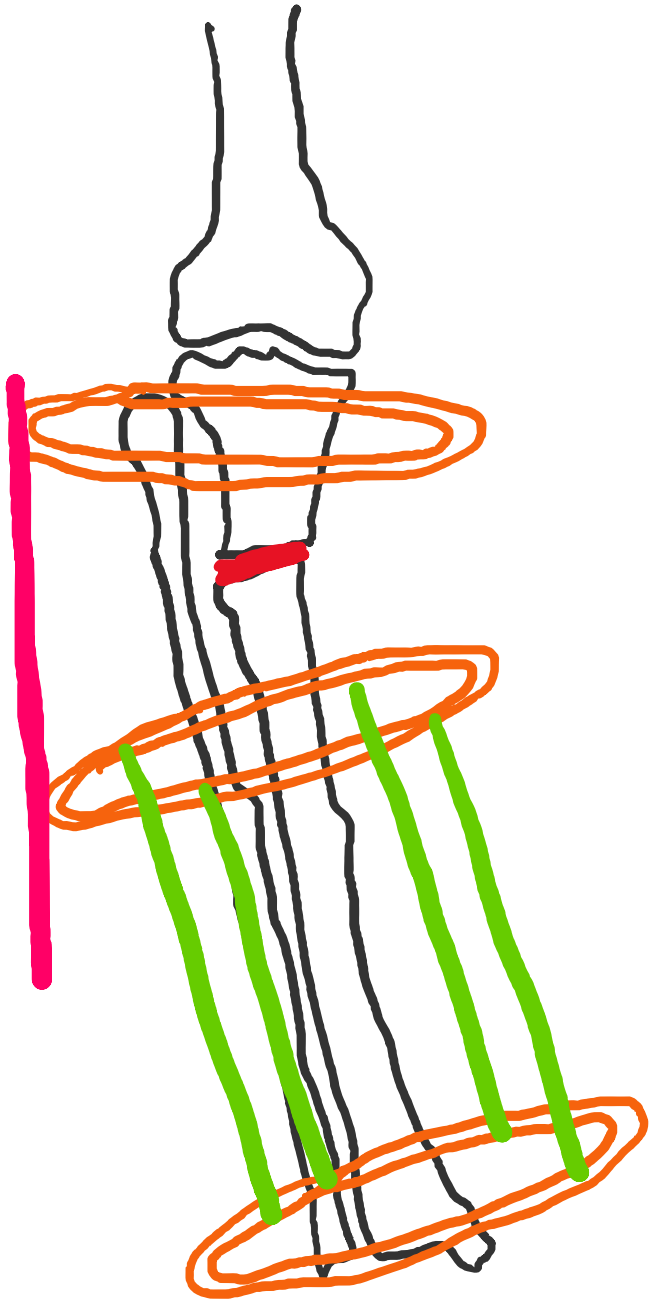
Rings are positioned with consideration of the bone resection and microfractures

Ring Orientation

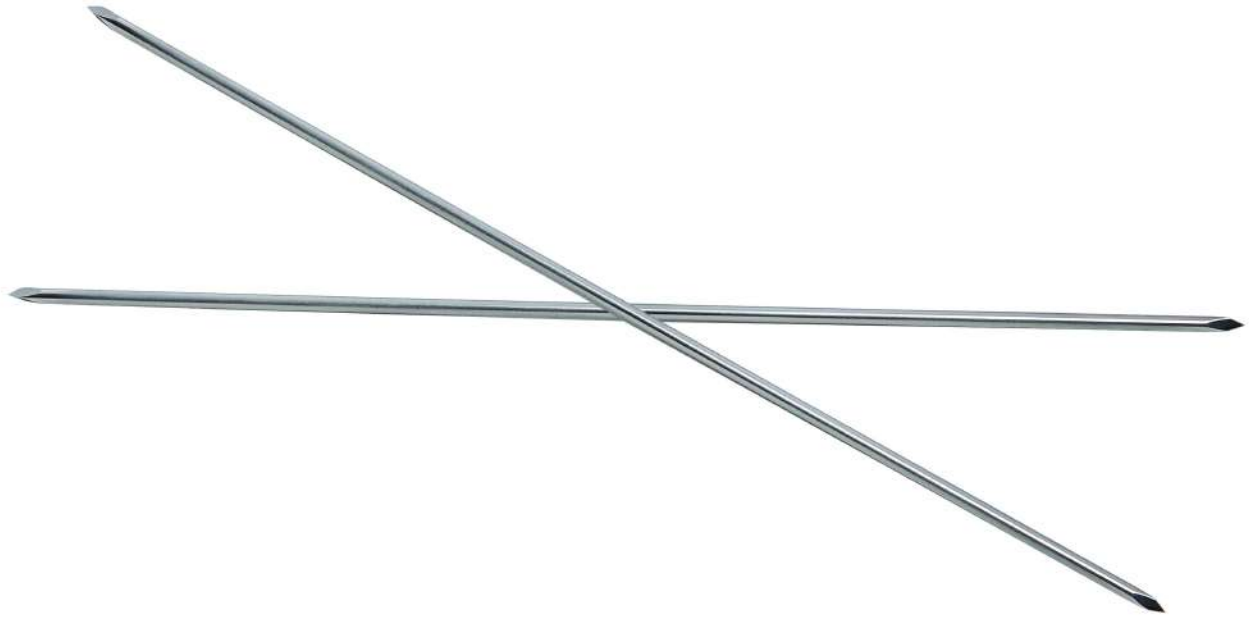
Regardless of the level, inclination or angulation at which different rings of the same frame are positioned, they all must be aligned in a configuration in which connecting parts of the half rings are situated along the same straight line



A



Wires : Types and Utilization



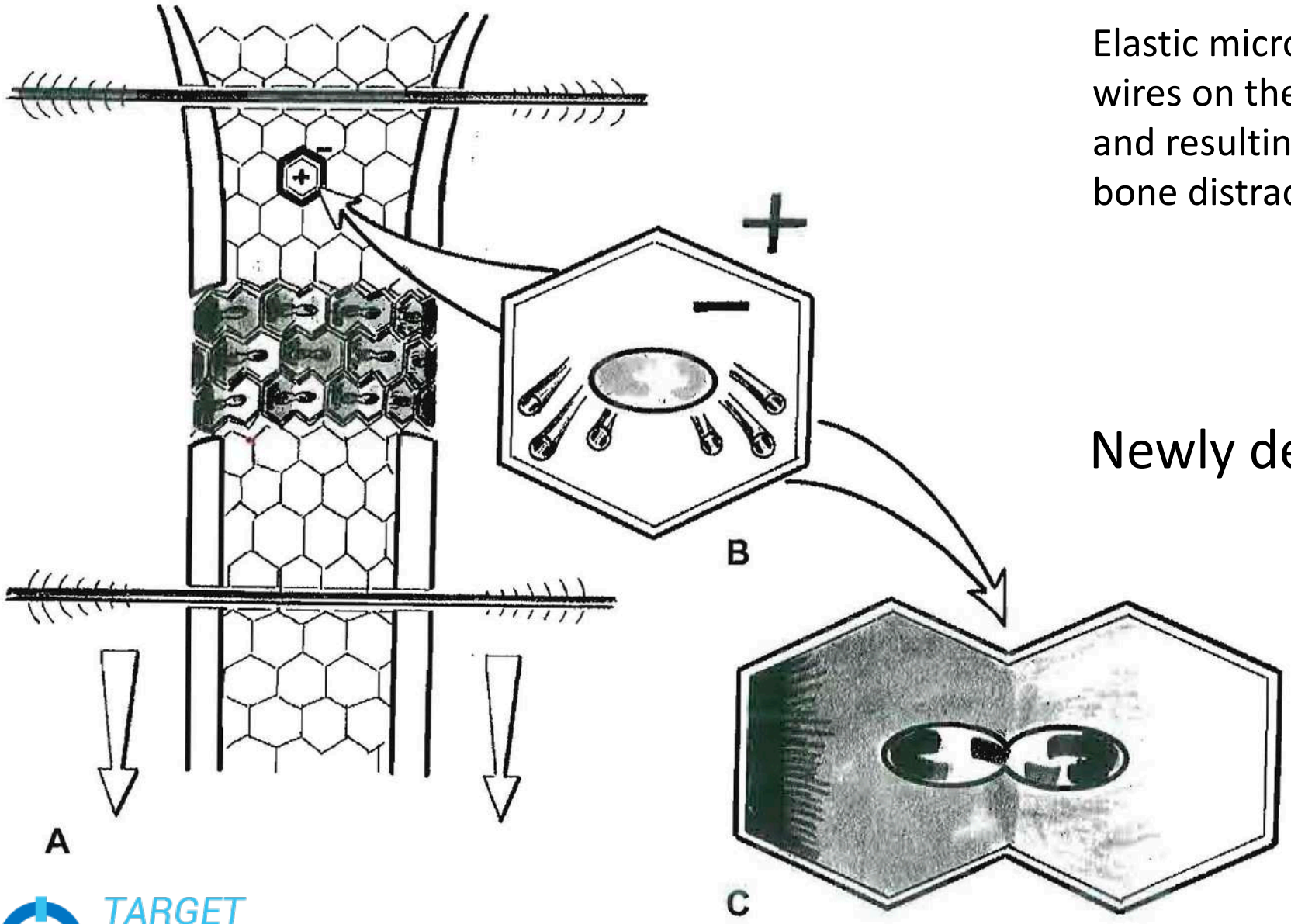
Kirschner Wire

- When drilled into tissue, it destroys very little compact bone and bone marrow
- If tensioned properly, it dampens vibration and prevents soft tissue and bony destruction because of elasticity
- After removal penetration holes are very small
- Its small diameter hole permits minimum external contamination

Advantage of K-Wires

- K wire has a combination of strong tensioning and elasticity which is the primary advantage of wire trans-fixation.

- Limited elasticity type of fixation has a particular advantage – it generates rapid callus and maturation



Elastic micromotion stimulating effect of the wires on the ion channels of the bone cells and resulting rapid cellular mitosis during bone distraction

Newly developed regenerate

Which of the following is the incorrect technique of Wire insertion in Ilizarov?

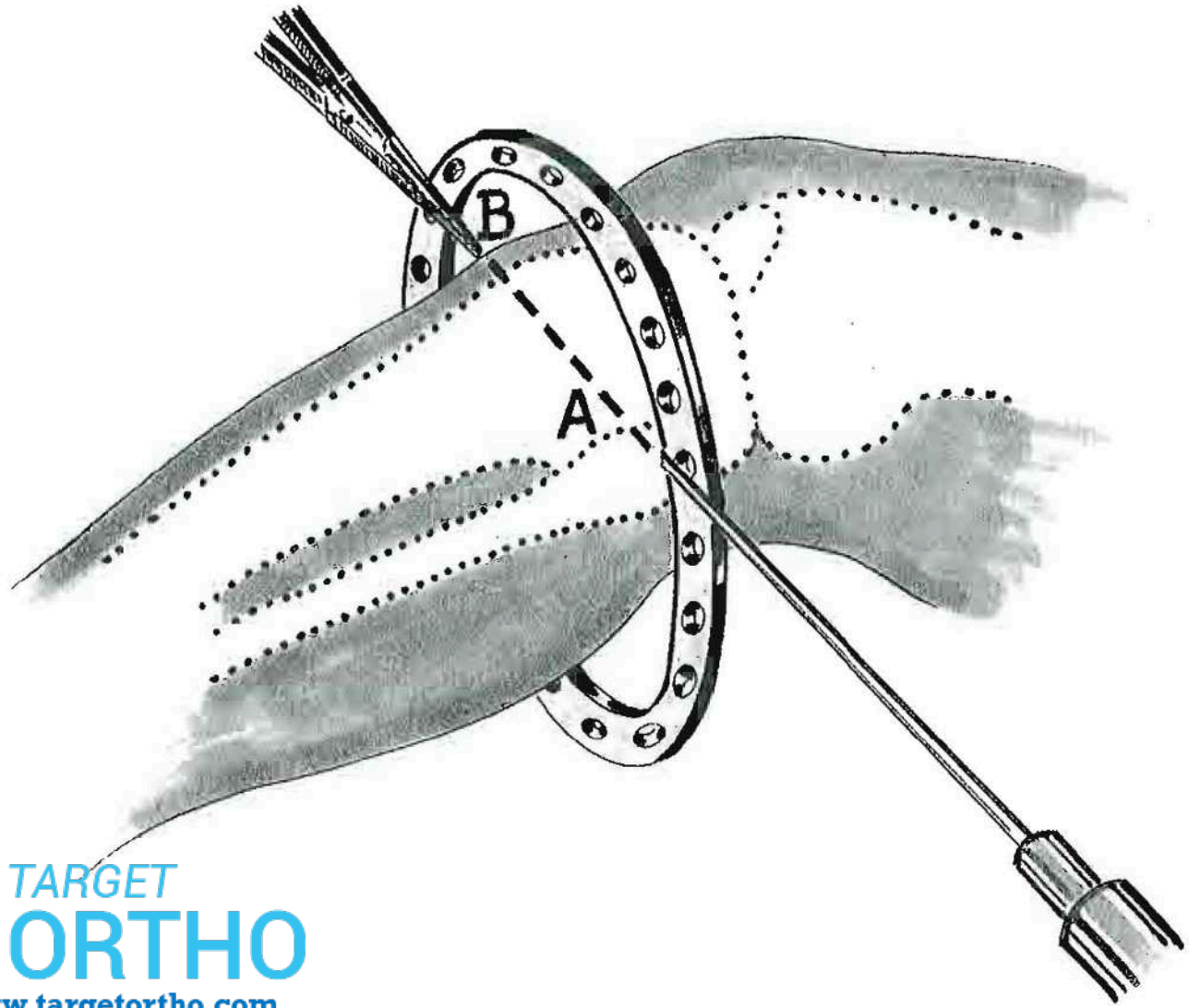
A) Low speed K-Wire tip introduction to avoid burning of tissue and prevent blood vessel and nerve injury

B) The entrance and exit points of K-Wire must be located atleast 1.5-2cms from major blood vessels

C) High speed K-Wire tip introduction to avoid burning of tissue and prevent blood vessel and nerve injury

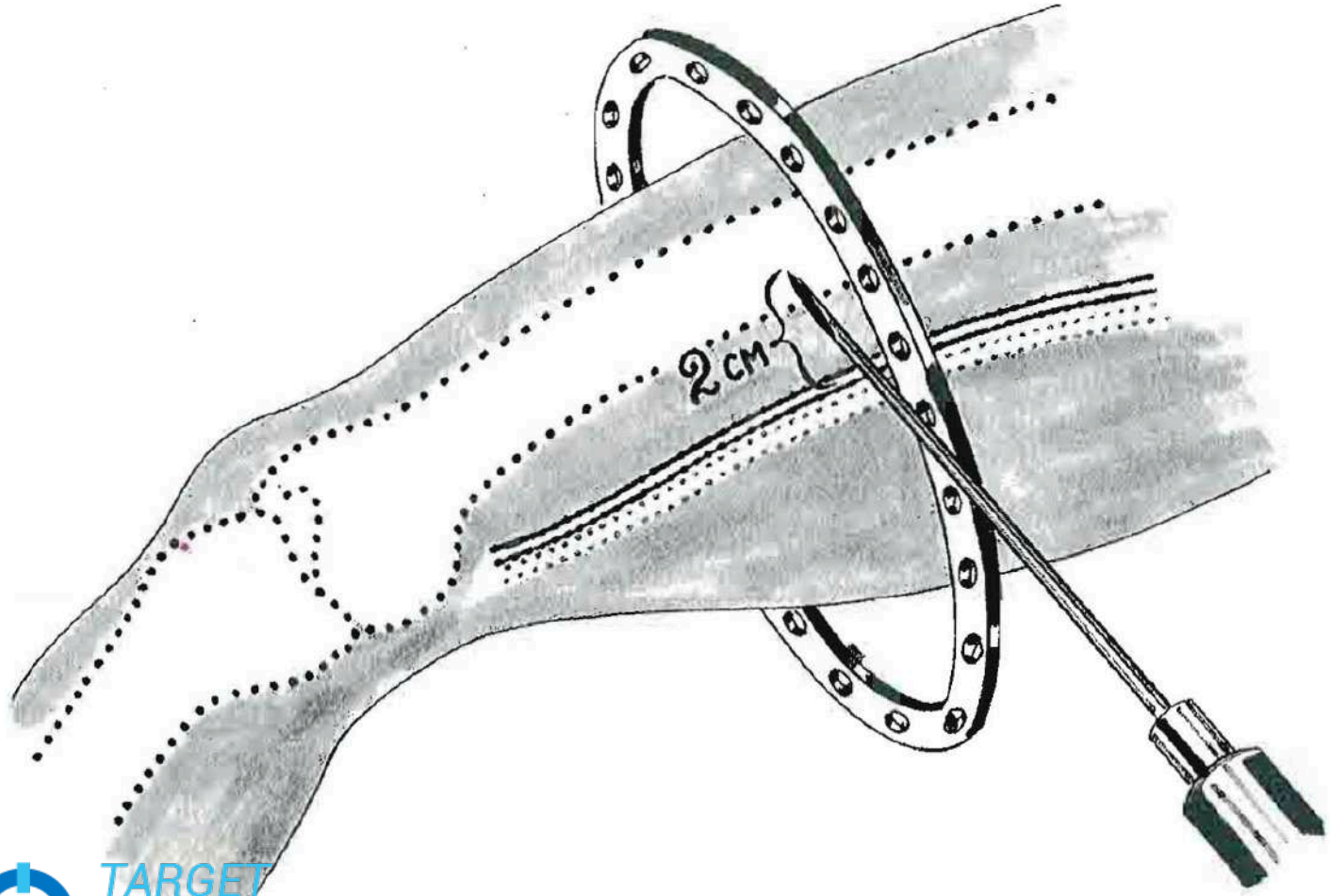
D) To prevent joint contracture, the muscles must be kept in a position of maximal functional length at wire penetration sites

Technique of K-Wire introduction



STEP 1
Before introduction, entrance and exit drilling sites must be determined

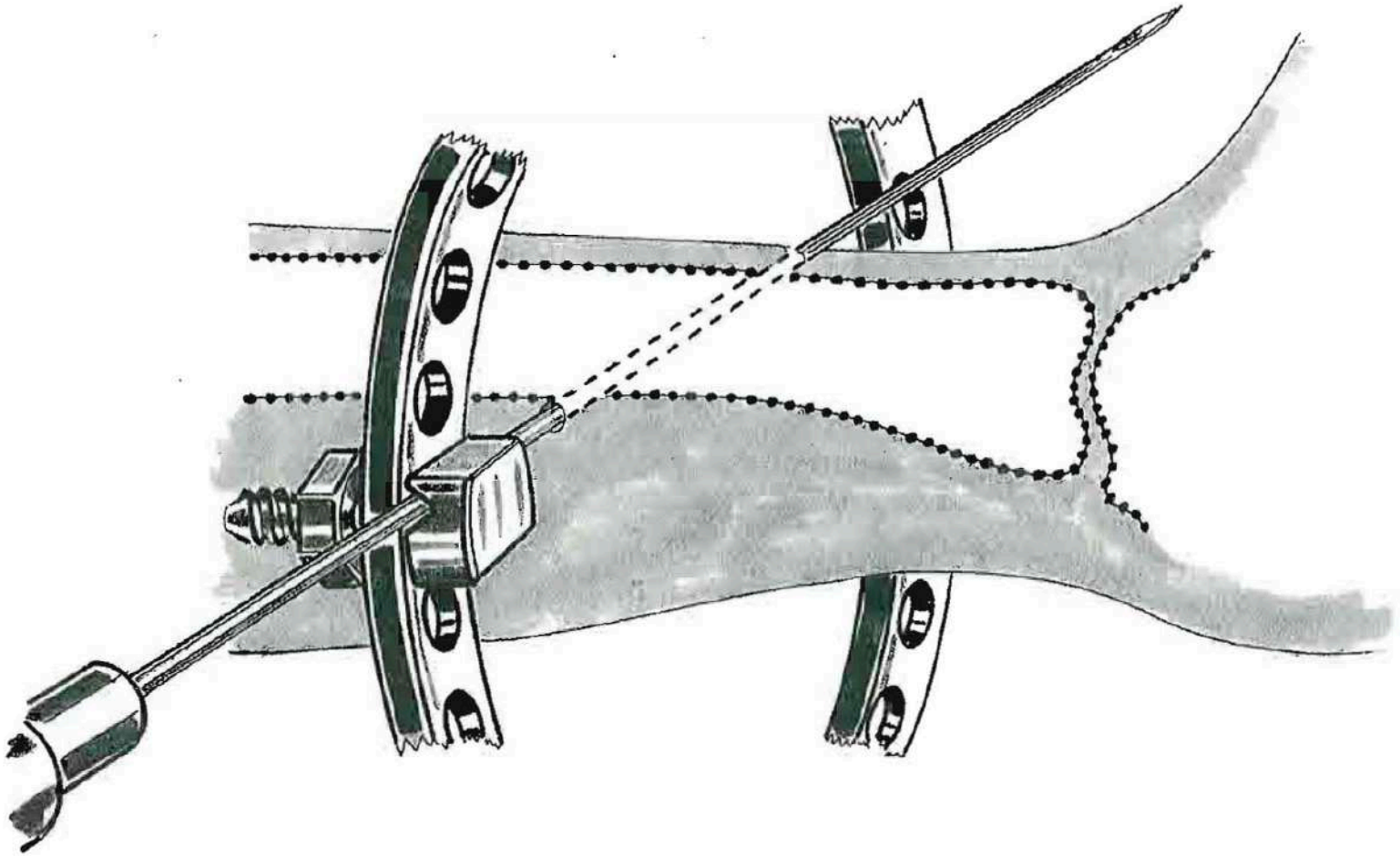
Technique of K-Wire introduction



STEP 2
Mark the projection of pulsating artery on skin with pen.

