

Evolution of Plate Design and Function -Indications for Locked Plating-

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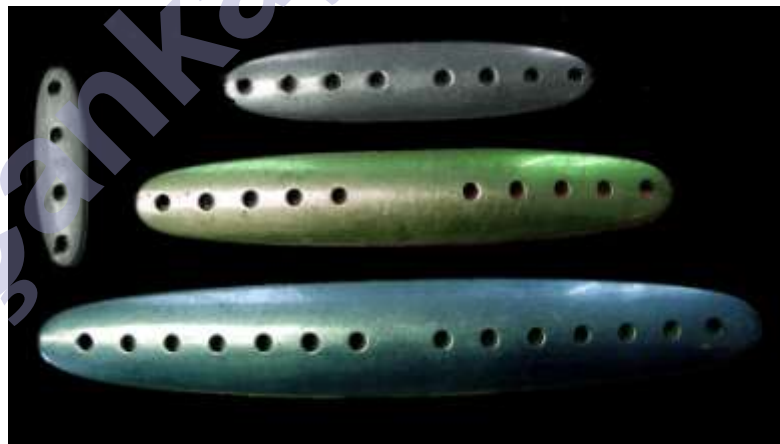
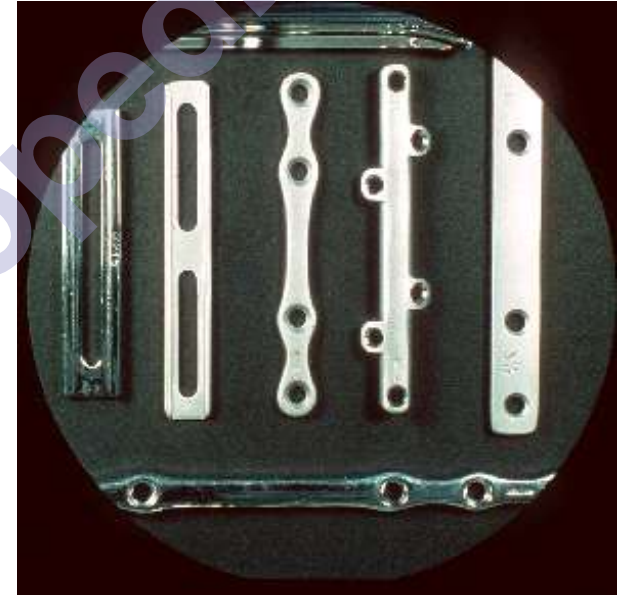
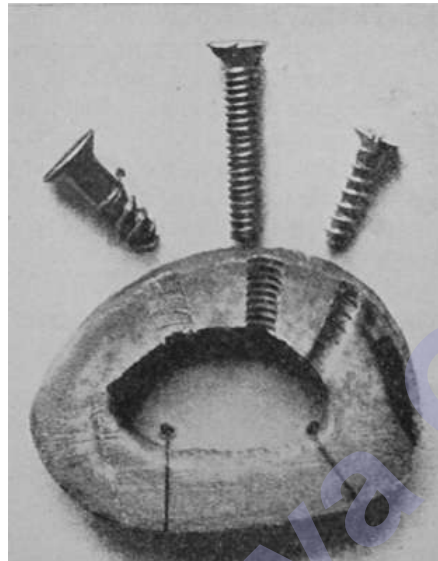
***Çankaya Hospital
Dept. Orthopedics and Traumatology
Ankara, TURKEY***

***AO Trauma Advanced Course
Krakow, 2014***

Learning Outcomes

- **Spectrum of fixation methods using different plates**
- **Evolution of plates**
 - Biomechanical considerations
- **Mechanics of locking head screws**
- **Indications for locked plating**
- **Correct application of locked plating**

Historical implants

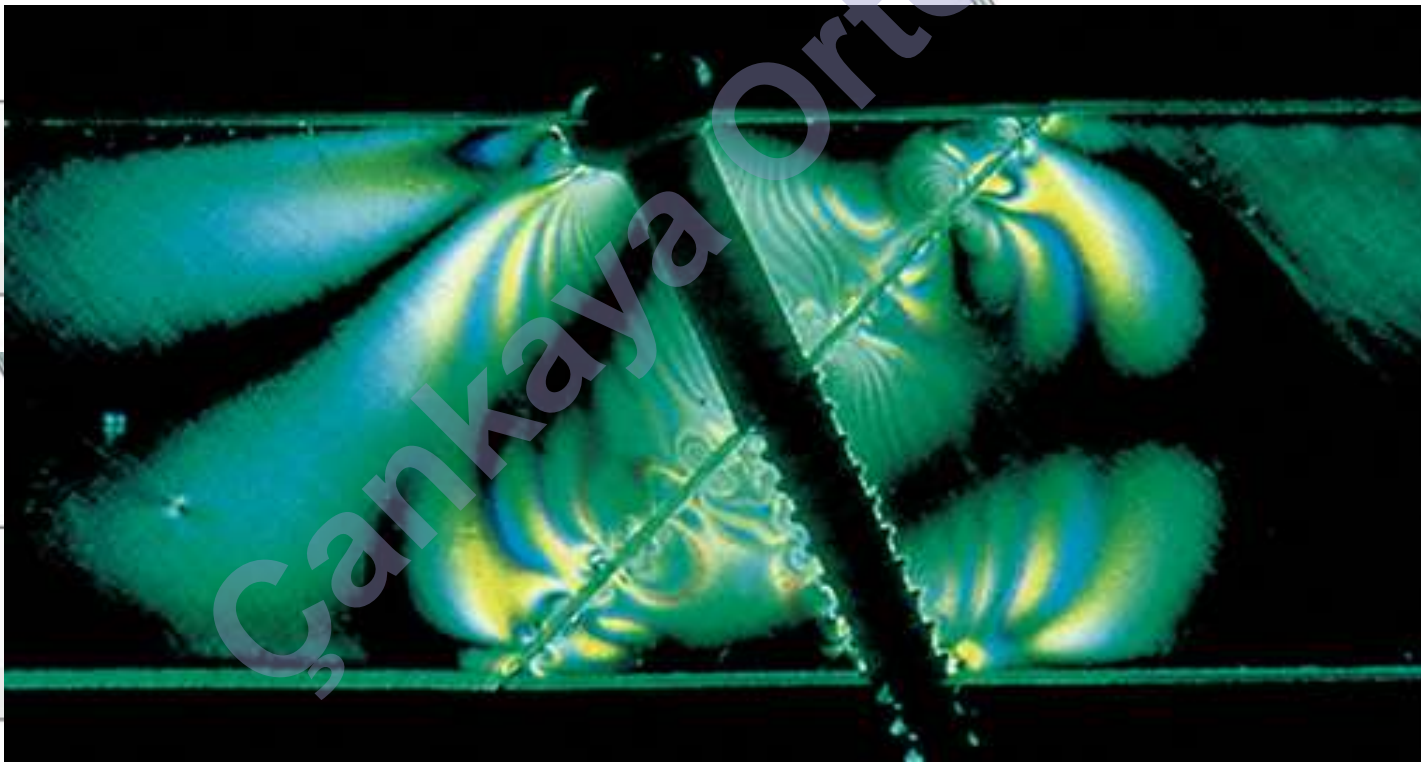


Original AO Principles (1958)

- 1. Anatomical direct reduction**
- 2. Rigid fixation with fracture compression**
 - Stable internal fixation
- 3. Preservation of blood supply and soft tissues**
- 4. Early active pain-free mobilization**

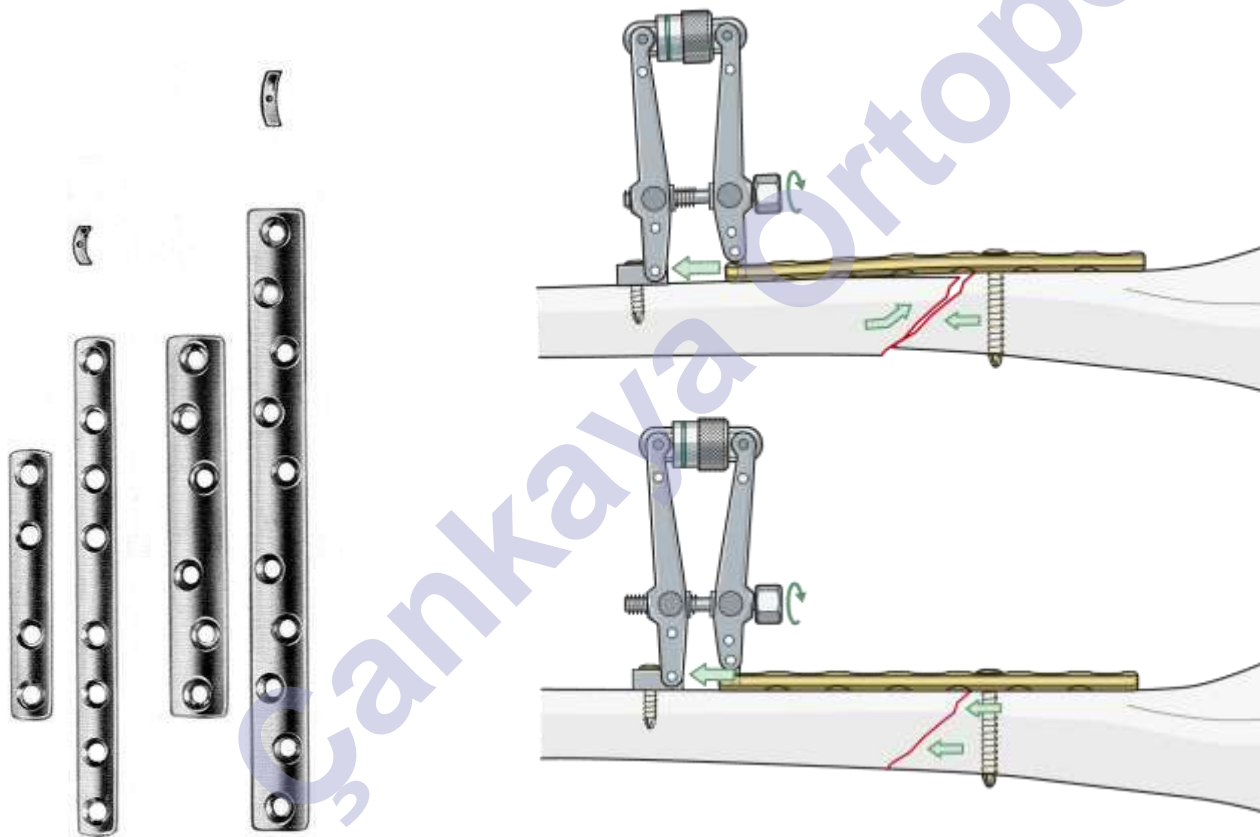
Lag screw

The lag screw is the basic tool used to create interfragmentary compression

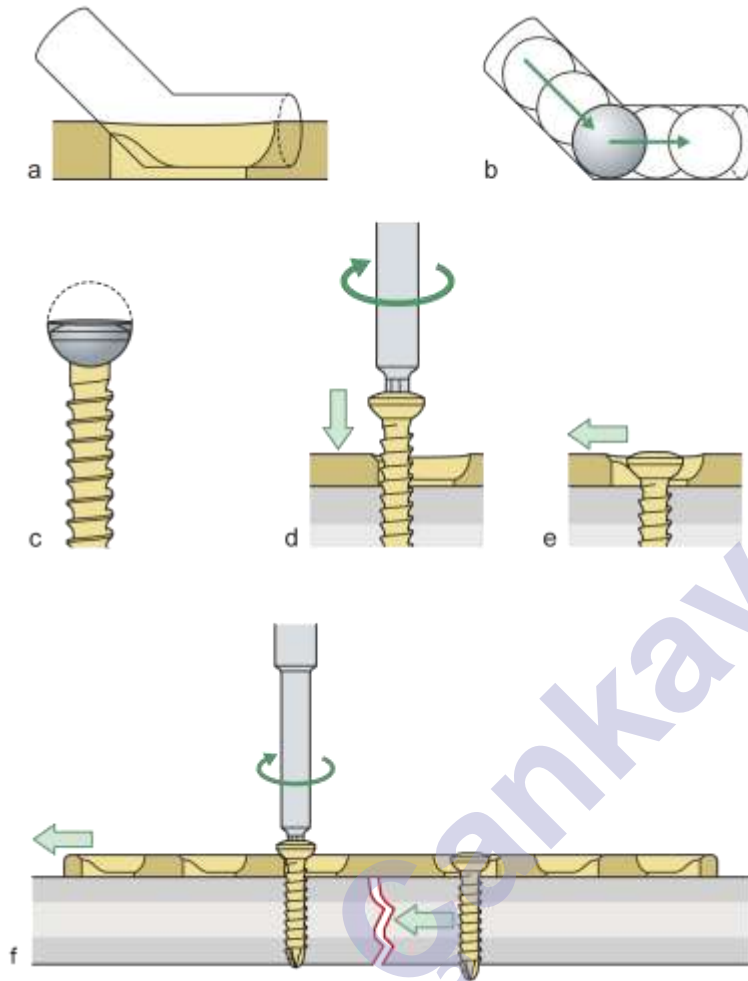


Round-hole plate (1958)