Entrance and exit of K-Wire points must be at least 1.5 to 2 cm from major blood vessel and nerve

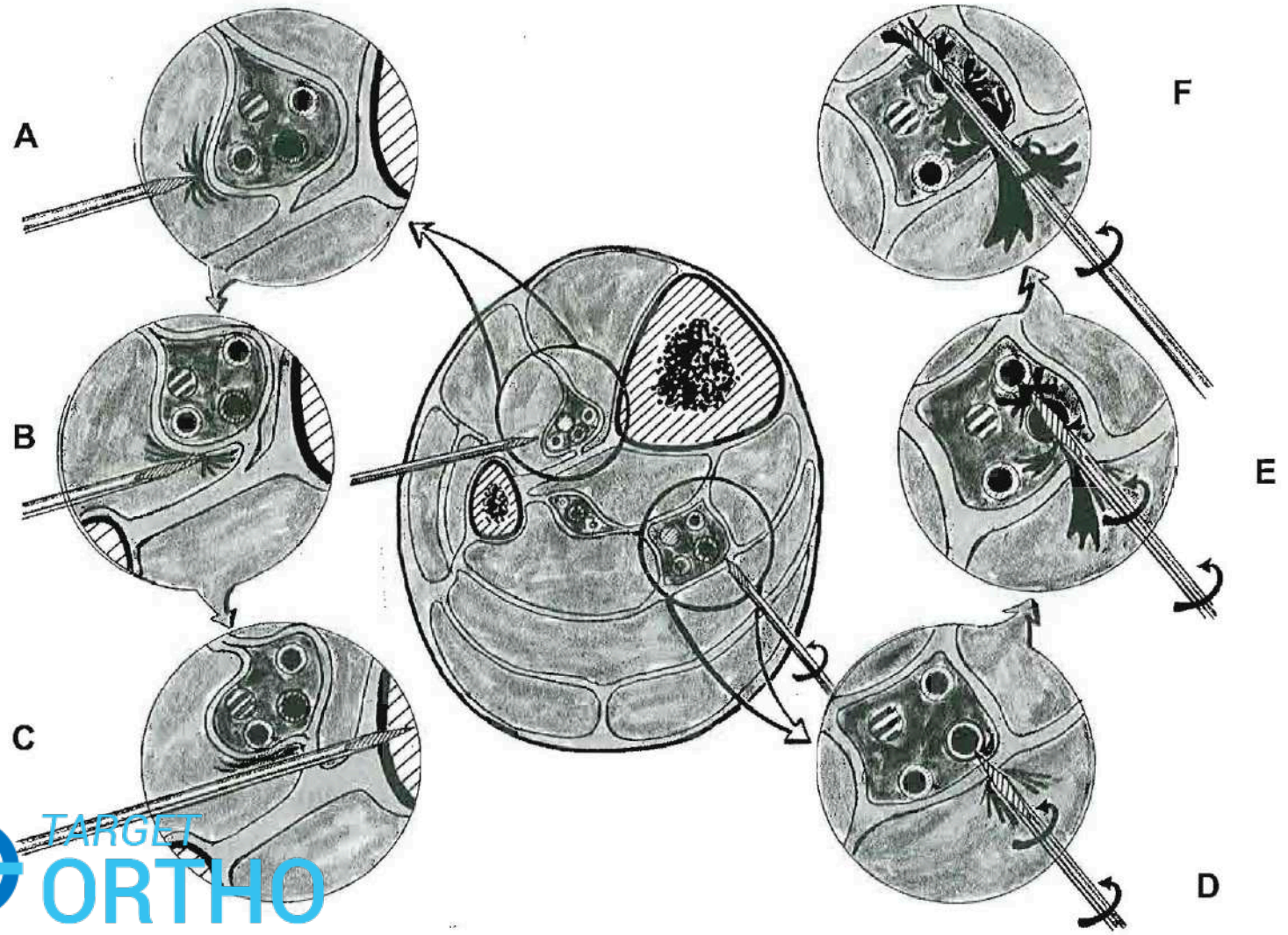
Technique of K-Wire introduction



STEP 3

K-Wire has to be positioned according to ring plane

Technique of K-Wire introduction

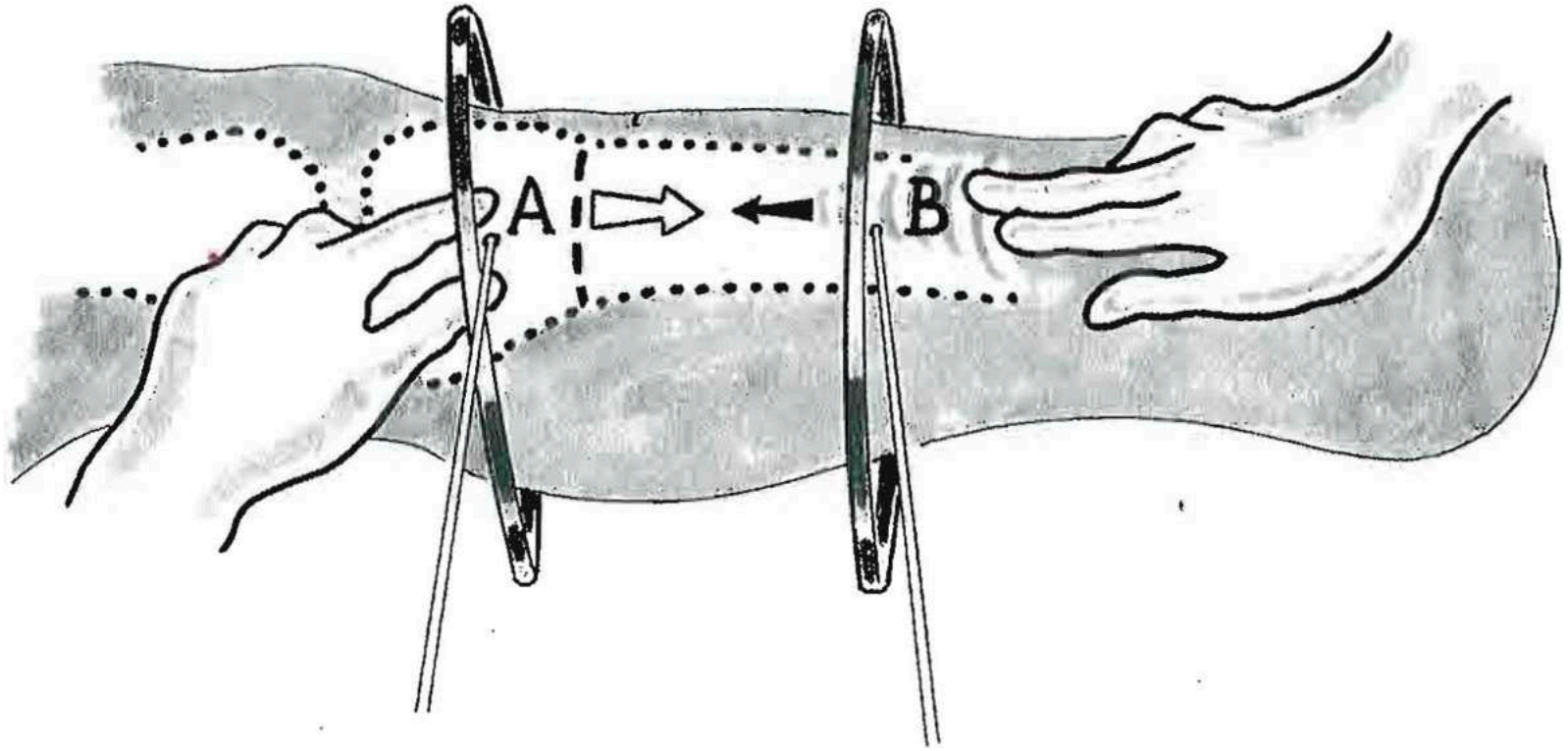


STEP 4

K-Wire must be introduced slowly pausing several times during the procedure to avoid burning of tissues

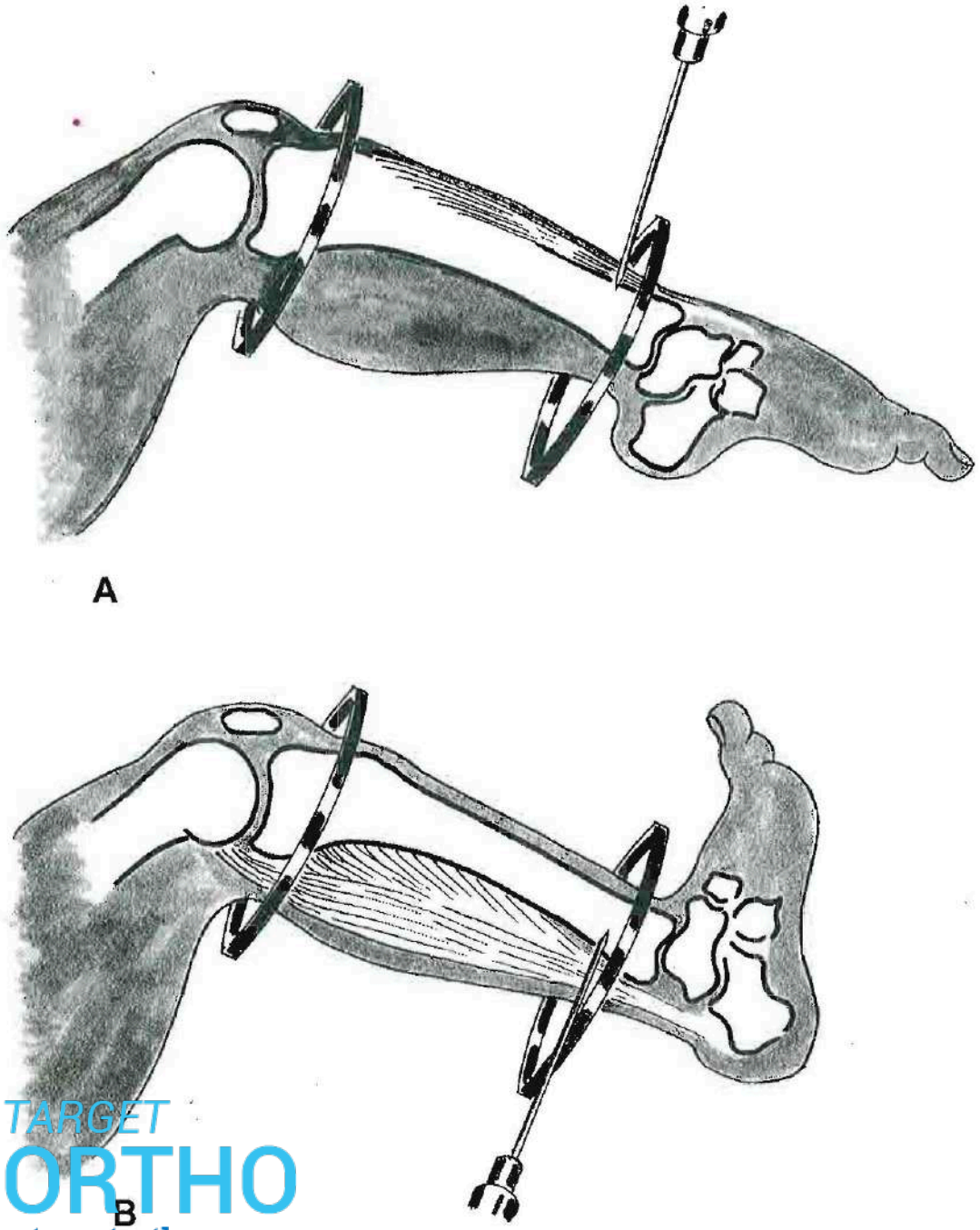
Low speed wire (< 30-40rpm)

Permits moving aside of important structures – minimum wire tip penetration



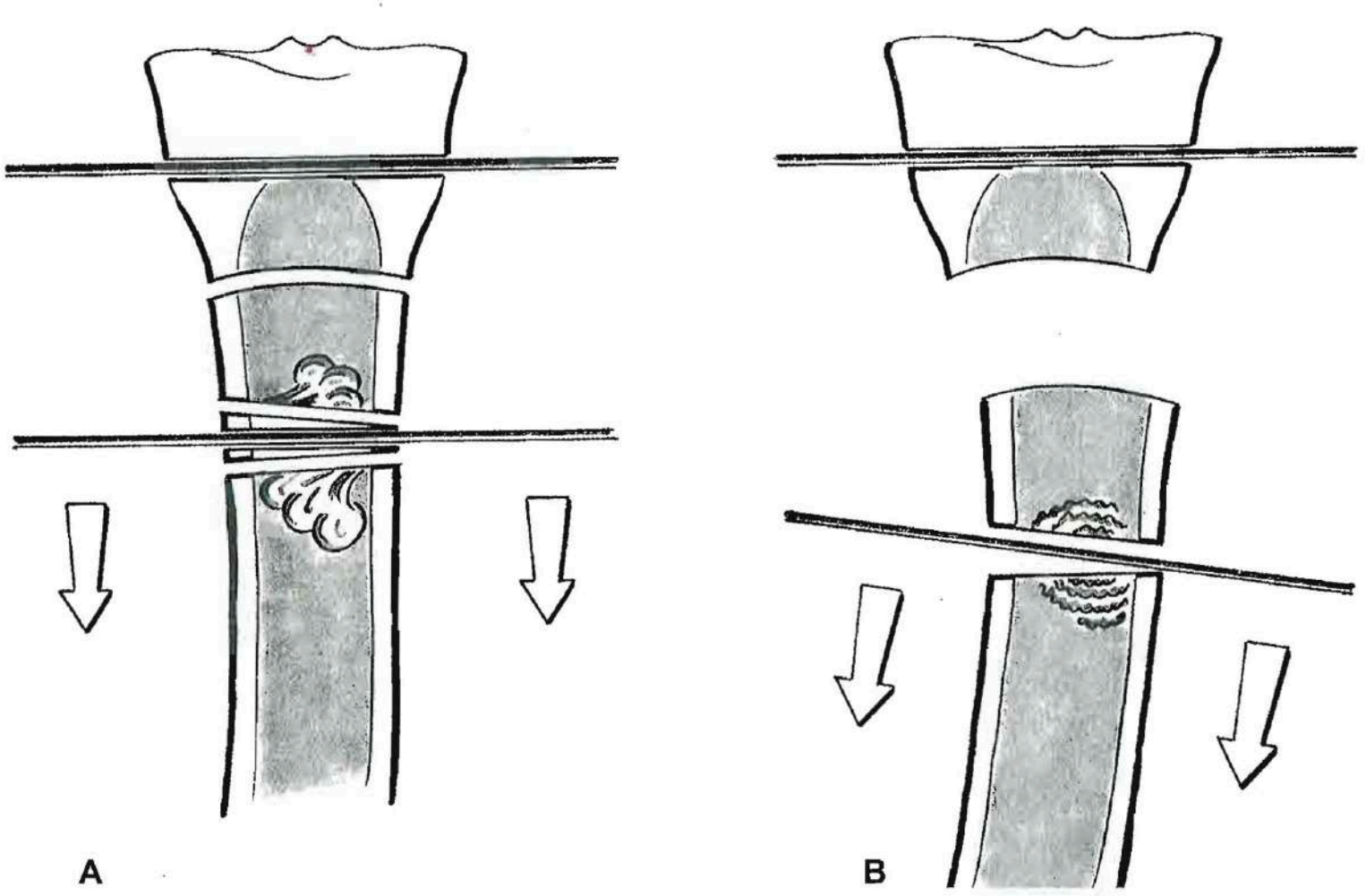
Step 5 : At the entrance and exit sites the skin must be supported by finger pressure to secure exact point of wire penetration

Trans-fixation – skin held firm and perpendicular
In planned distraction – skin pushed towards site of corticotomy
In planned compression - pushed away from site of compressed ends



STEP 6

To prevent joint contractures the muscle must be kept in a position of maximal functional length at moment of wire penetration