Axial compression could only be obtained using the external compression device

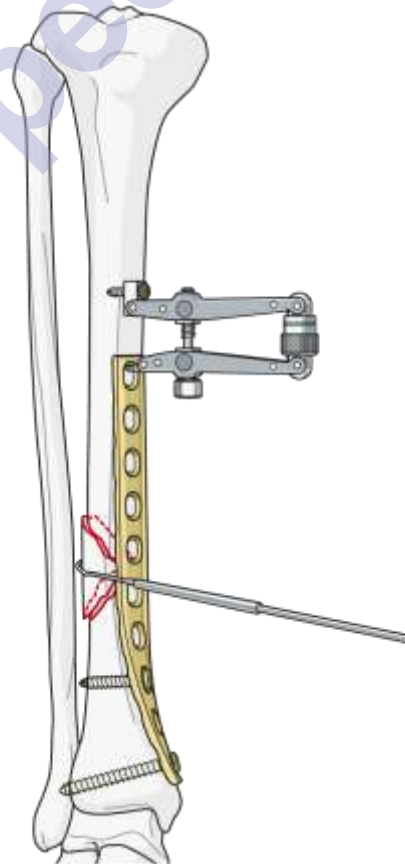


Dynamic compression plate (DCP)



Dynamic compression plate

“Still—don’t forget”



External tension device

Plate Function

- Compression
- Protection – neutralization
- Buttress – antiglade
- Tension band

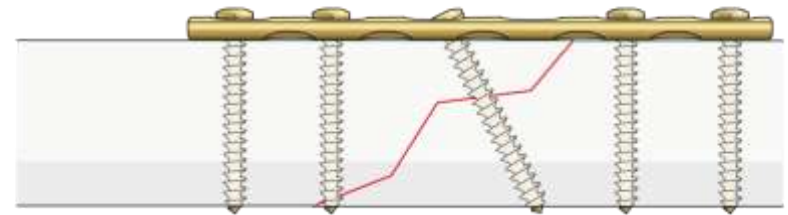
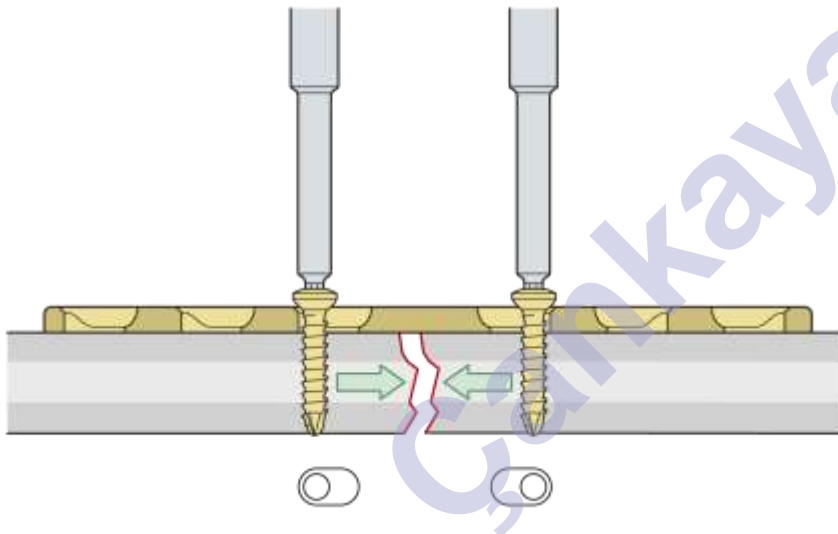


***absolute
stability***

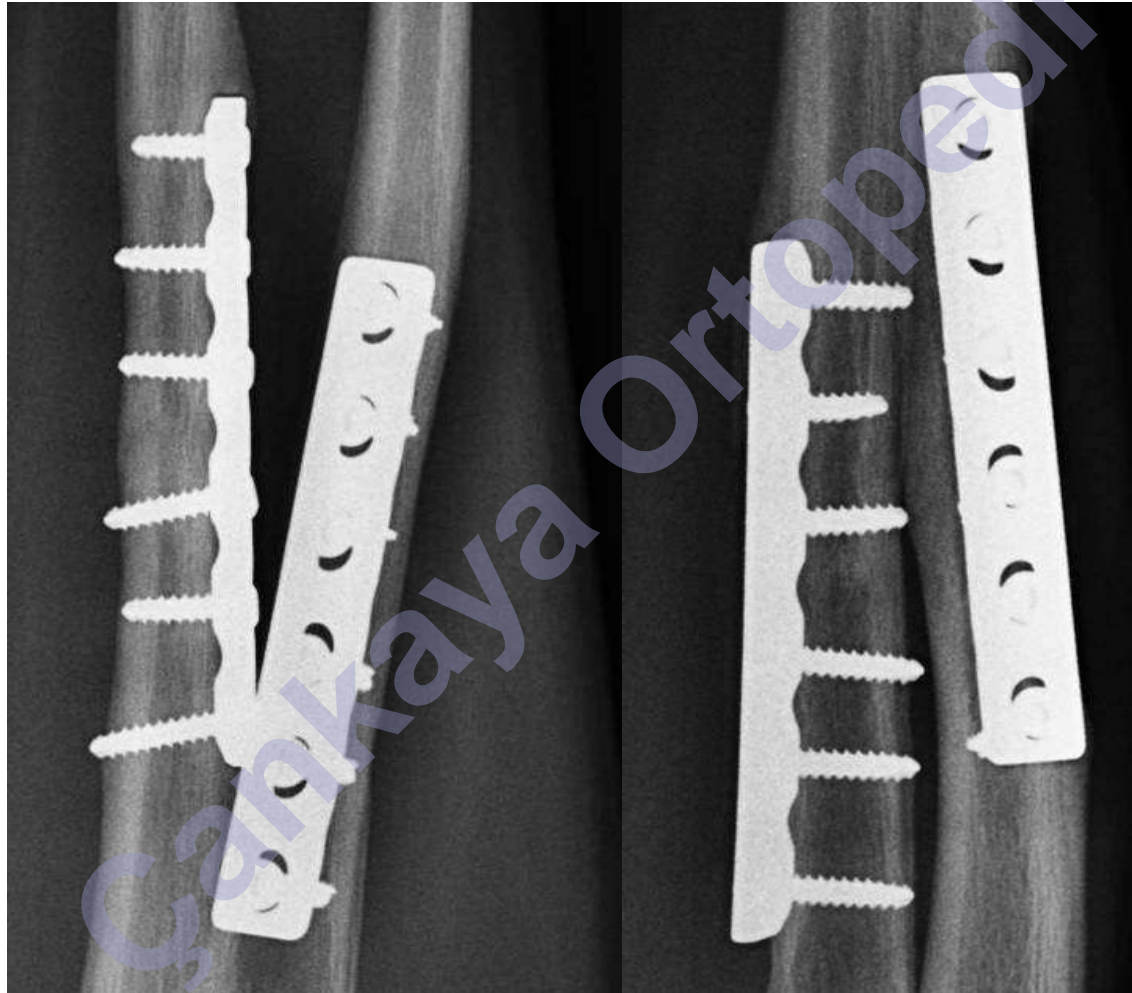
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Compression plate

- Absolute stability
- Direct healing
- Transverse or oblique 2-part fractures
- Screws compress plate to bone



Compression plate



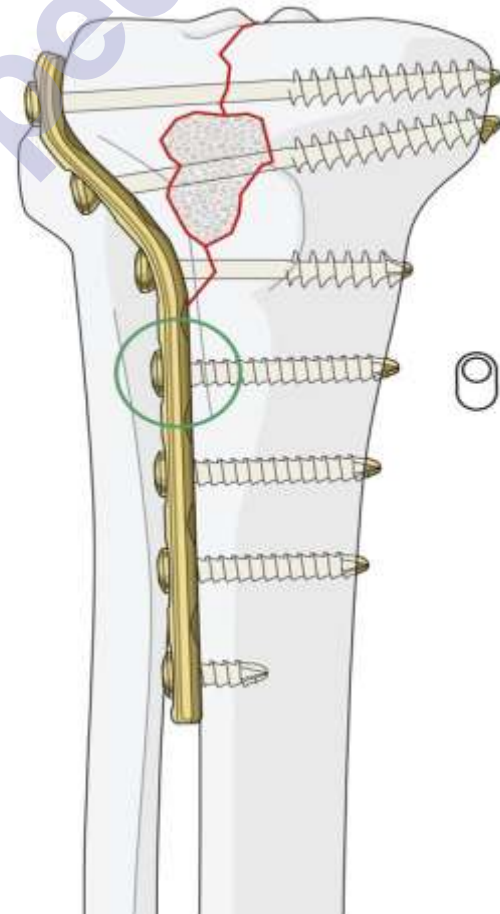
Neutralization Plate

- Protects interfragmentary lag screw(s)
- ↓ rotational and axial forces



Buttress Plate

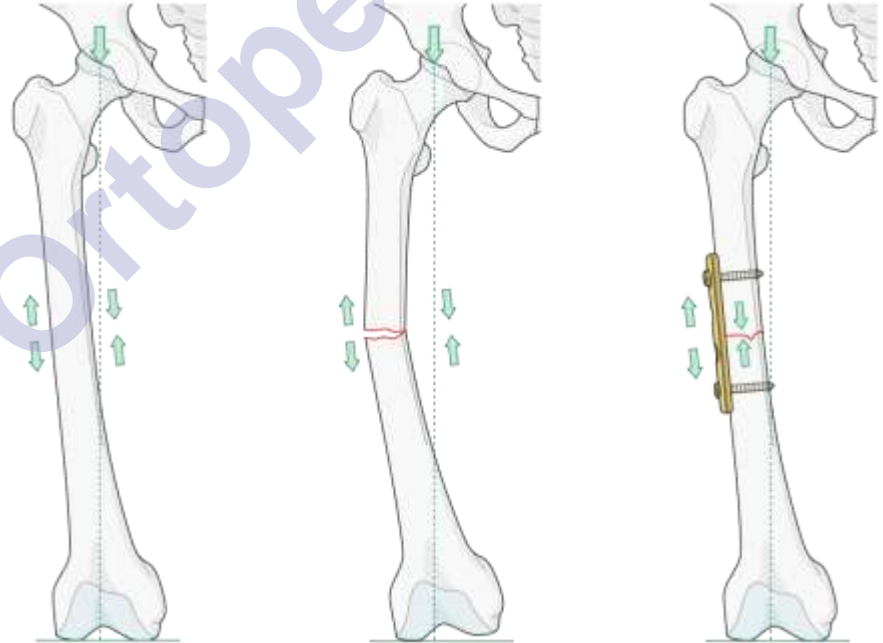
- Displacement in one direction
- Resists axial loading (antigliding)
- Metaphyseal fractures (“B” type partial articular)



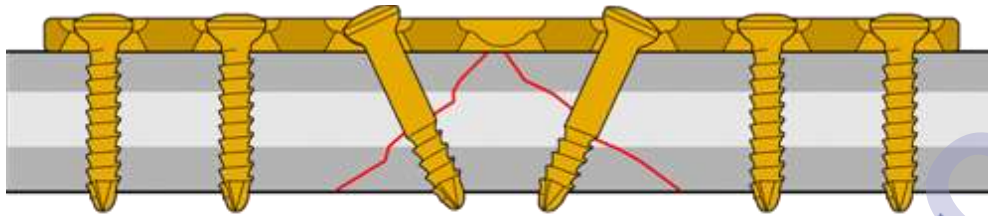


Tension Band Plating

- Eccentrically loaded bone
- Plate on tension (convex) side
- Compression at concave side