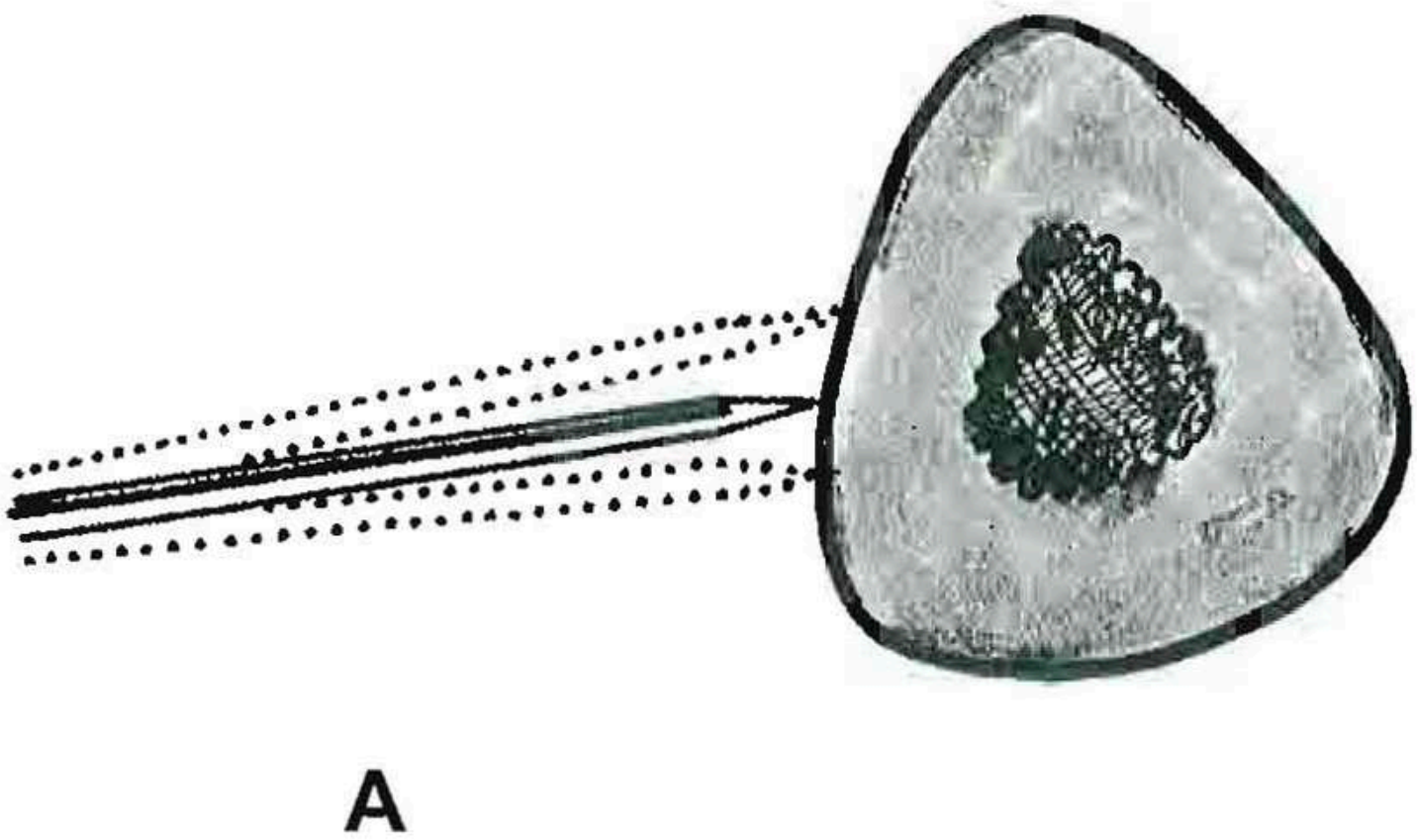
STEP 7

One wire, one hole rule

Multiple holes – destroy compact bone by mechanical damage and burning

Surgical technique

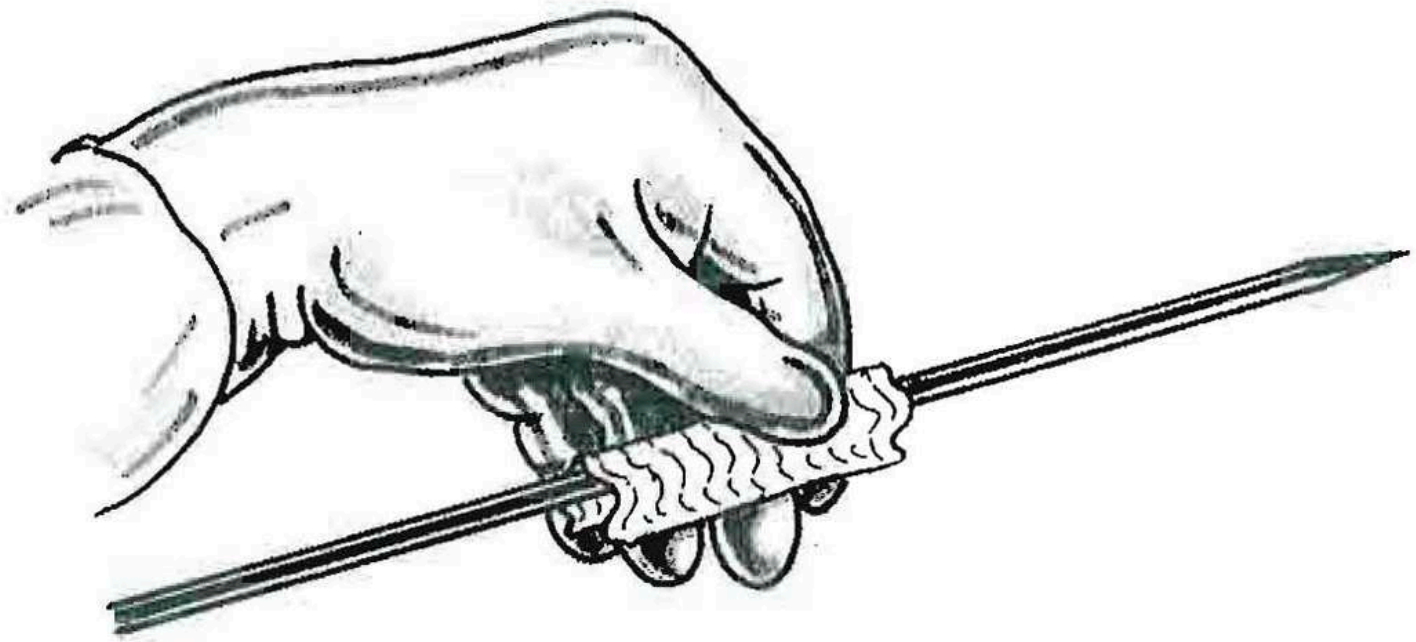
Tip of the wire is introduced through the fascia and muscles manually without drilling until it touches the cortical bone



A

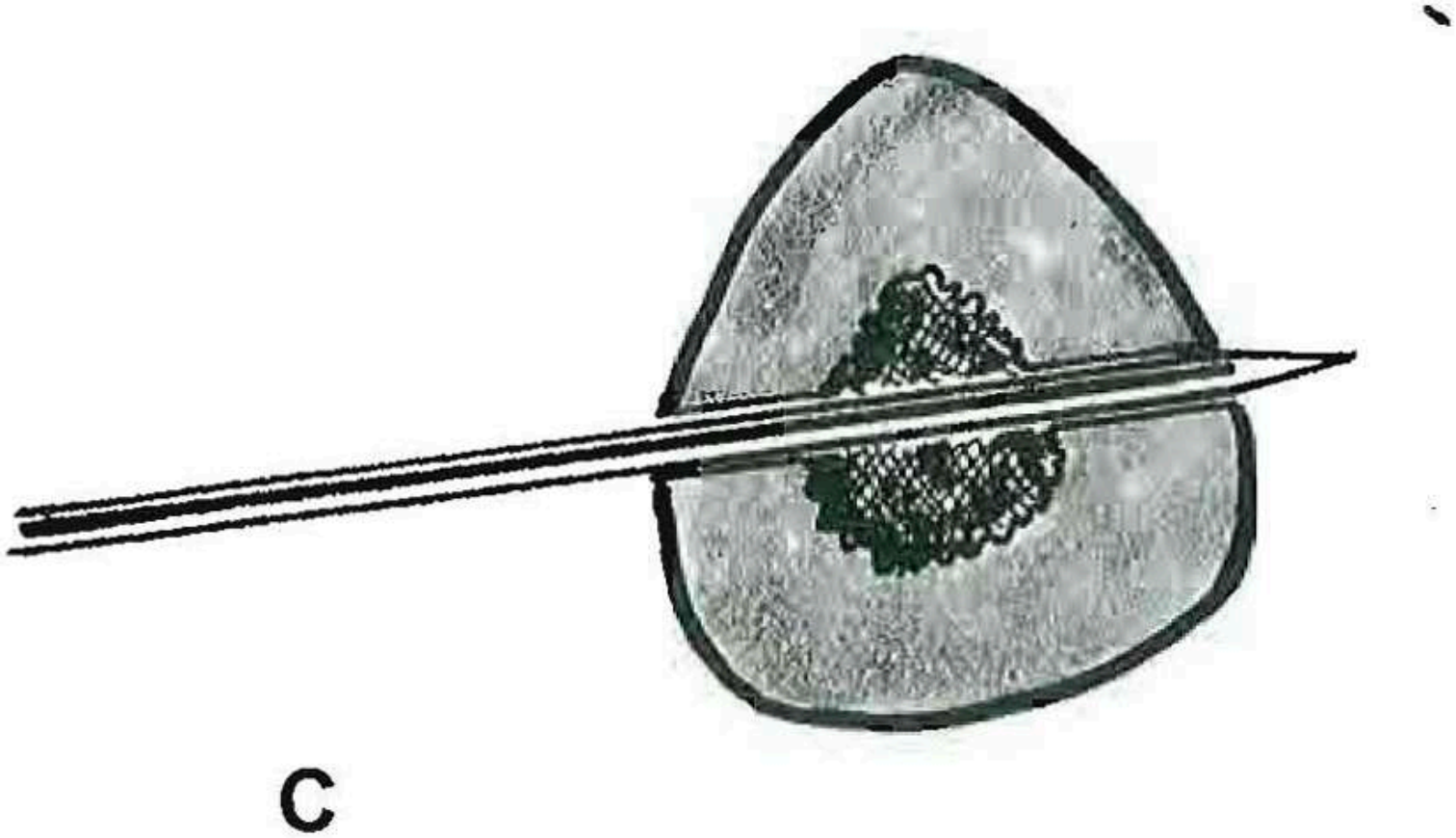
Surgical technique

Low speed drilling To avoid bending of wire and to maintain straight trajectory- Grip wire with wet sponge



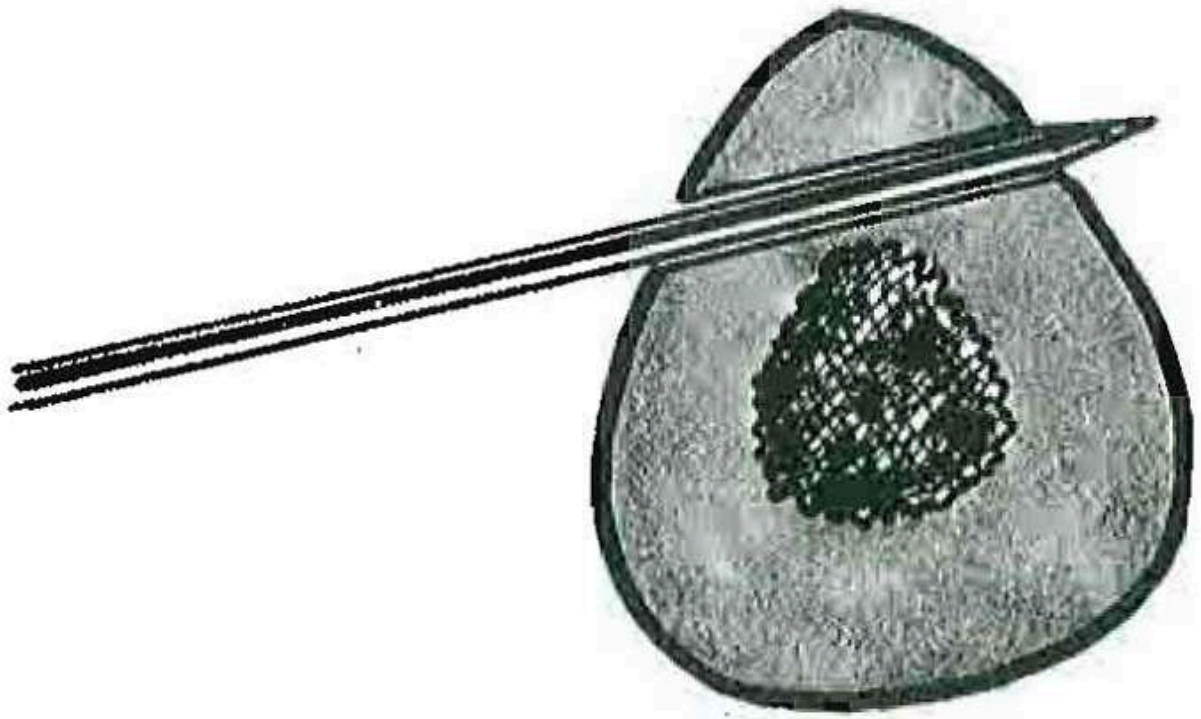
B

Wire is drilled through both sides of the cortex passing through bone canal and bone marrow trans medullary

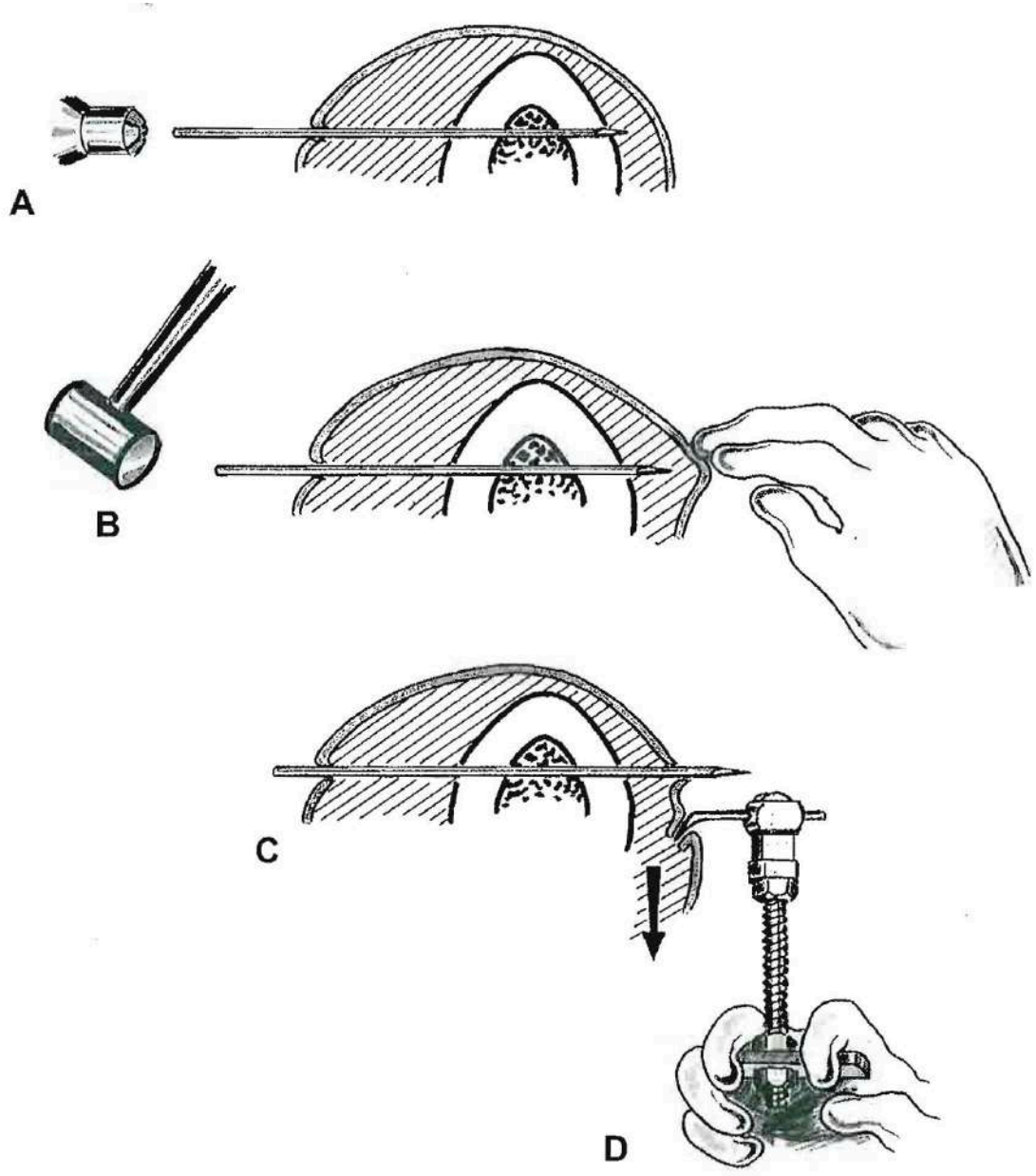


Drilling incorrectly through the cortex

-Poor wire stability
-Cortical Osteomyelitis



D



If the angle of introduction of two wires on the same ring is _____ degrees or lesser it leads to side-to-side displacement of the bone

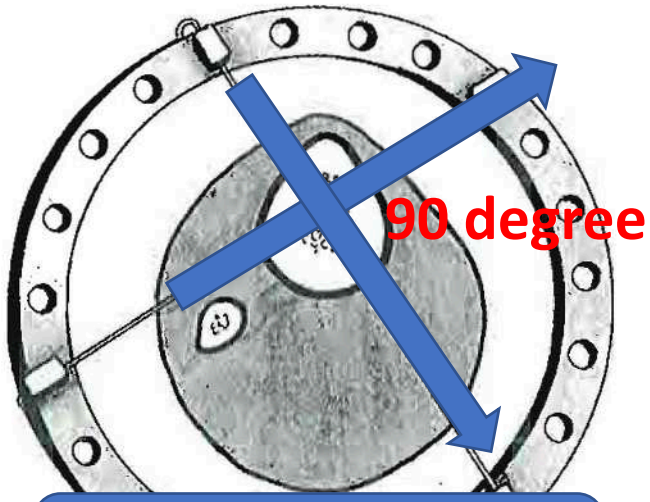
a) 90 degrees

b) 15 degrees

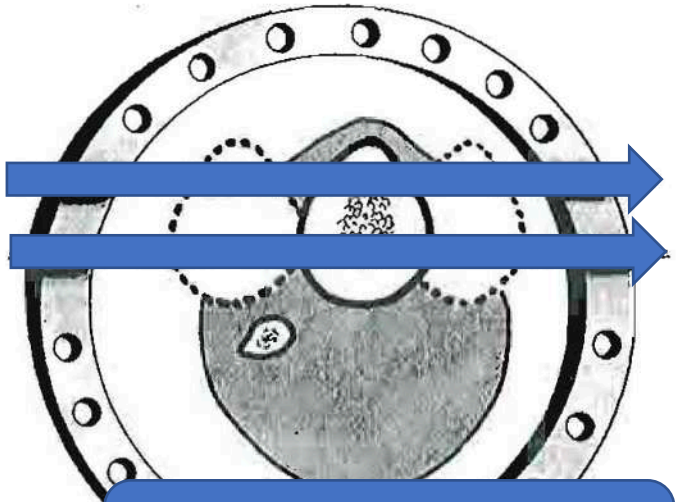
c) 45 degrees

d) 30 degrees

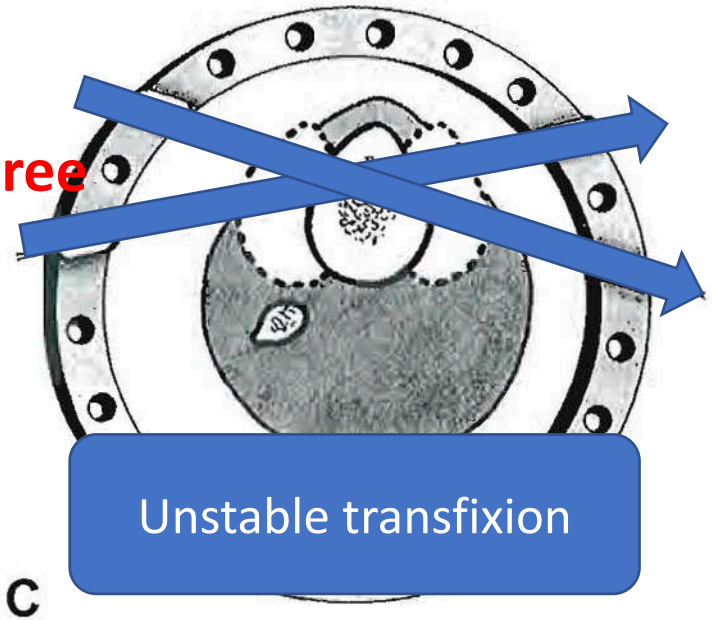
If the angle is between 30 and 45 degree there is possibility of creating **Ring shearing movement**