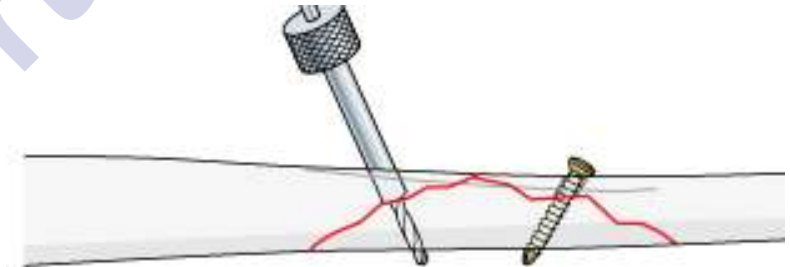
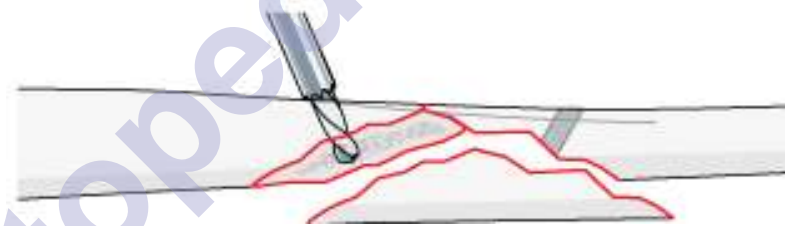


Wedge Fractures



Lag screw through plate

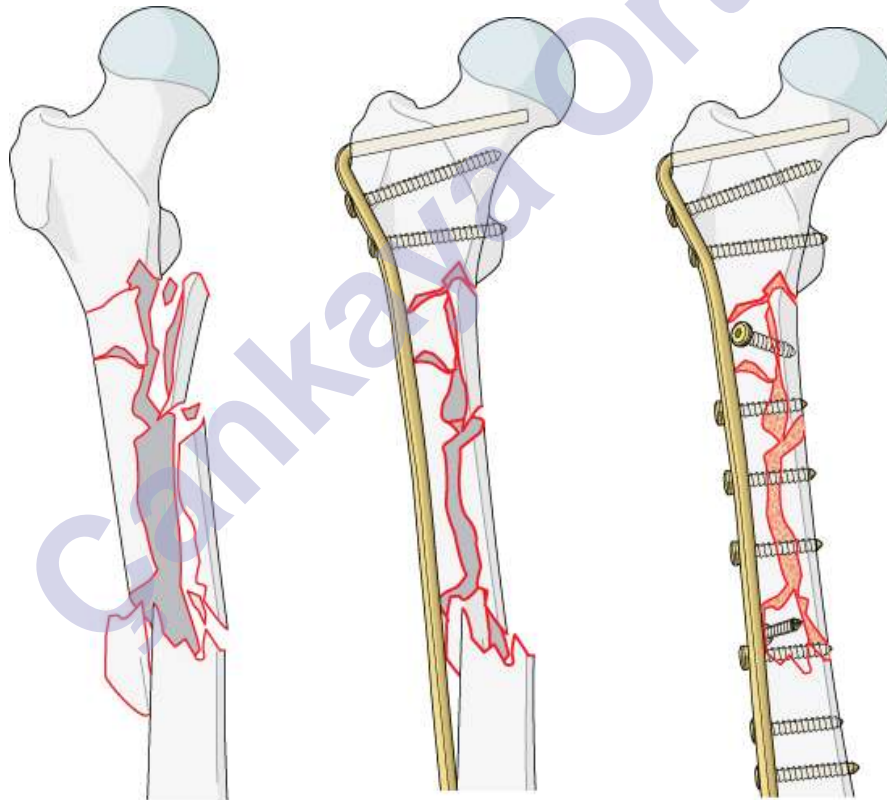
More soft tissue stripping



Lag screw and neutralization

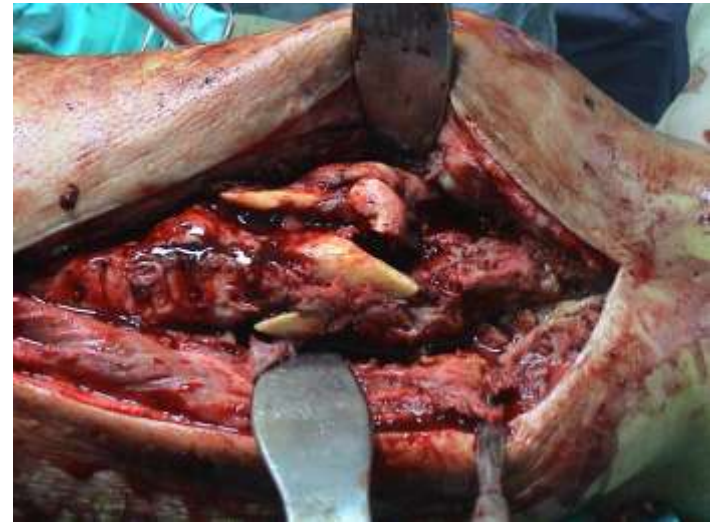
Comminuted Fractures ?

- Require substantial soft tissue disruption
- Bone grafting on contralateral side



Problems with Absolute Stability

- Too extensive surgery
 - Periosteal stripping
 - Soft tissue damage
 - Too many implants
-
- Delayed union
 - Implant failure
 - Nonunion
 - Wound problems and Infection



Biological Solutions

- New plate designs
- New surgical techniques

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Traditional Compression Plate

Plate pressure - necrosis



Limited contact DCP (LC-DCP)