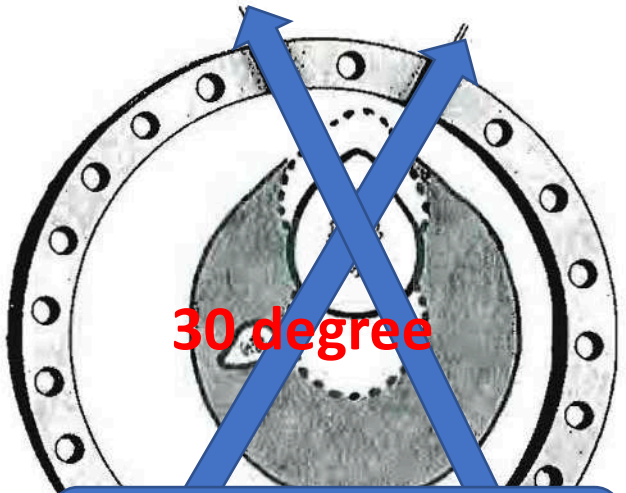
A Very stable transfixion



B Unstable transfixion

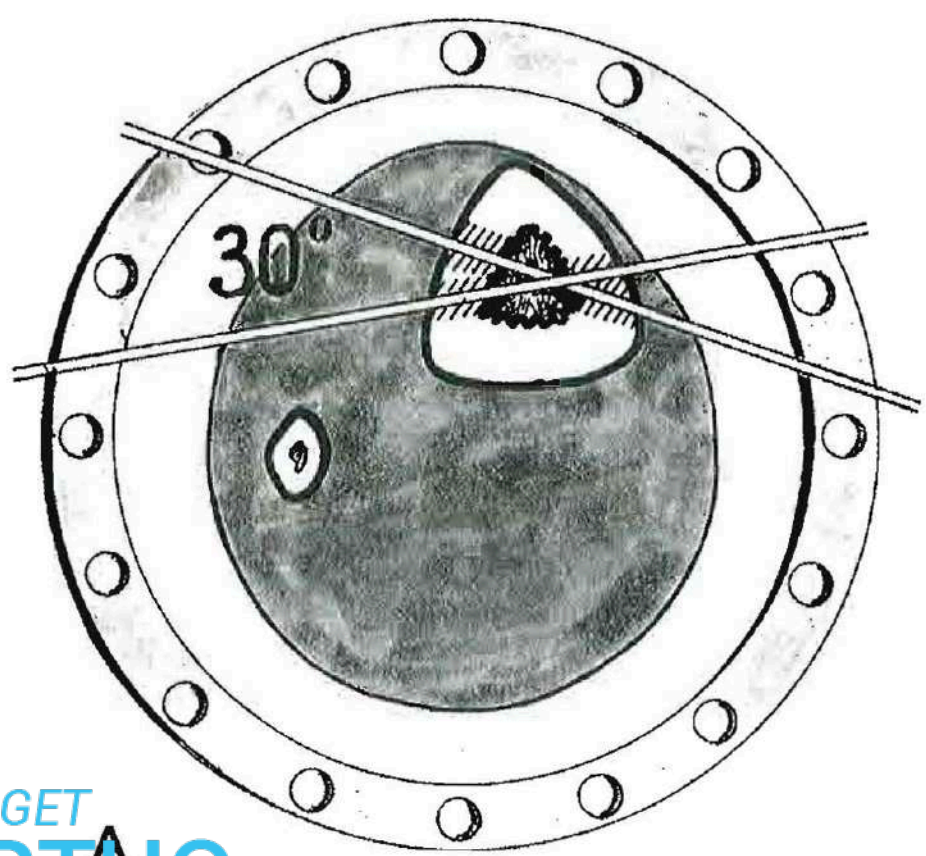


C Unstable transfixion

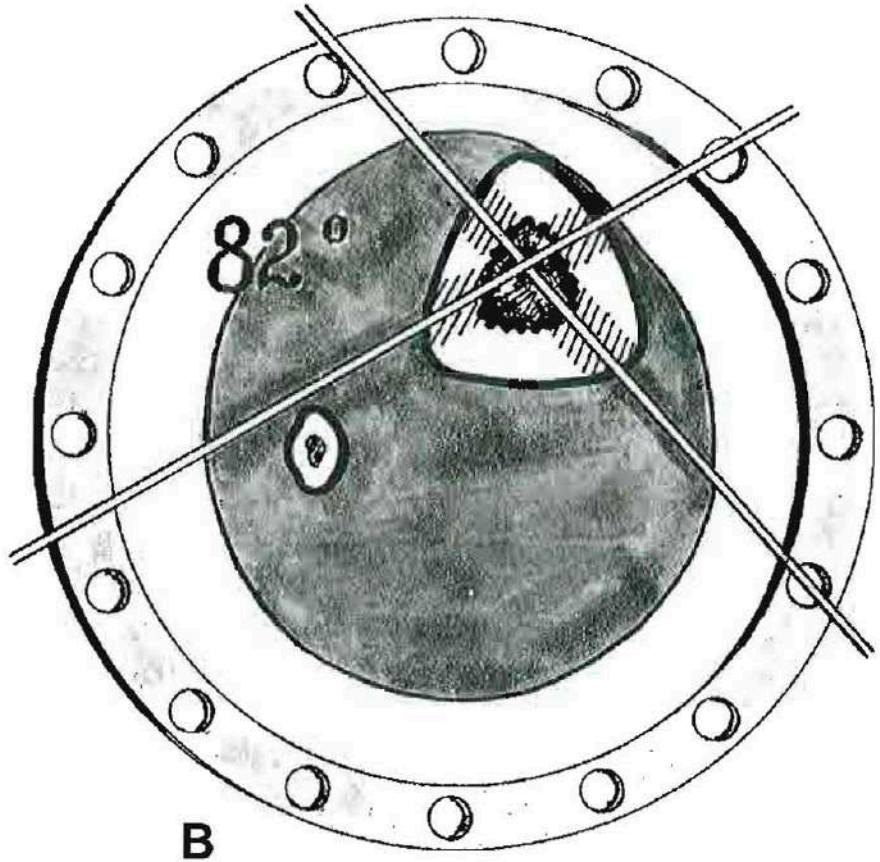


D Unstable transfixion

Wide Angulation = More even distribution of loading forces on bone cortex along the plane of the ring



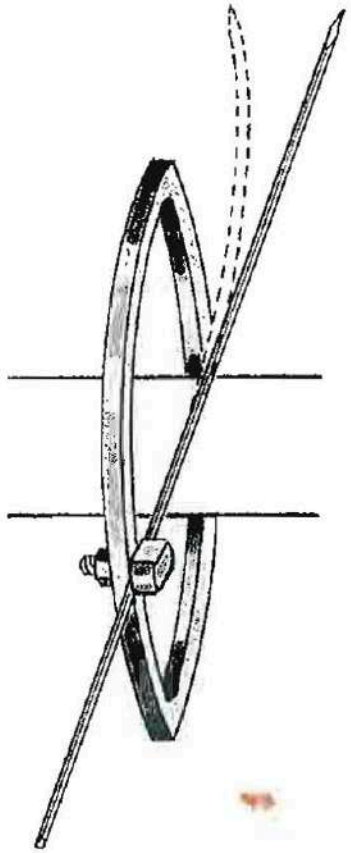
A



B

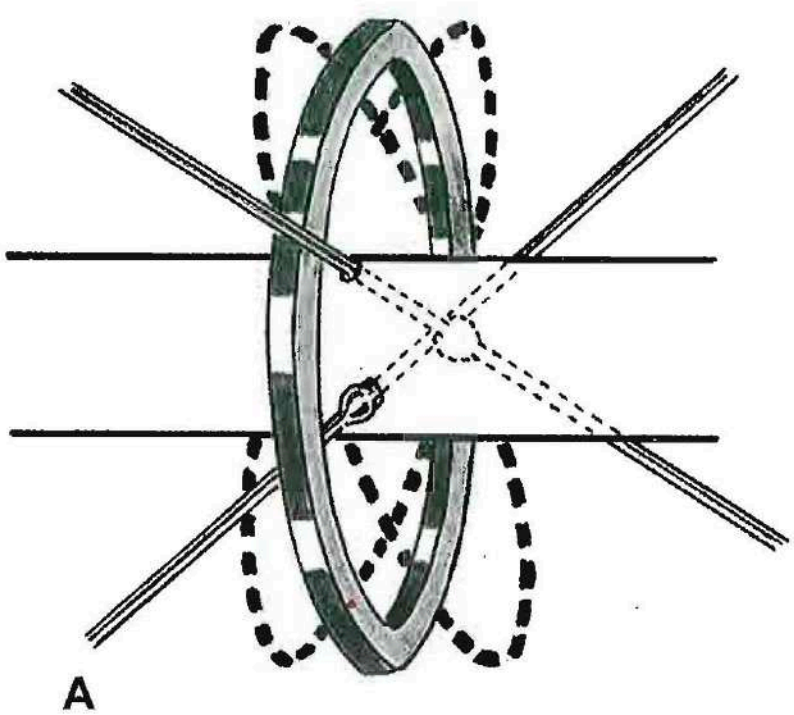
Rule: The wire should not be brought down to the ring; rather the ring should be brought up to the wire. Done by using washer, post, support, hinges

Bending the wire down to ring leads to permanent pressure, skin necrosis



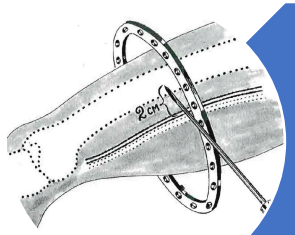
A

Offset Wire Positioning

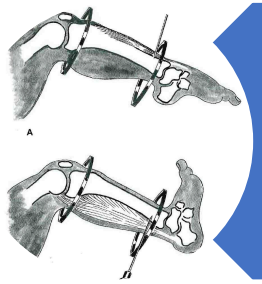


OFFSET WIRE – AUGMENTS RING STABILITY

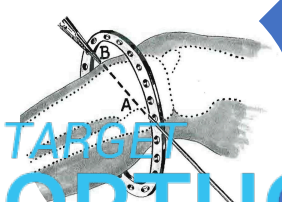
Proper distance of wires from joints and direction of introduction



Wires must be placed away from joint capsule

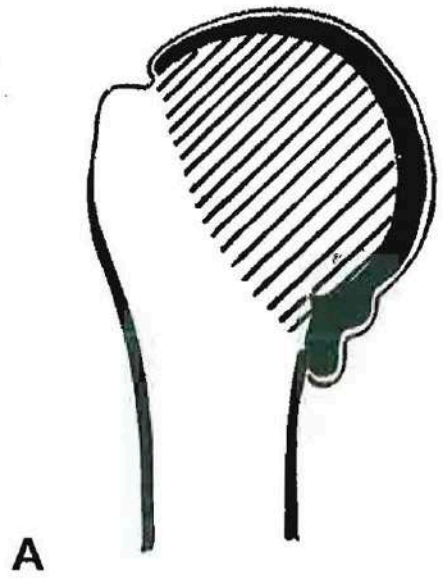


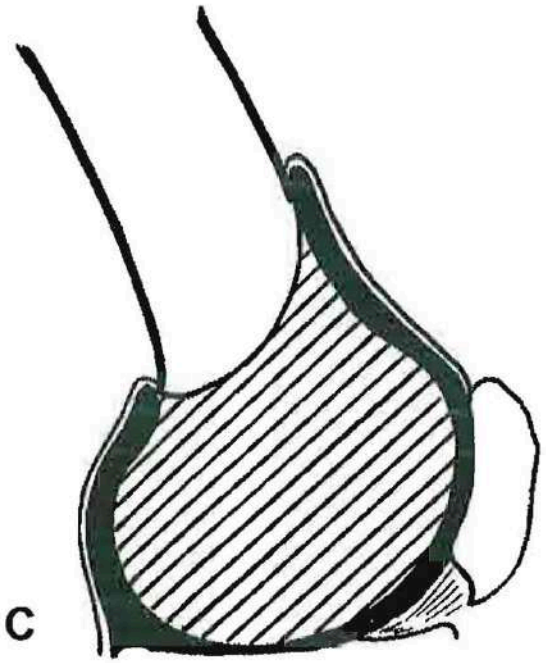
Wire must not penetrate the tendons



Wires close to joint – introduced through muscle fibres at max stretch

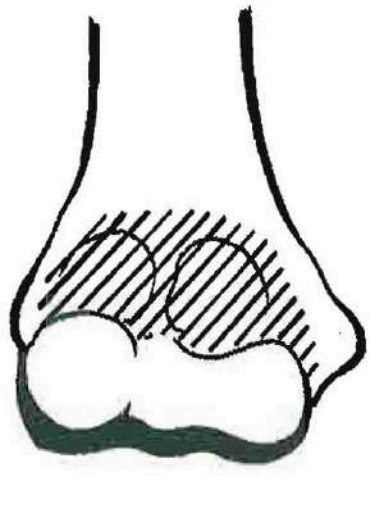
The auxiliary recess of shoulder joint reaches below surgical neck level





Top of suprapatellar bursa of knee joint can reach a distance of 4-5cm from upper patellar pole

The elbow articular capsule spreads above coronoid and olecranon fossa

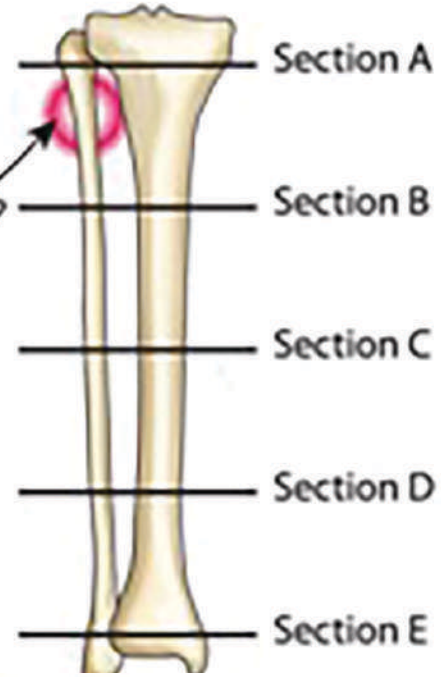


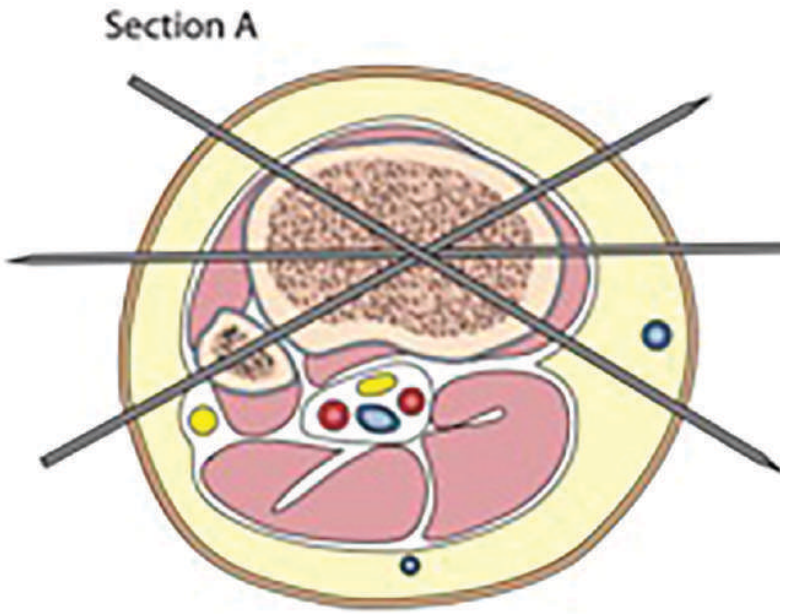
The ankle articular capsule spreads above the level of tibia tendon grooves

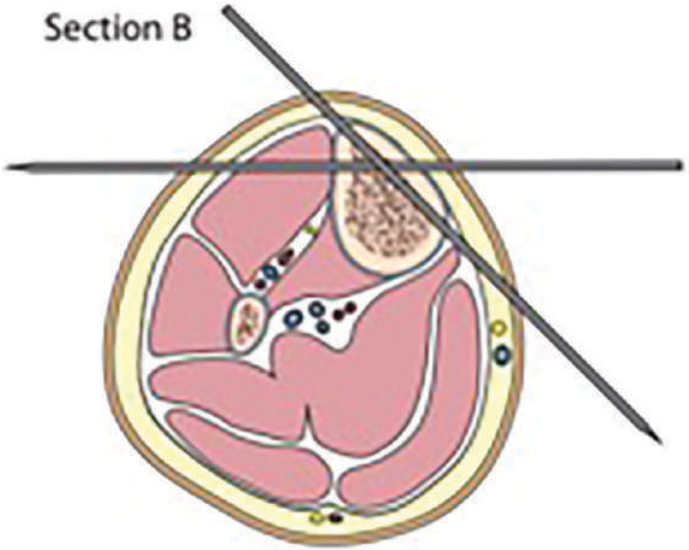
Safe Zones for Wire Placement: Tibia

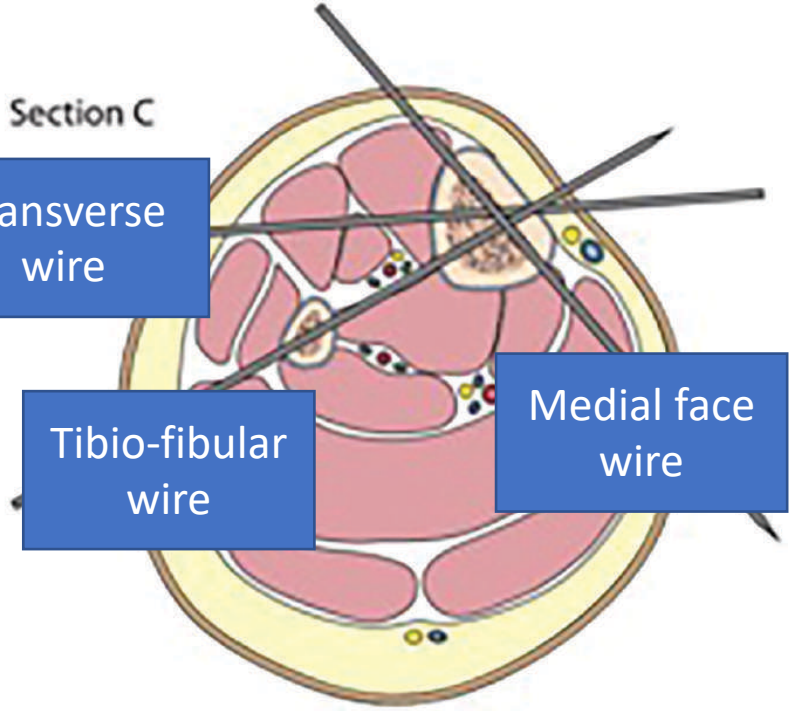
Three types of wires can be inserted in the tibia: transverse, tibiofibular, and medial face.

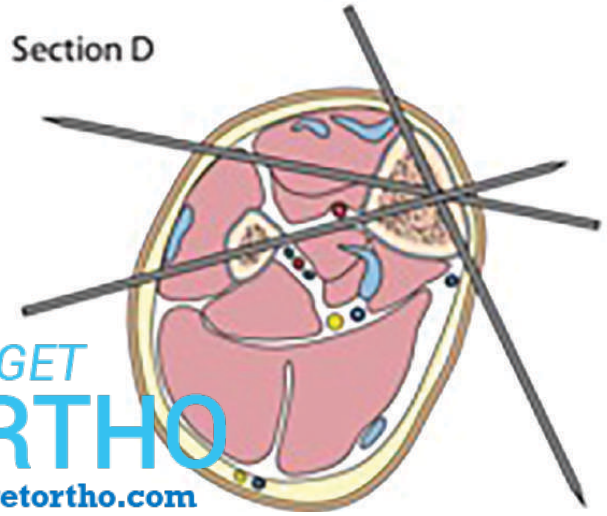
Avoid tibiofibular wires near the peronel nerve at the neck of the fibula.

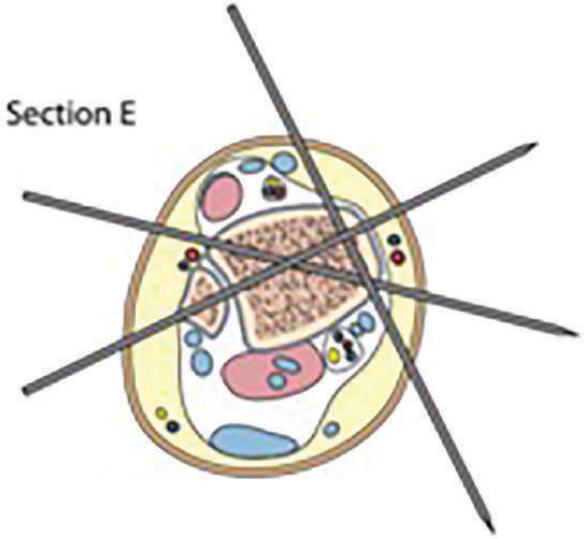




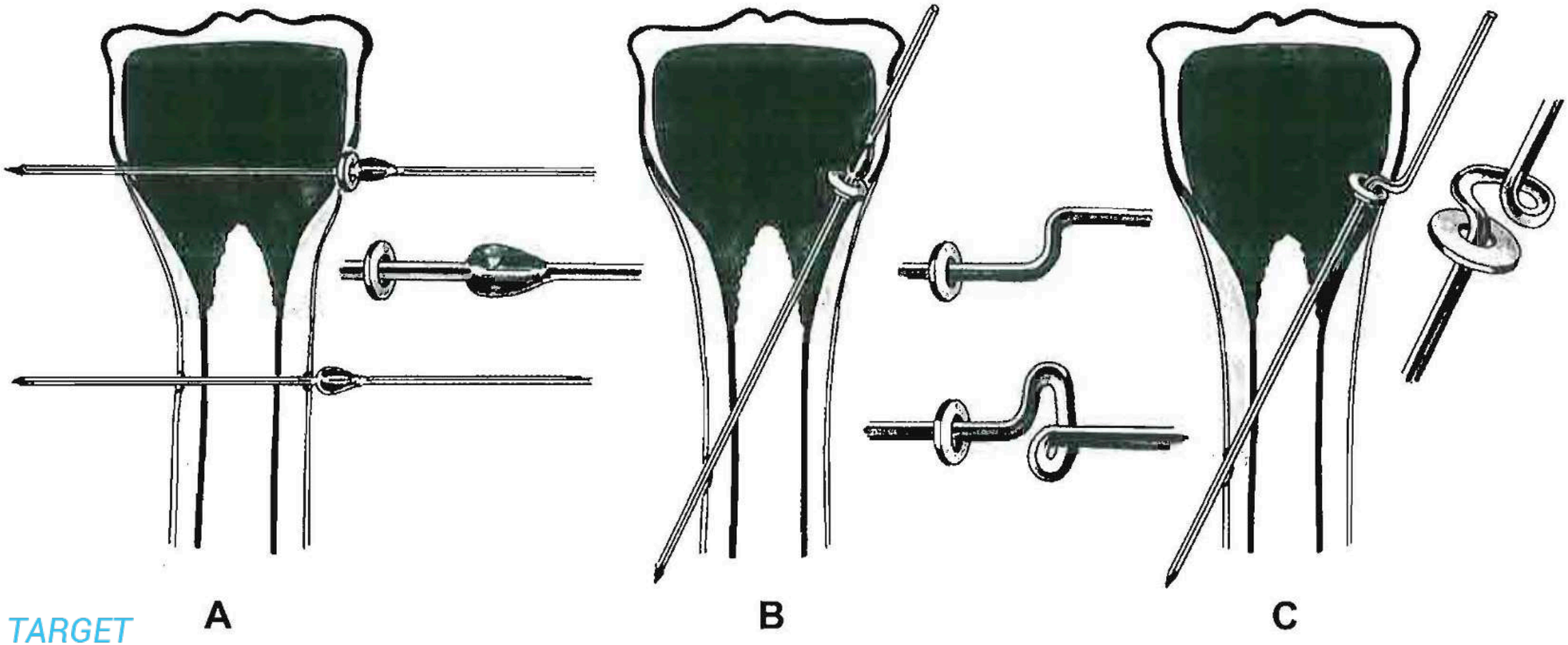








Wires with stoppers



Olive shaped stopper wire used for:

1. Bone fixation
2. Bone fragment displacement reduction
3. Bone fragment deviation correction
4. Technique of bone fragment pulling in an internal transport
5. Interfragmentary compression
6. In osteoporotic bones

Tensioning

Range : 50-130kgs

1. Wire on half-ring: 50 to 70 kg
2. Offset (drop) wire, depending on size of the supporting posts: 50 to 80 kg
3. Single wire on a ring: up to 100 kg
4. Two to three wires on a ring in a young patient: 110 kg for each wire
5. Two to three wires on a ring in an adult patient: 120 to 130 kg for each wire
6. Wire with an olive stopper: 100 to 110 kg
7. Wires with olive stoppers used for interfragmentary compression, depending on bone condition; 50 kg.

All of the methods increase the stability of the Ilizarov fixator EXCEPT

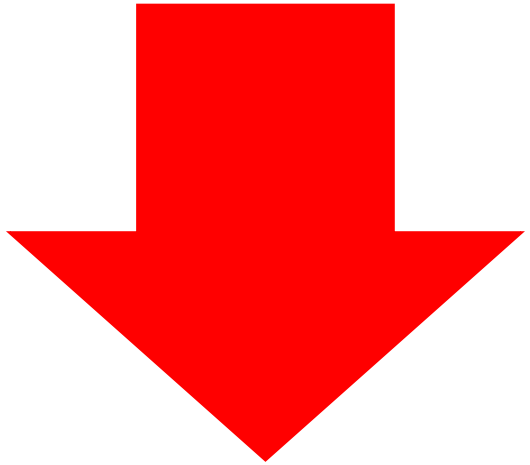
A) Increase the diameter of the pins

B) Increase the number of pins

C) Increase the pin to fracture distance

D) Increase the diameter of the connecting rods

Stability of Ilizarov fixator



Pin to fracture distance

Bone to rod distance

Diameter of pins

Number of pins

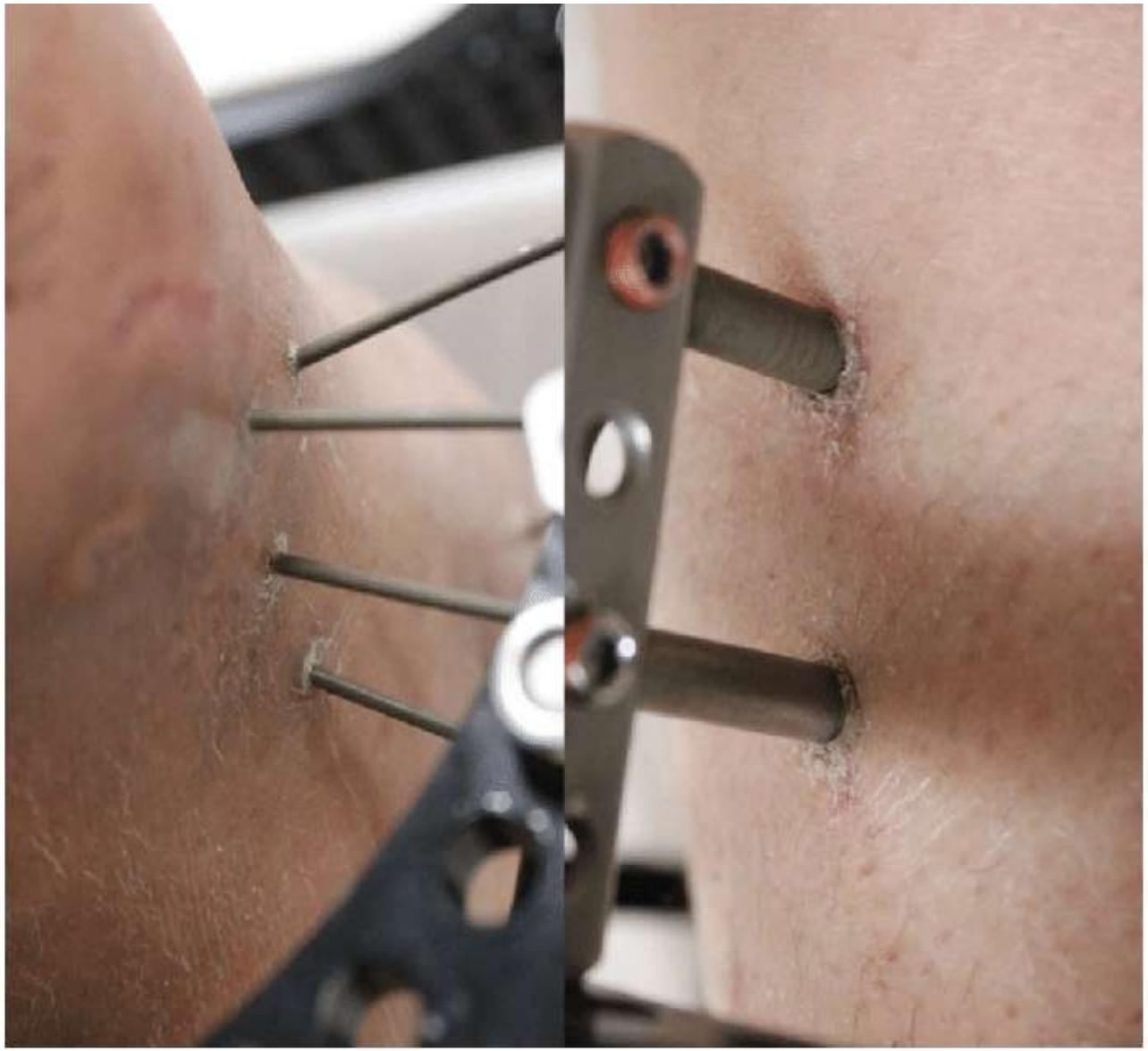
Pin spread

Number of planes

Diameter of rods

Number of rods

Pin site care



Following application of the Illizarov apparatus, after a significant period you note that there is erythema, discharge and soft tissue infection at several pins. There is no radiological bone involvement noted .What is the next best step?

a) Retain the pins and improve pin care

b) Retain the pins and start topical / oral antibiotics

c) Remove entire fixator construct and curettage pin tract

d) Remove loose pins and start antibiotic coverage

Checketts Otterburn Classification

GRADE	APPEARANCE	TREATMENT
1	Slight erythema, little discharge	Improved pin care
2	Erythema, discharge and pain in soft tissue	Topical and/or oral antibiotics
3	Grade 2 but no improvement with antibiotics	Remove pin and change antibiotic regimen
4	Soft tissue infection involving several pins	Remove any loose pins
5	Grade 4 and radiological evidence of bone involvement	Remove entire fixator construct and curettage pin tract
6	Infection after fixator removal (clinical and radiographic)	Debridement, irrigation and systemic antibiotics

Following application of the Illizarov apparatus, after a significant period you note that there is erythema, discharge and soft tissue infection at several pins. There is no radiological bone involvement noted .What is the next best step?

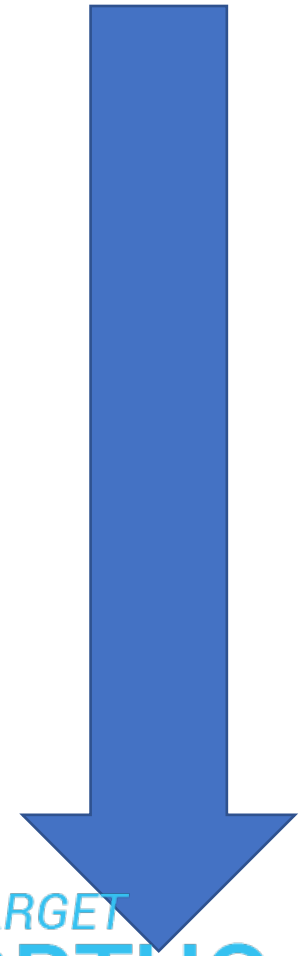
a) Retain the pins and improve pin care

b) Retain the pins and start topical / oral antibiotics

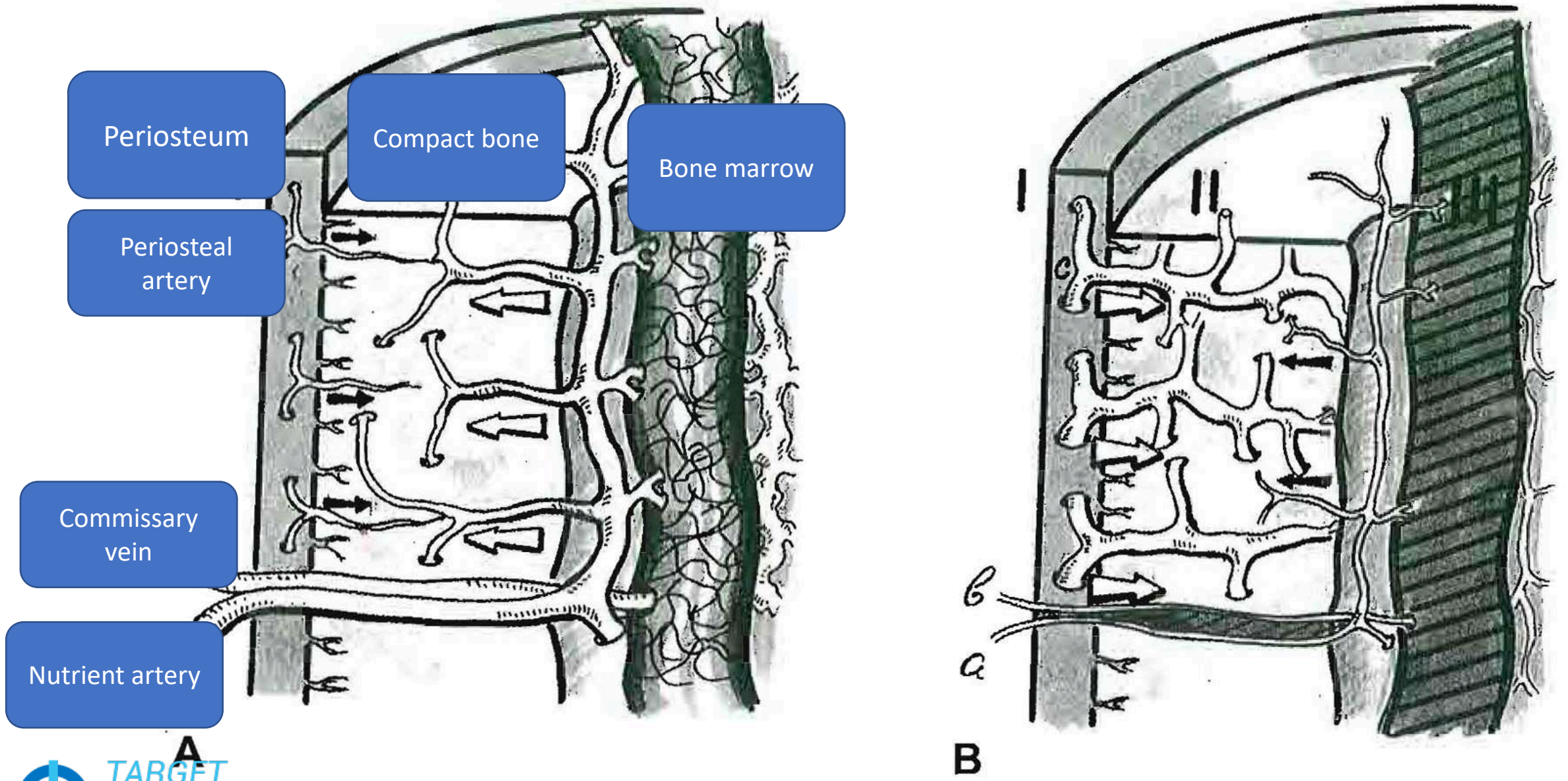
c) Remove entire fixator construct and curettage pin tract

d) Remove loose pins and start antibiotic coverage

Stages of Ilizarov treatment

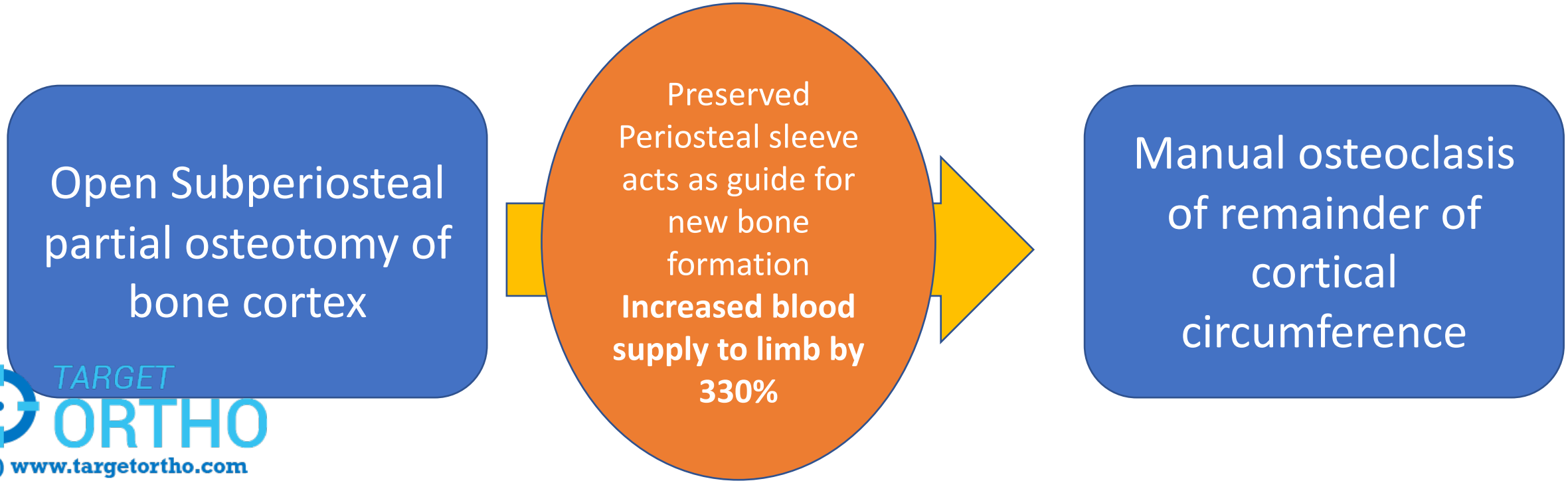


- Fixator application
- Corticotomy
- Latency period
- Period of distraction / compression
- Period of consolidation
- Frame dynamization
- Period of immobilization



CORTICOTOMY

- Low energy cortical osteotomy with transection of only the bone cortex preserving local blood to both periosteum and medullary canal



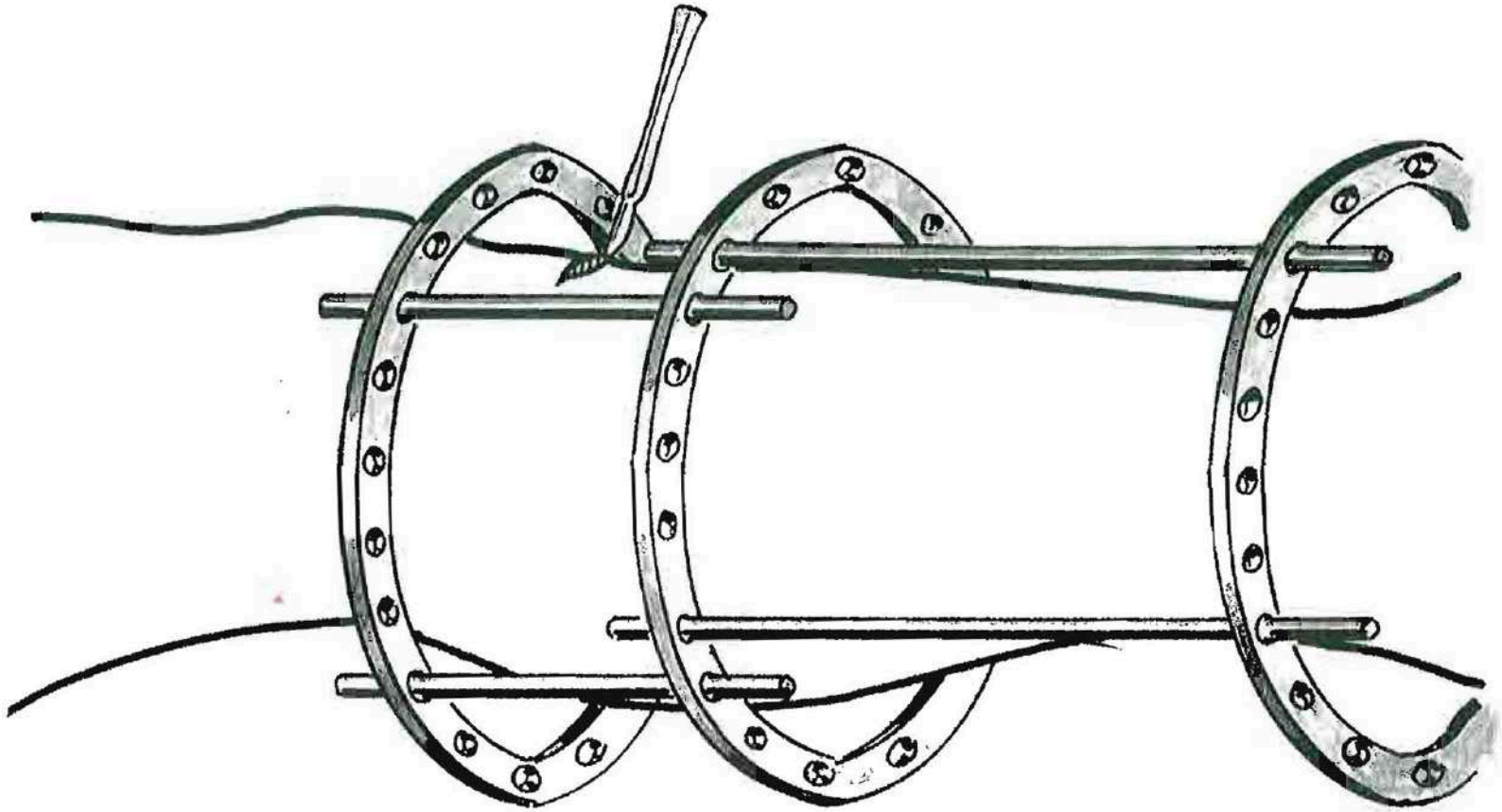
Corticotomy technique

- Cutting through compact bone only with preservation of periosteum and bone marrow.