1991

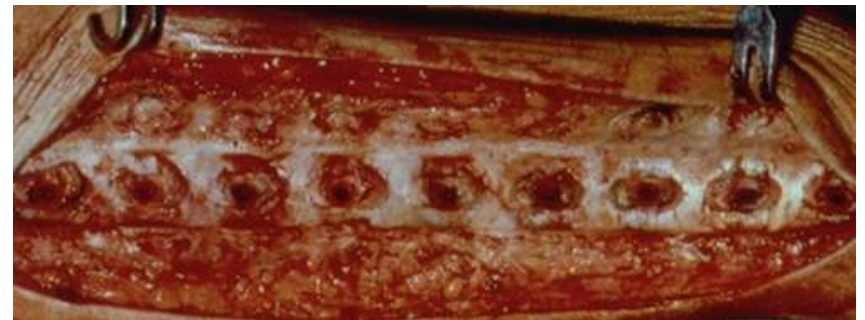
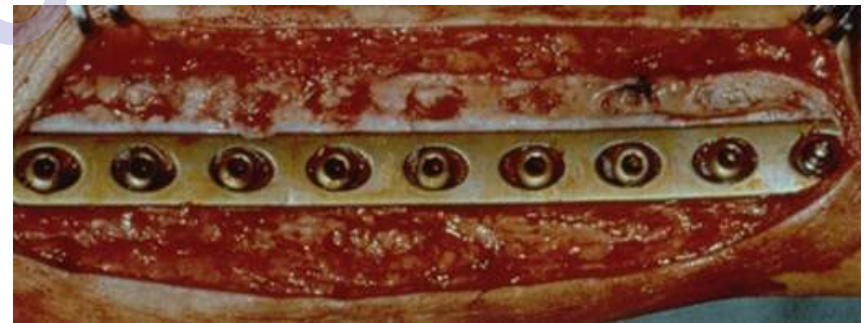
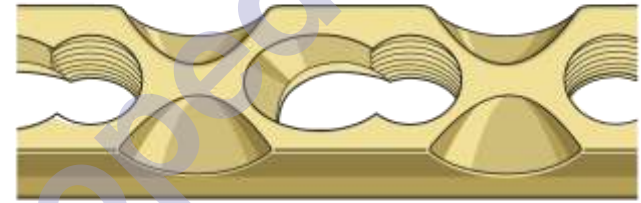
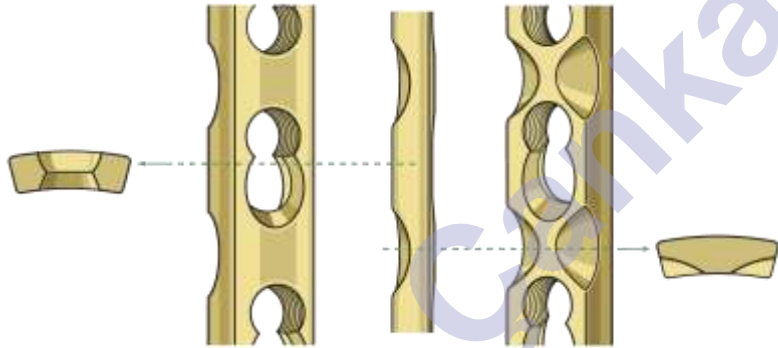
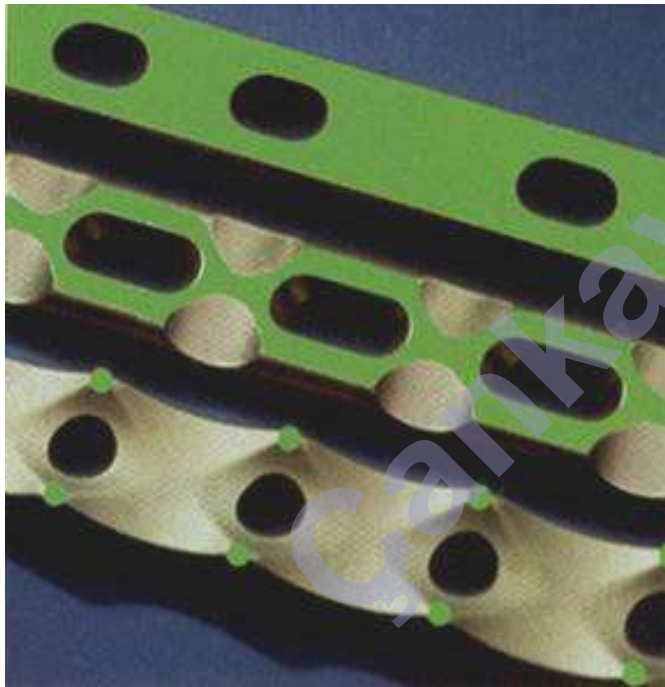
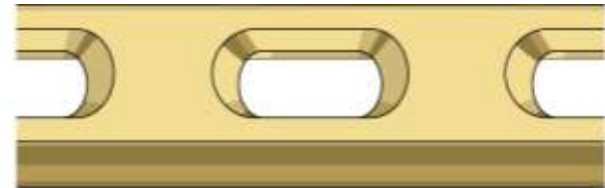