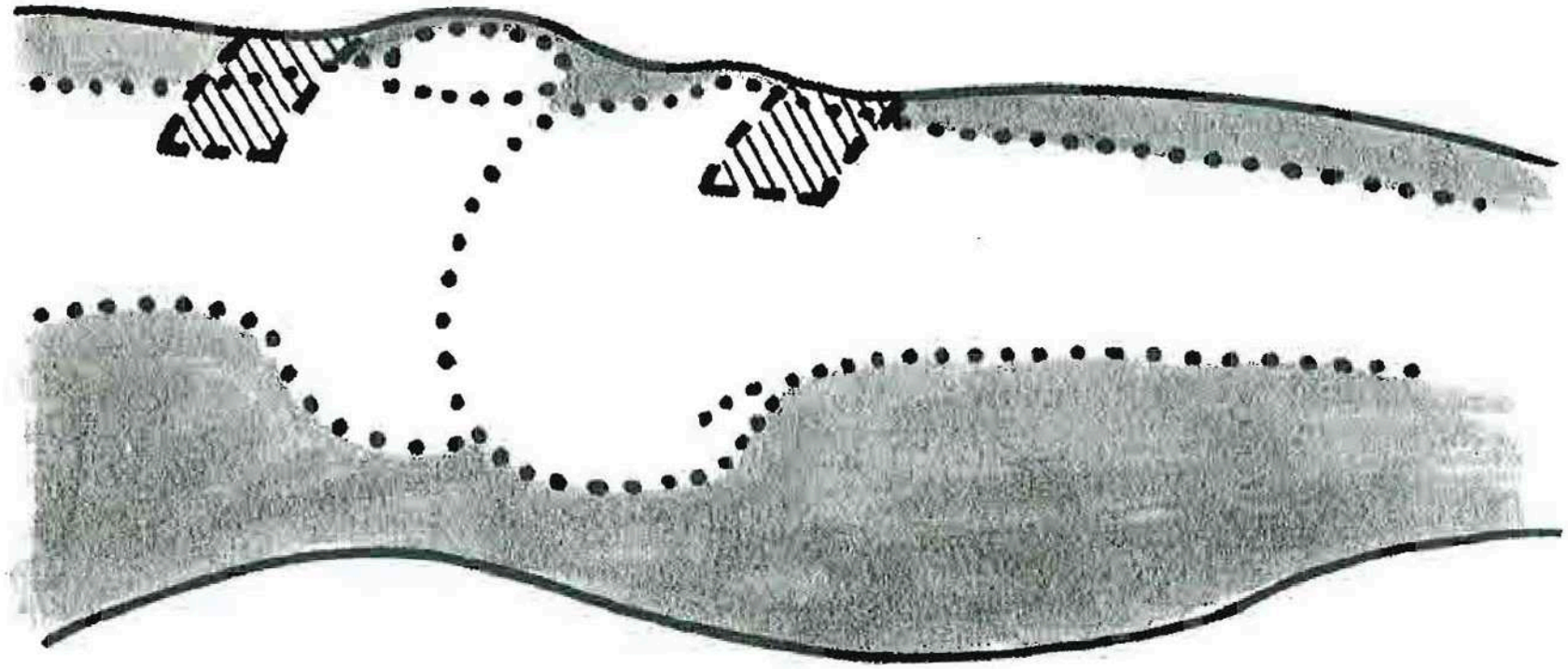
- Bone cut serves 3 main purpose:

1. Create mechanical gap for development of distraction
2. Store new bone forming cells that were developed during lengthening and deposited along lines parallel to mechanical stress
3. To develop the area with increased blood circulation necessary for increased metabolic transformation of local tissue

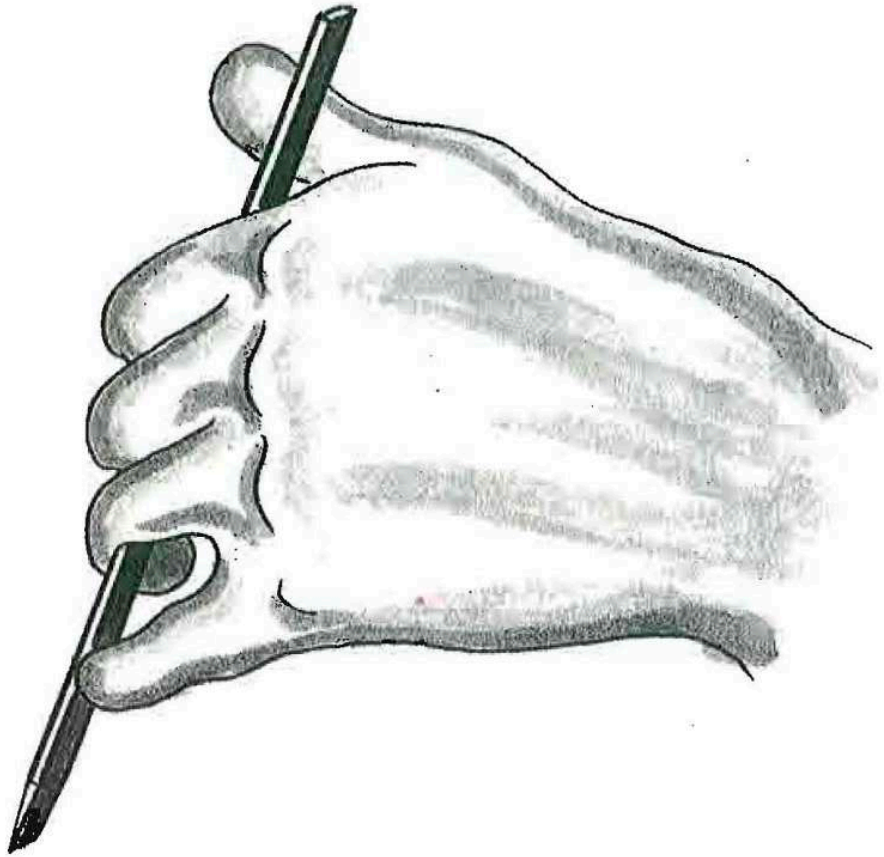
Length of skin and soft tissue incision is only 0.5 to 1.0 cm



Location of the incision must be at the site where the bone is situated close to skin – control direction of transection

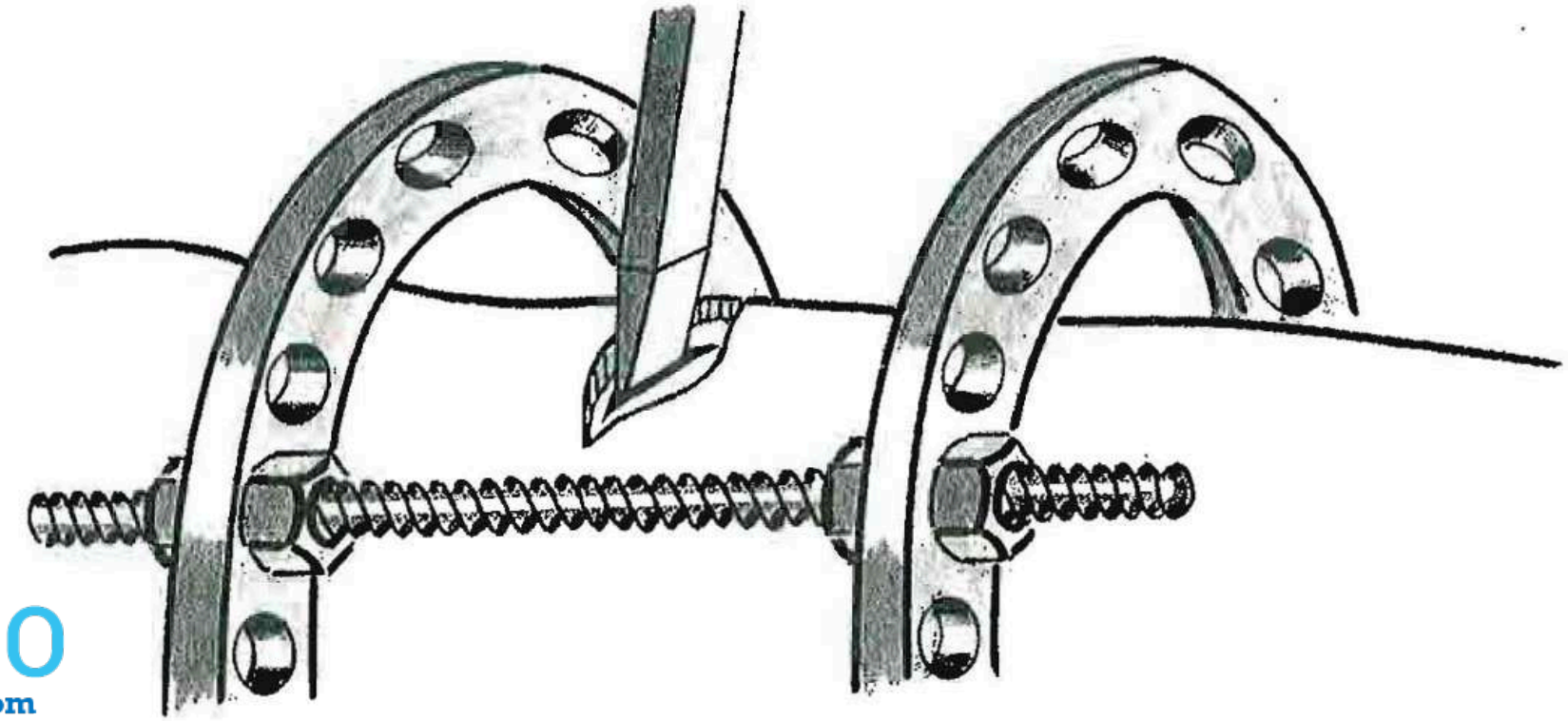


Cortex transection performed with a small osteotome preferably 0.5cm wide – guarantees edge does not slip too deep



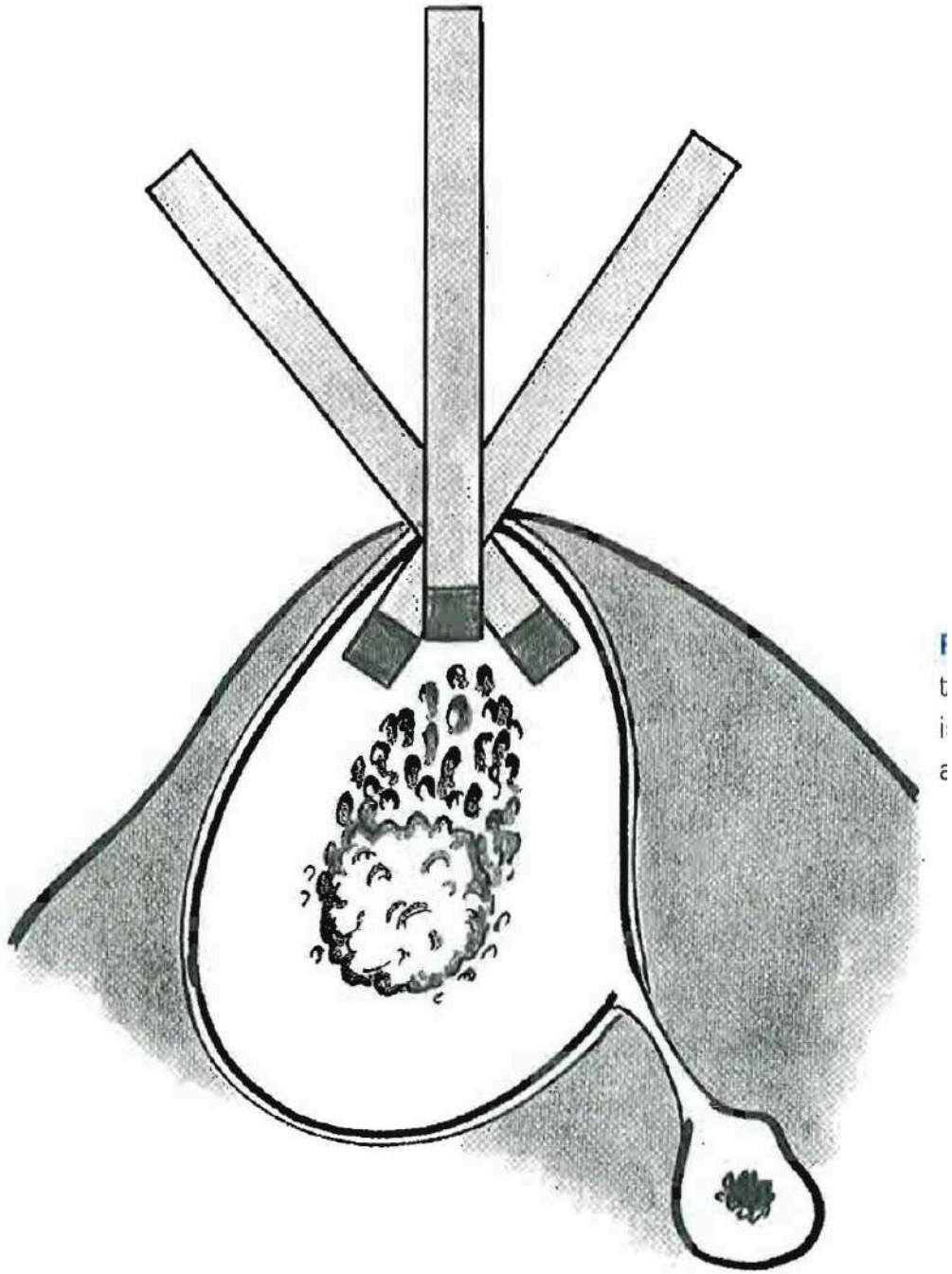
Avoid periosteum separation and cleavage at initial bone cut.

Direct transverse cut through adjoining periosteum made by tapping osteotome - recommended

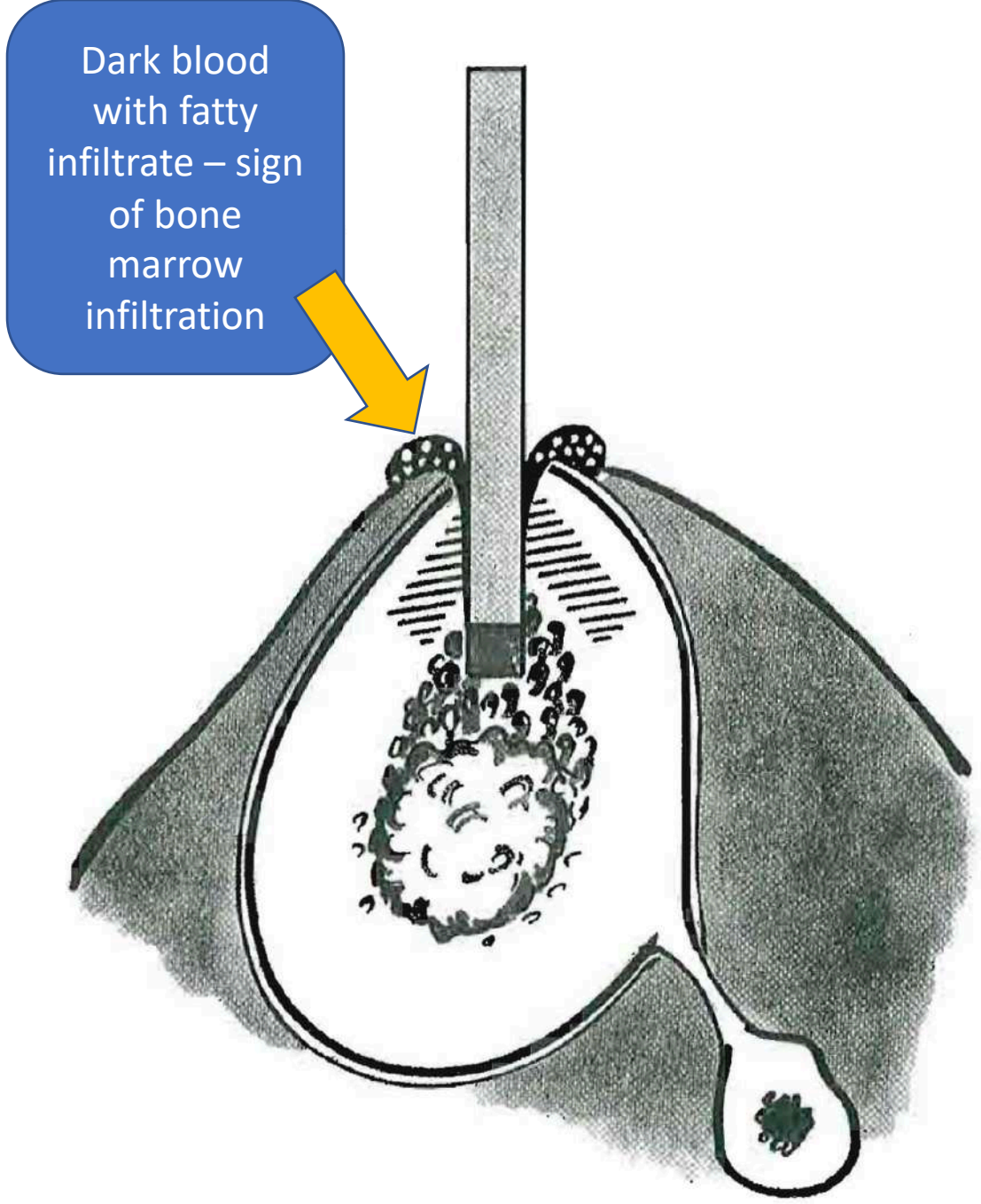


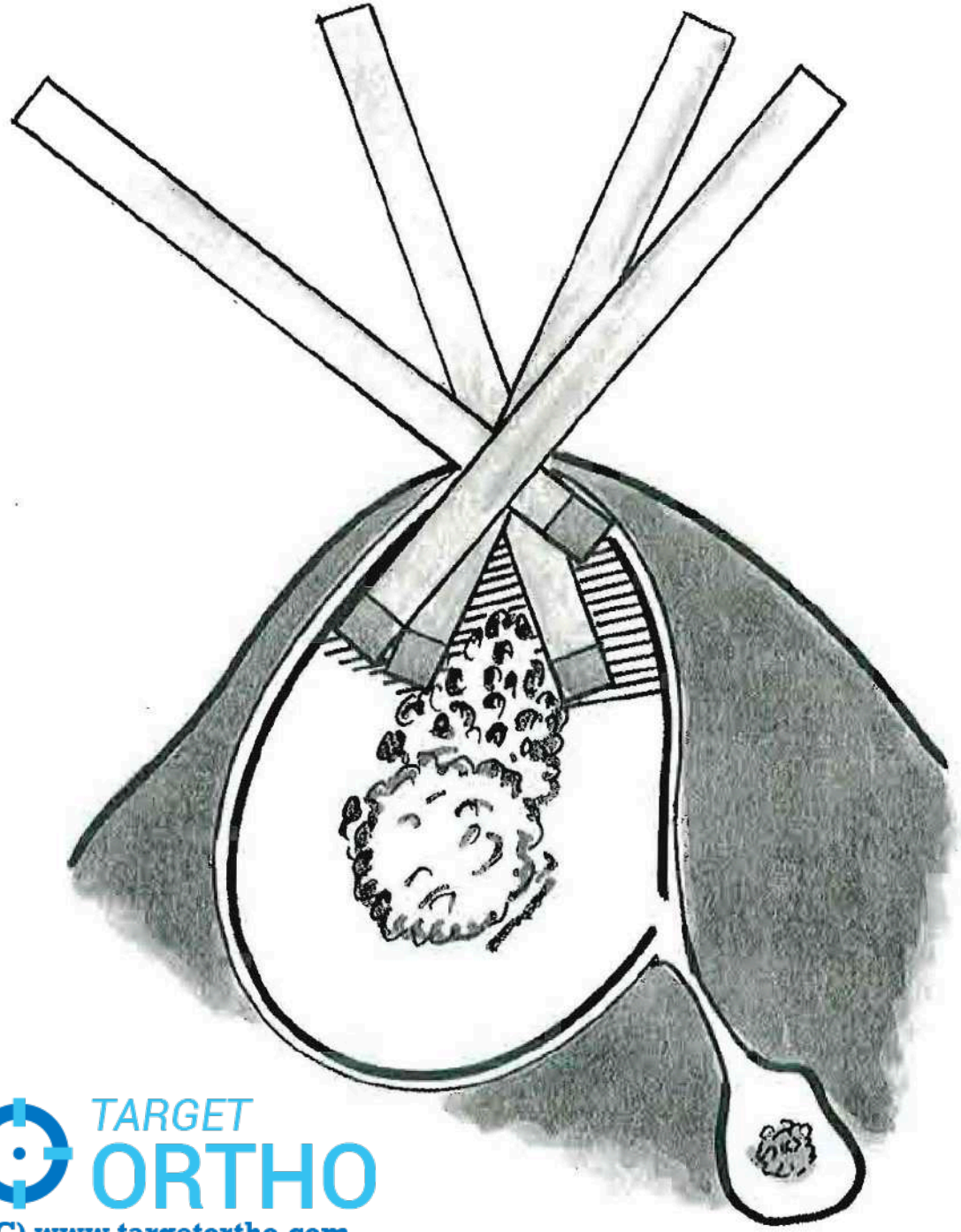
After periosteum is cut, the cortex transection is begun by further hammering.

Narrow osteotome in a fan shaped manner directing osteotome tip laterally and medially



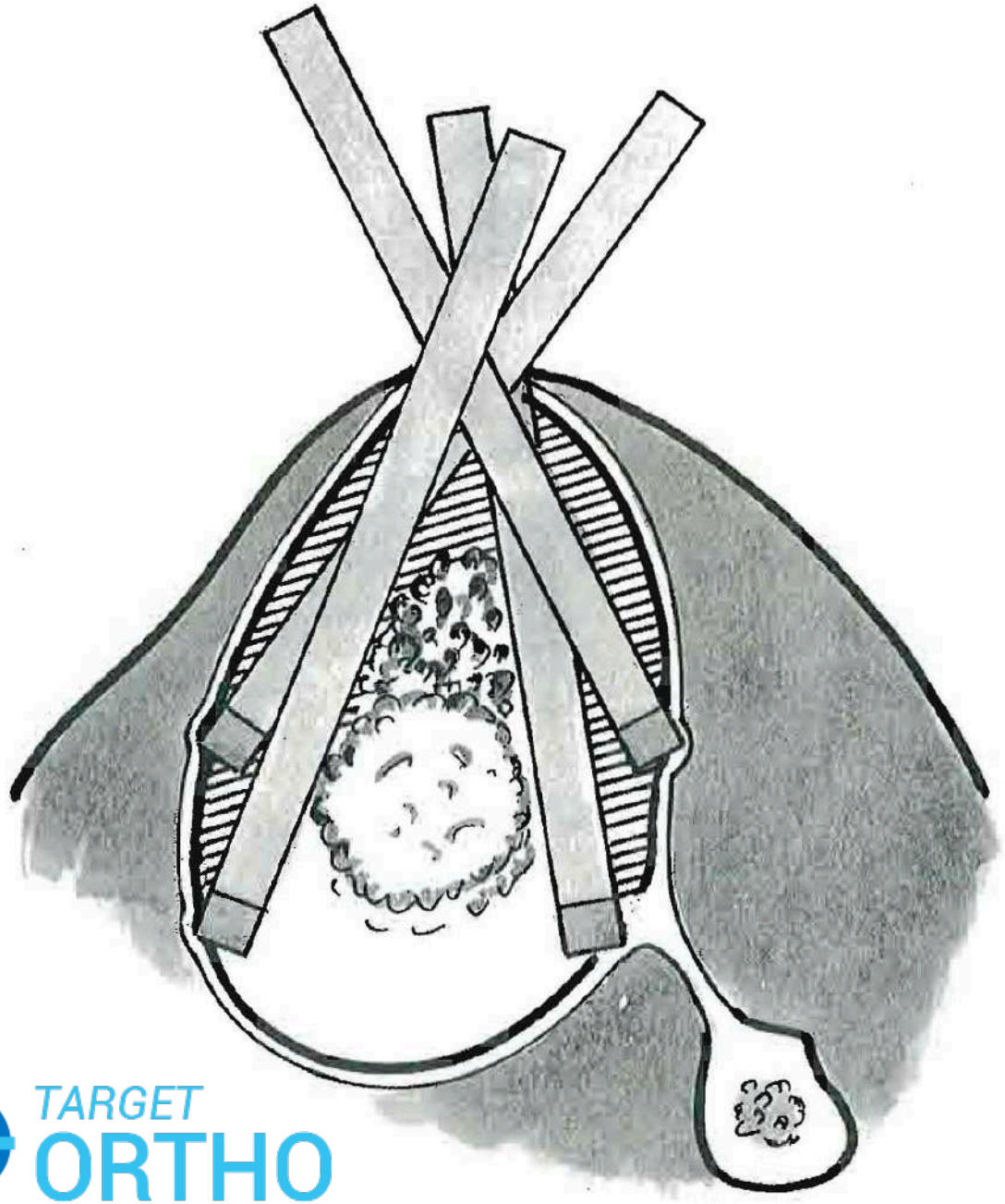
No bleeding until this stage
As soon as osteotome tip penetrates endosteum layer it penetrates vascular structure.





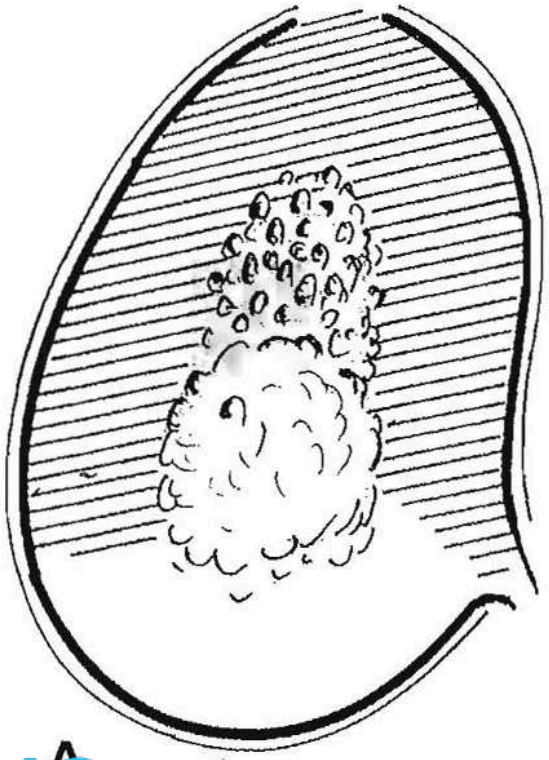
Tapping of bone is continued by spreading the transection laterally and medially

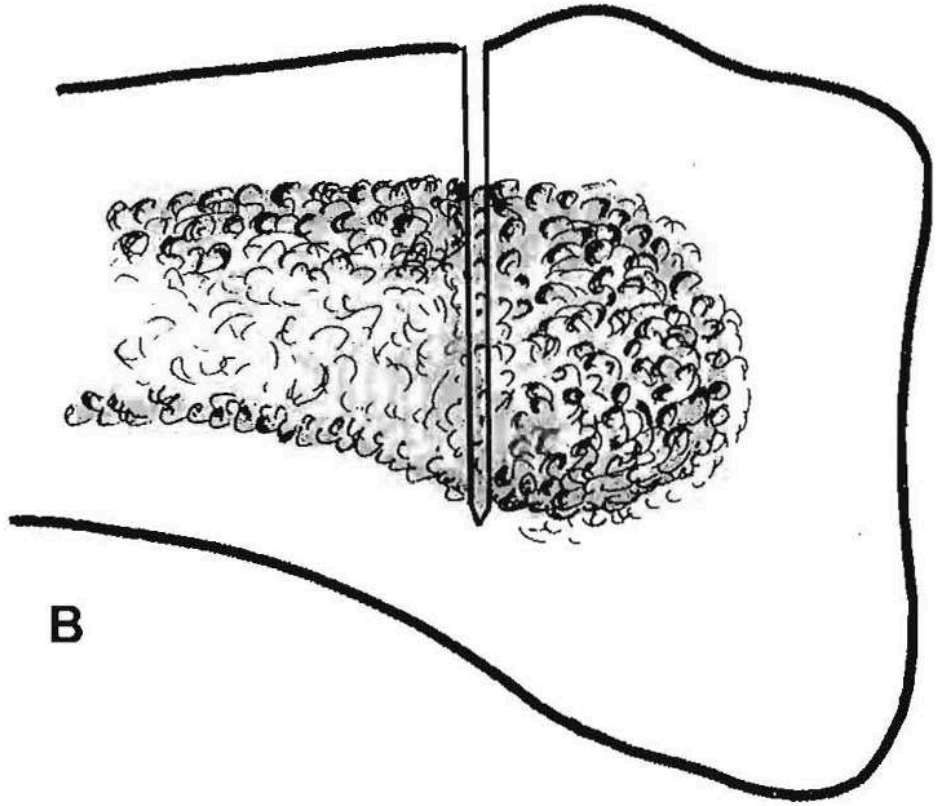
High pitch sound – Cortex
Low pitch sound – Change



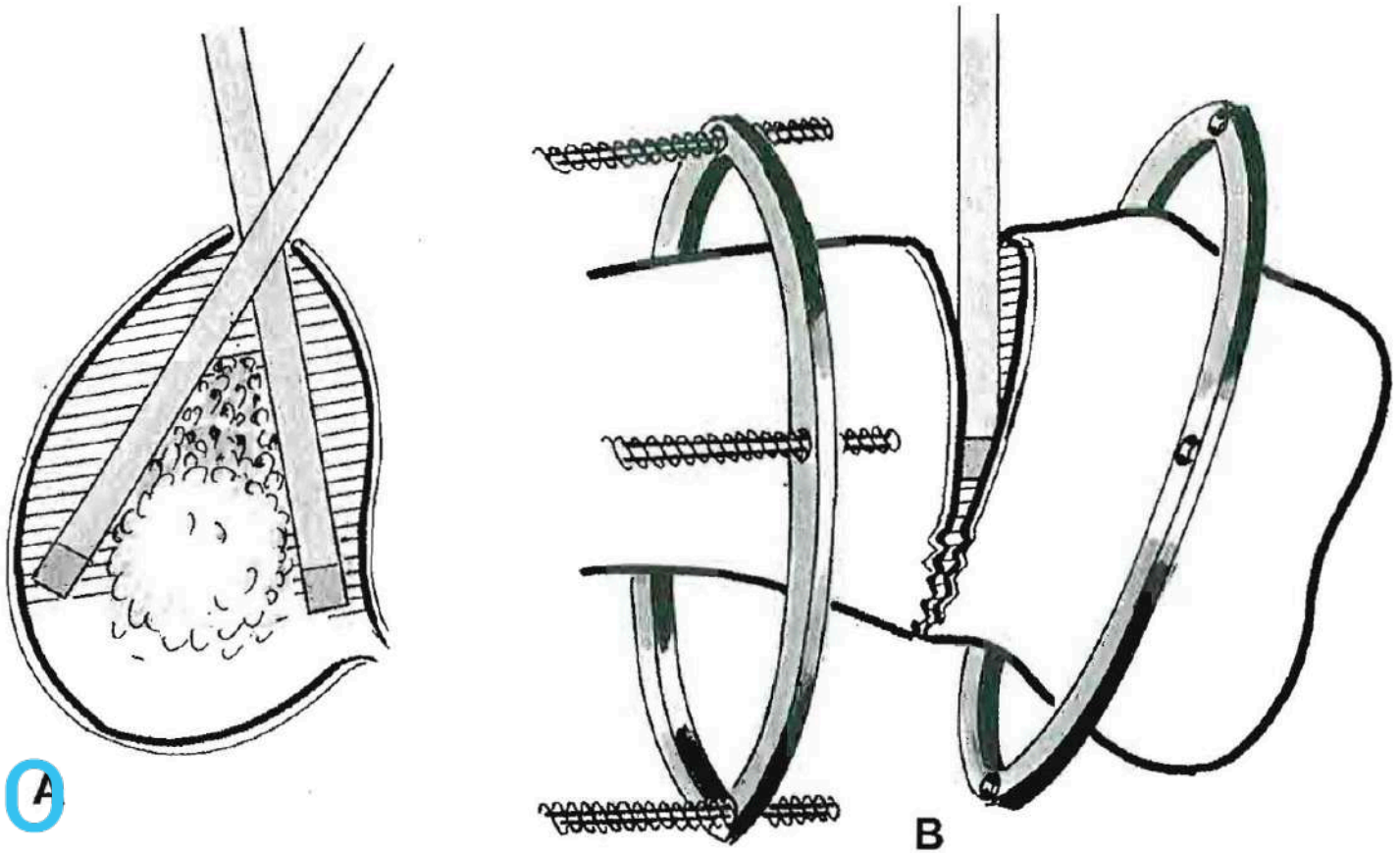
After adjoining cortex wall is transected, the direction of osteotome must be changed preferably without extraction

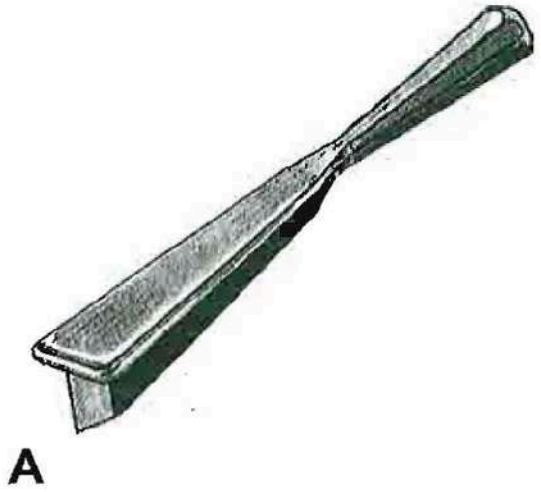
When transection of the bone walls are complete there will be signs of penetration seen
Triangular transection is seen

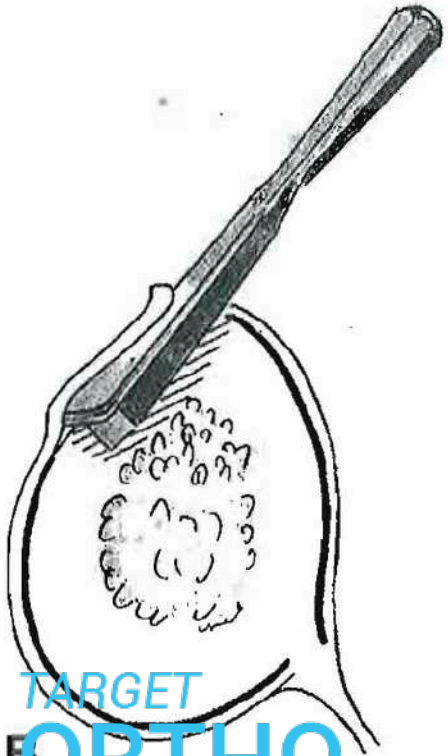


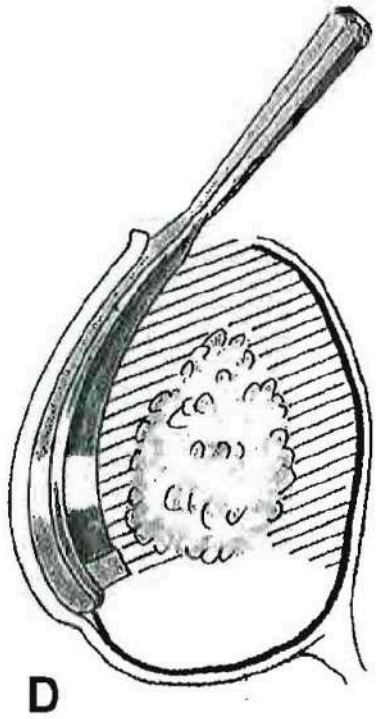


At this point we stop tapping and osteotome handle is turned alternately with pliers
Crackling sound of its divergence should be sign of completed corticotomy









Use osteotome for corticotomy

The osteotome is removed and careful rotational movement is performed by distal ring rotation.

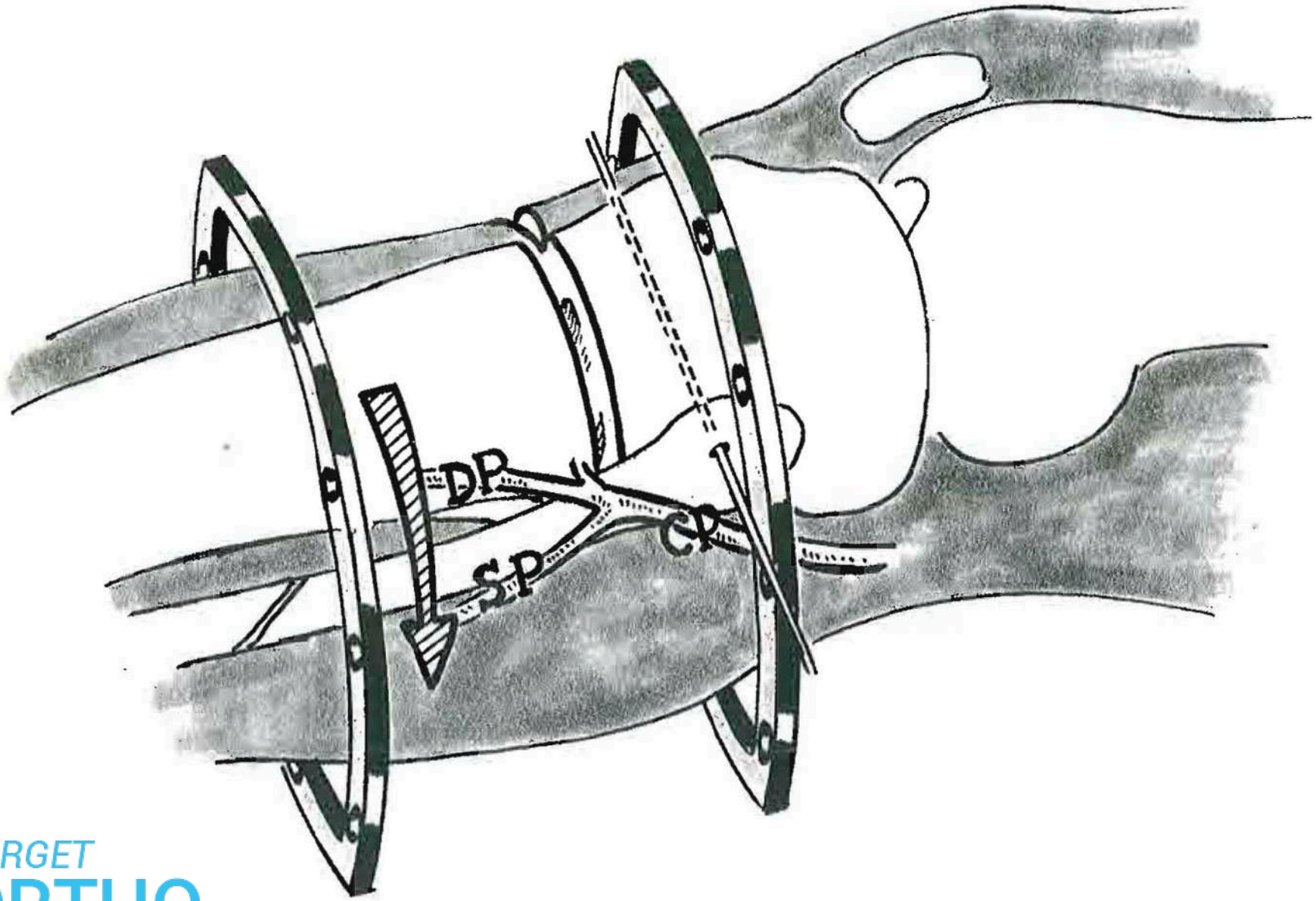
Following corticotomy at the proximal tibia, the rotational movement performed is:

a) Internal rotation

b) Internal rotation after fibular osteotomy

c) External rotation

d) External rotation after fibular osteotomy



Following corticotomy at the proximal tibia, the rotational movement performed is:

a) Internal rotation

b) Internal rotation after fibular osteotomy

c) External rotation

d) External rotation after fibular osteotomy

Incomplete Corticotomy

Oblique fracture of the posterior upper Tibia at the site of the thick soleal line

Butterfly fracture of the posterior upper tibia

Comminuted fracture which extends to the sites of wires introduced too closely

To ensure complete corticotomy

- Radiographic imaging
- Two views – Anteroposterior and Lateral
- 5mm distraction should be achieved before radiographs

Level of Corticotomy ?