Plate Design

- Gradual evolution
- Minimize detrimental effects on bone



DCP



LC-DCP

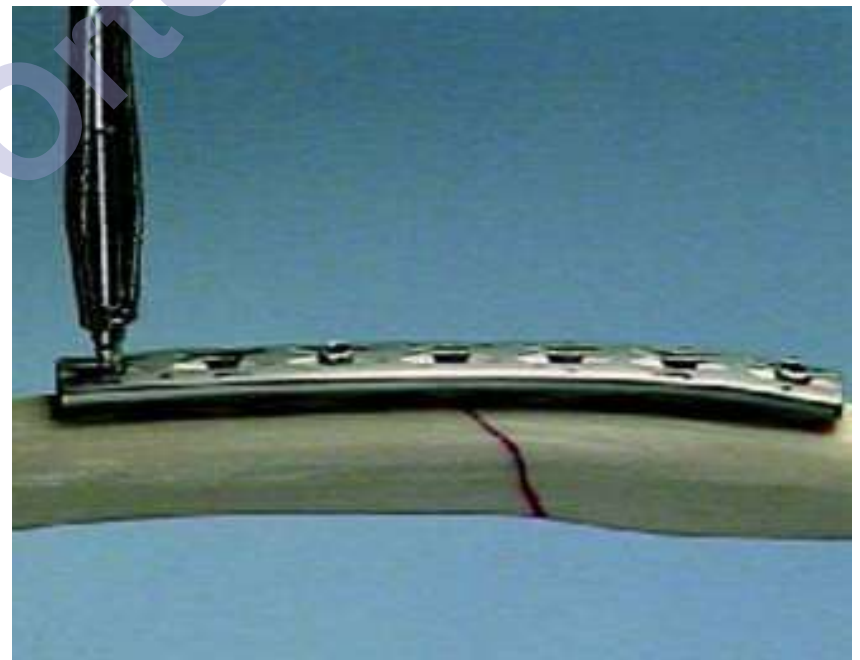
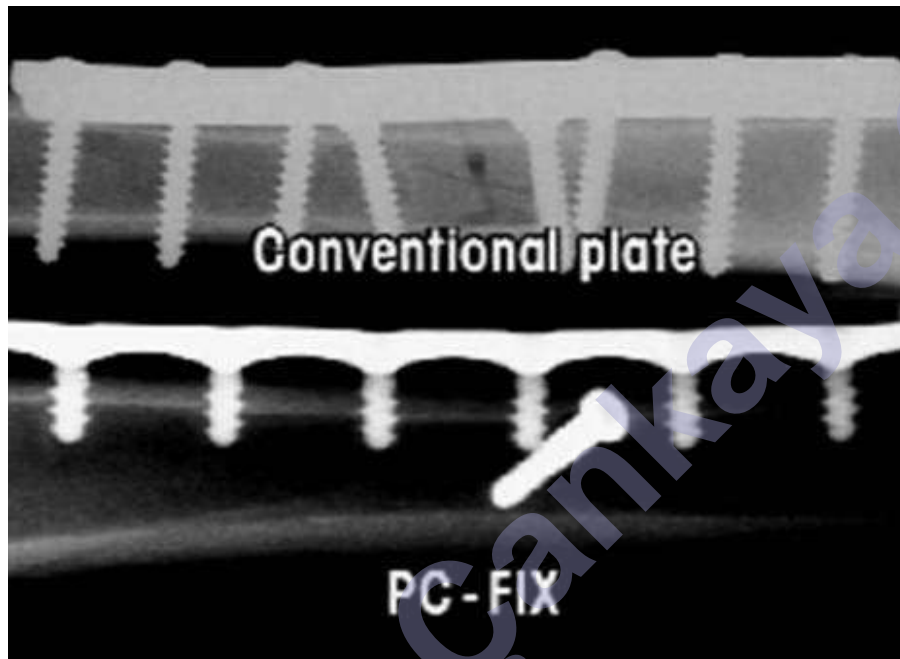


PC-Fix



Point-contact fixator (PC-Fix)

An evolutionary breakthrough

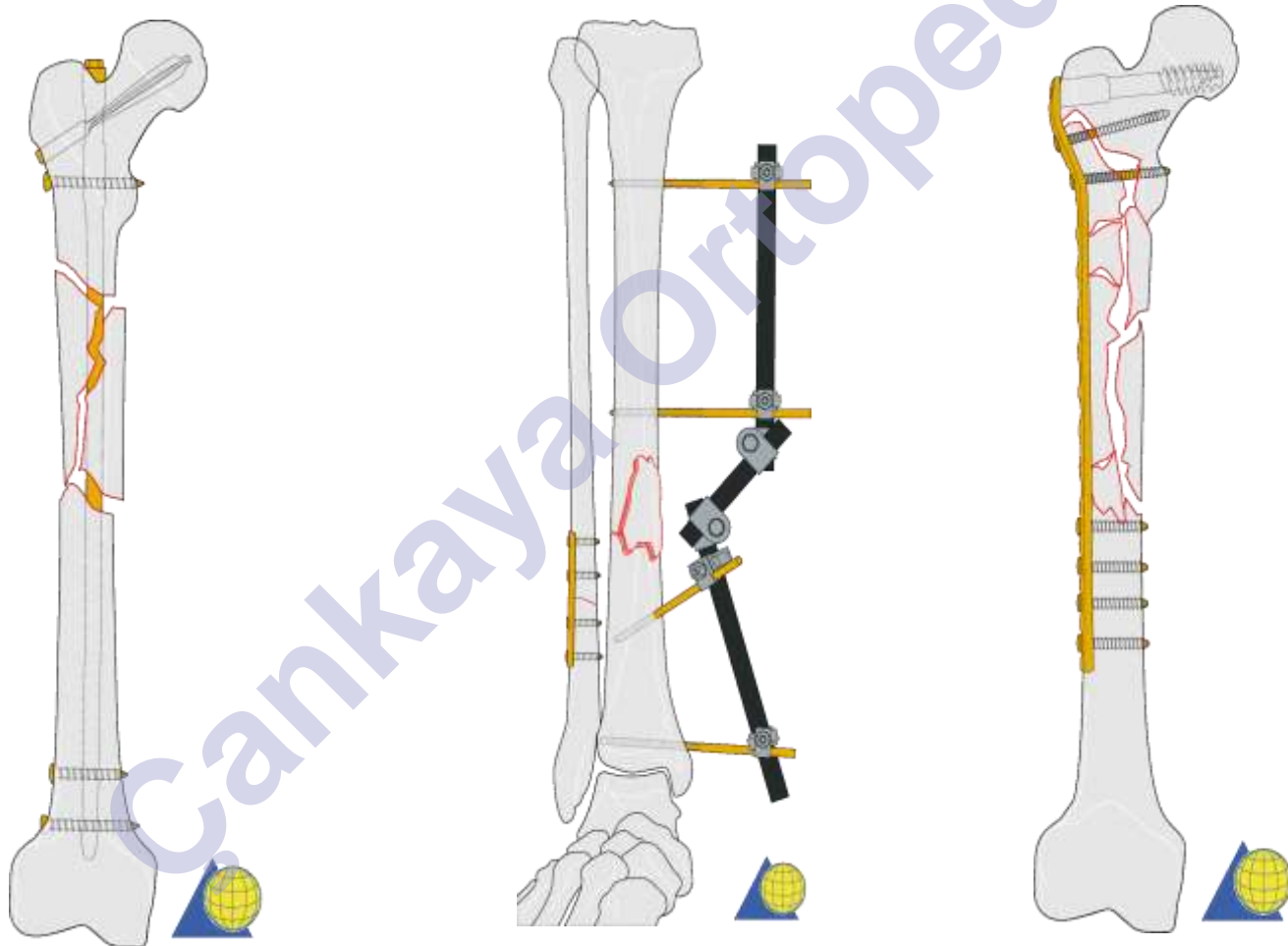


New Surgical Techniques

- **Relative stability concept**
- **Bridge plating**
- **Minimally invasive surgery**
 - Indirect reduction
 - Percutaneous plating