Level of Corticotomy ?

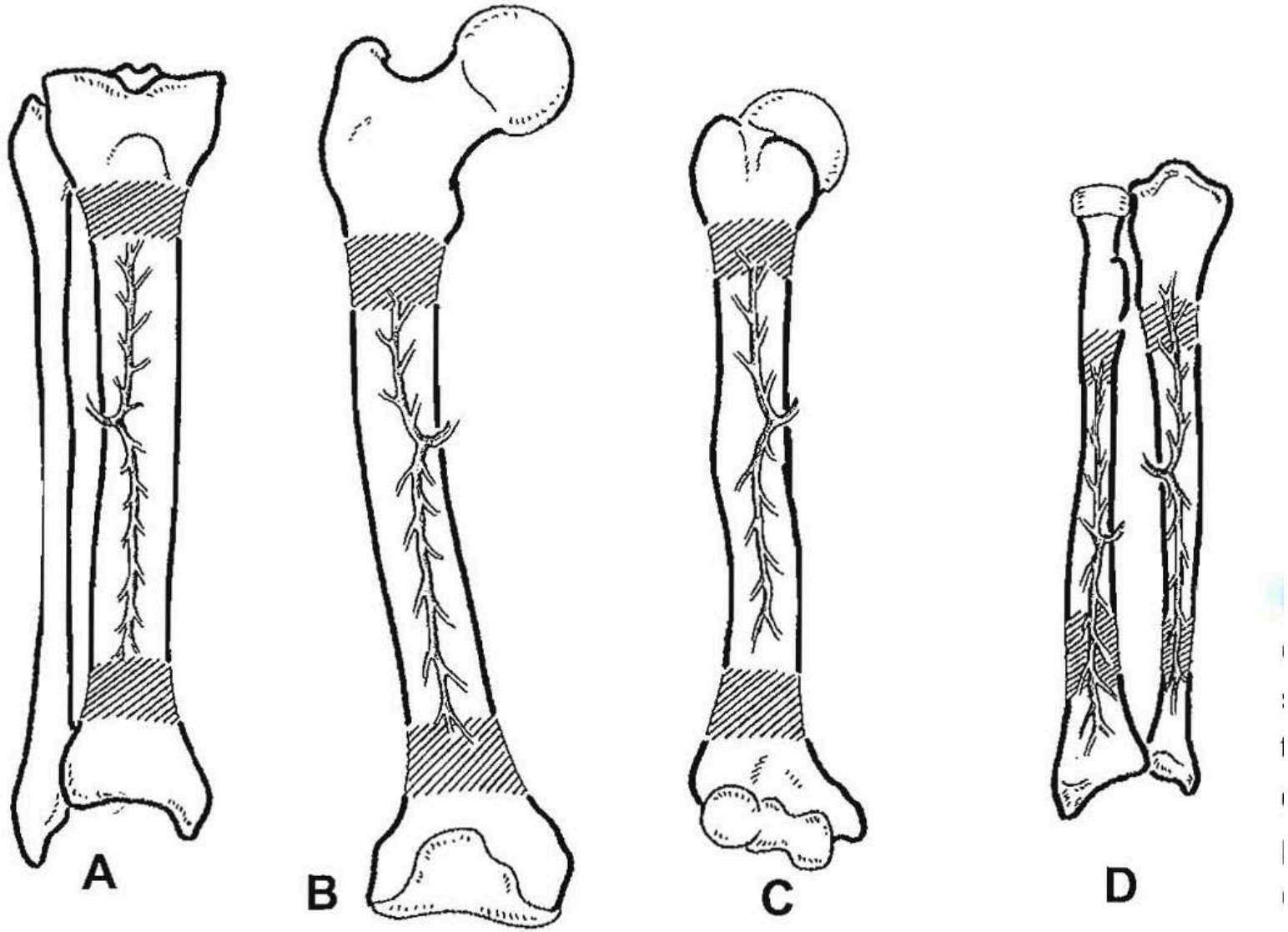
- Anatomic factor
- Biomechanical factor
- Physiologic factor

Anatomic

Important not to cut the nutrient vessels

Entrance canal is in a middle part of tubular bone

Avoidance of bone transection in its center is a wise precaution



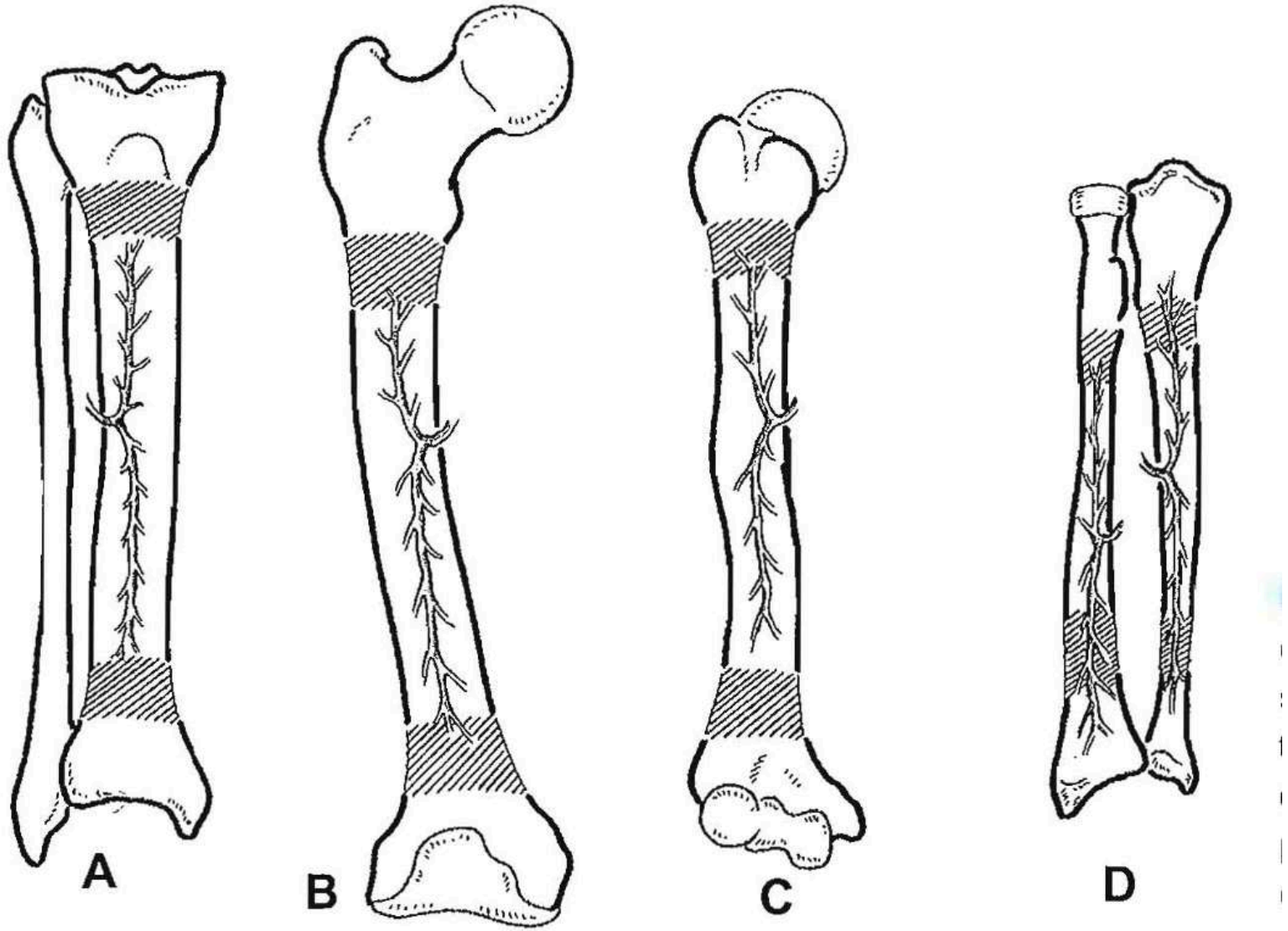
Anatomic

Anatomic texture of bone segment

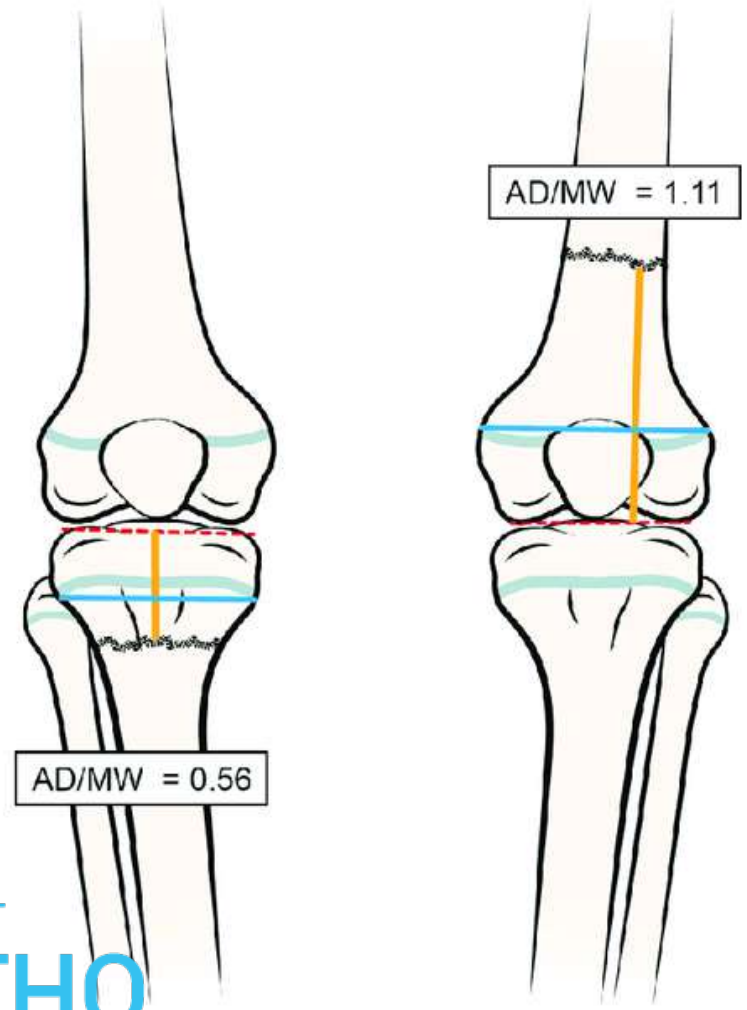
Suitable segment is relatively thin compact layer

Transition of medullary cavity into trabecular bone

Less probability of bone vascular net cutoff



Biomechanically



Corticotomy should not interfere with its motion

Bone segment must be large enough to accommodate a supporting ring or two rings situated between the joint and bone transection

Estimated distance – At least 6-7cms

Physiologically

- Scars from previous injuries
- Infection
- Previous Surgery

Interferes with osteogenesis

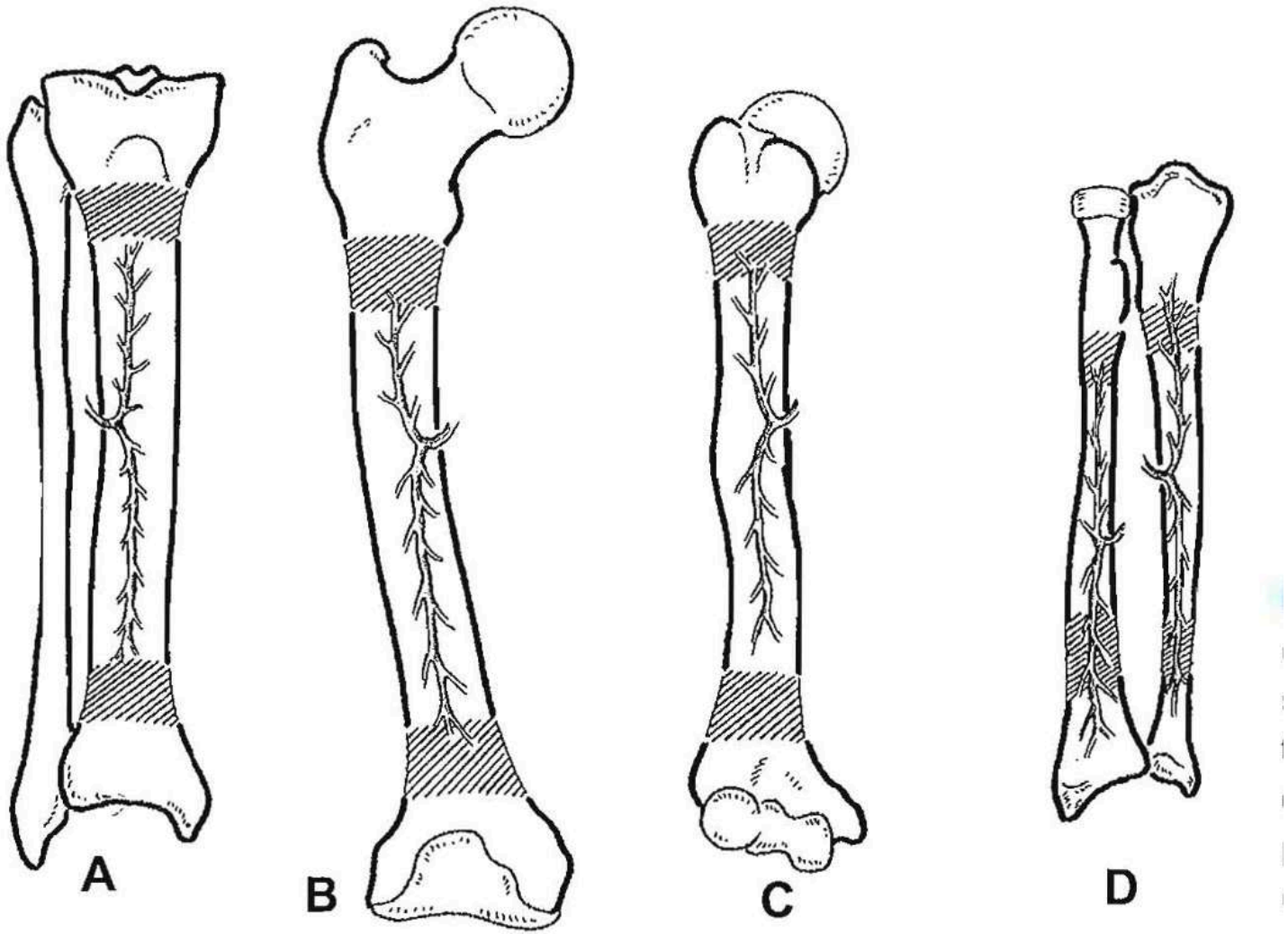
Bone structure change

- Zone of sclerosis
- Zone of porosis
- Cyst formation in the bone

Delays or prevents bone regeneration

Most suitable level

Meta-epiphyseal segments of the bone



Mono focal and Bifocal Corticotomy

- Depending on the goal of treatment in a particular patient:

Corticotomy can be performed at one level on same bone – MONOFOCAL

Corticotomy can be performed at two levels on same bone – BIFOCAL

Mono focal Corticotomy

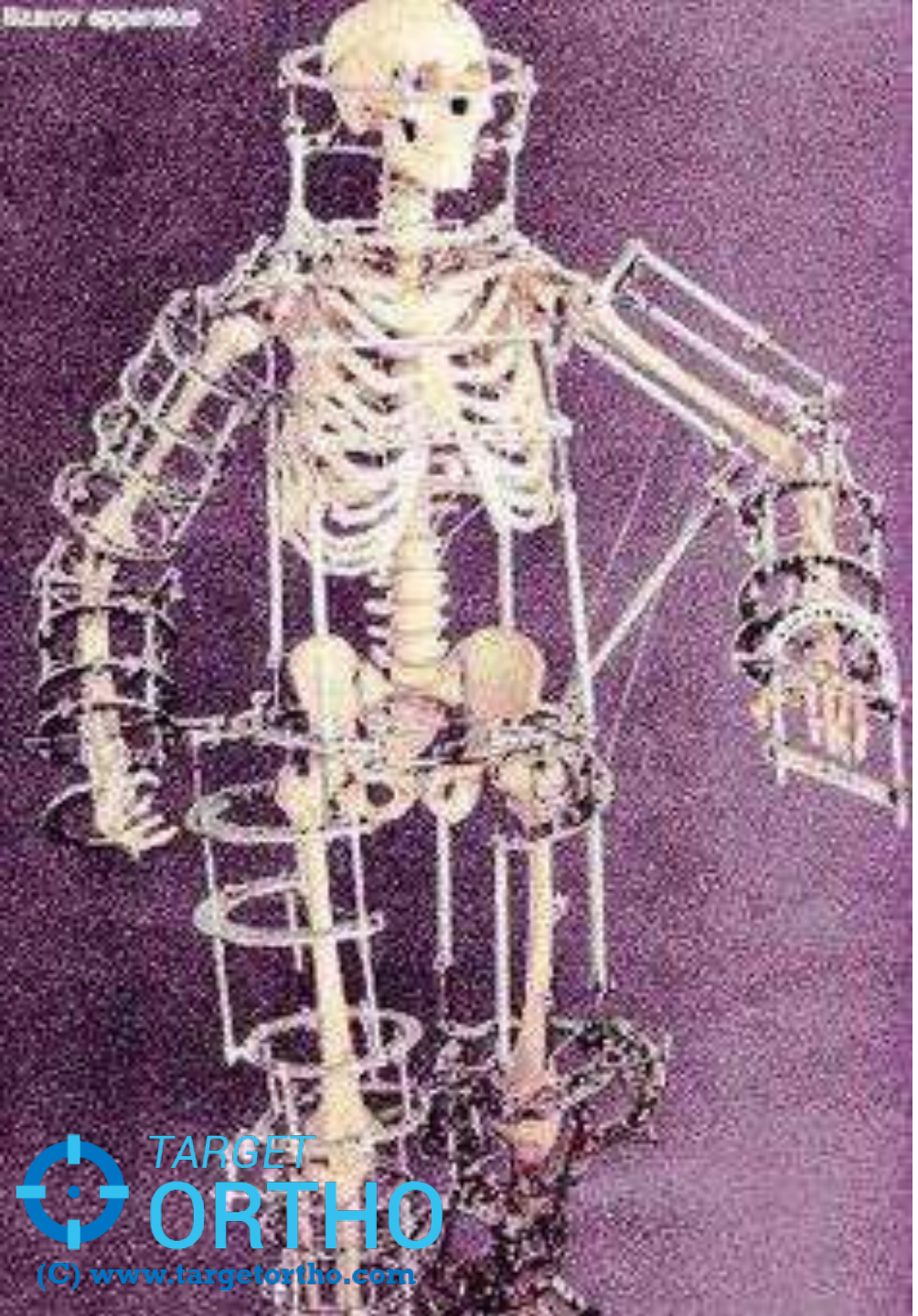
- Lengthening up to 5cm
- Bone fragment transportation up to 5-7 cm
- Stimulation of local blood circulation in the limb without significant lengthening but generation of osteogenesis (e.g. – Pseudoarthrosis or nonunion)
- Gradual correction of bone deformity

Bifocal corticotomy

- Lengthening up to 10-12cm
- Bone fragment transportation up to 10-16 cm by shifting them toward each other
- Simultaneous lengthening at one level and correction of deformity at another level
- Stimulation of osteogenesis in metabolic disorders (Paget's disease, Osteogenesis imperfecta, Ollier disease)

Distraction during Corticotomy

- The distraction gap does not damage vascular net.
- It contributes to the initiation of local tissue rebuilding – stays filled with hematoma – Micro blood lacunae
- Lacunae – New vessels – 3rd to 5th day
- Exact time to start distraction which brings about tension forces on the walls of the newly formed vessels
- And regeneration begins



Thank you

Next class :
Part 3 – Biomechanics of Ilizarov