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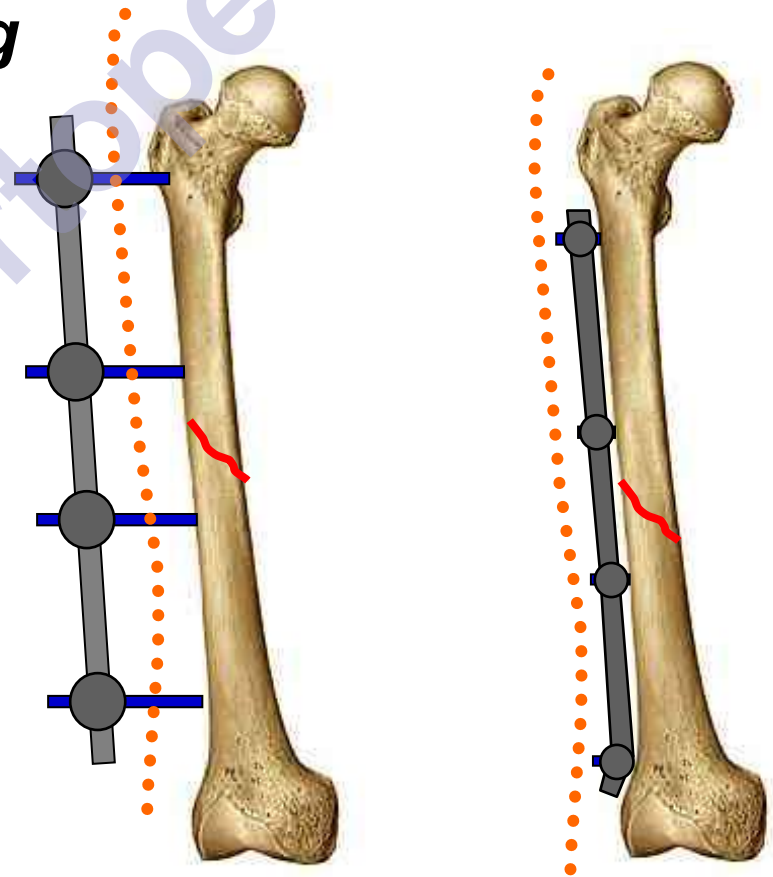
Bridging Techniques



Bridging Plating

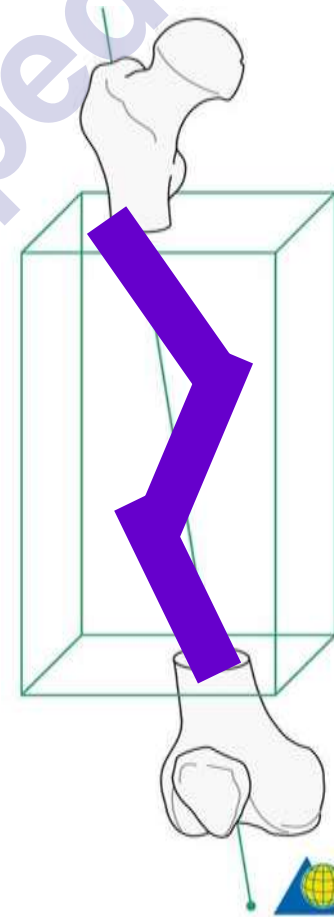
Internal extramedullary splinting

- Long plate
- Less screw



Indirect Reduction

- **Functional reduction to restore**
 - Alignment
 - Length
 - Rotation
- **No anatomical reduction of the fragments**



MIPO



Distal Tibia



Distal Tibia



Distal Tibia



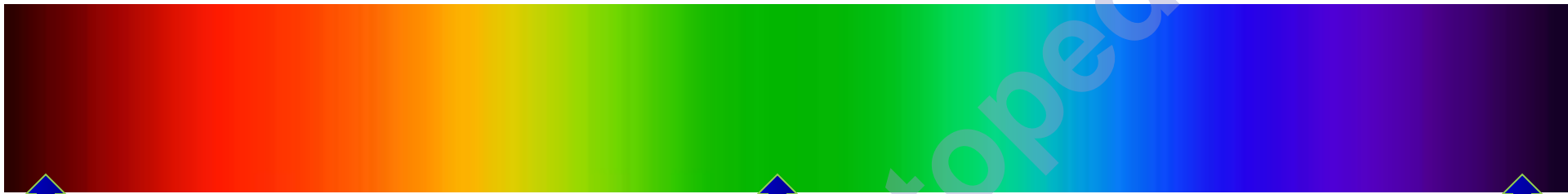
Distal Tibia





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Spectrum of stability



- **No motion**
- *Absolute stability*

- **Some motion**
- *Relative stability*

- **Excessive motion**
- *No stability*

**Compression
Neutralization
Buttress
Tension band**

Bridge

AO Principles now !

1. *Reduction*

- Anatomical → articular, simple fractures, forearm
- Functional → comminuted meta-diaphyseal fractures

2. *Adequate fixation*

- Absolute or relative stability depending on the fracture pattern

3. Preservation of blood supply and soft tissues

4. Early active pain-free mobilization

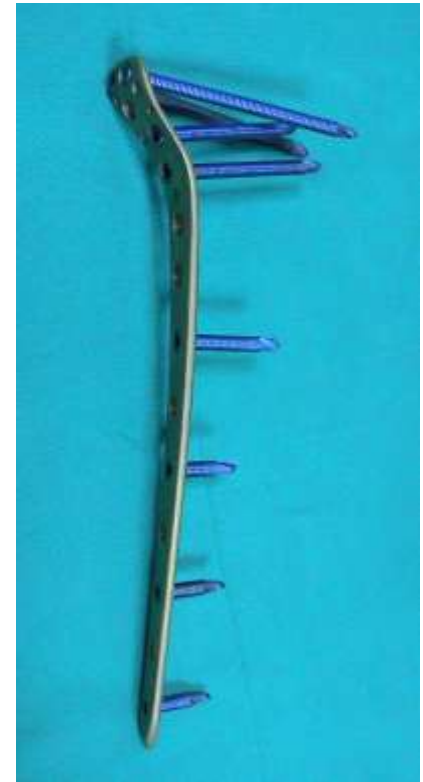
LISS

“Less Invasive Stabilization System”

- Designed for MIPO
- Internal fixator



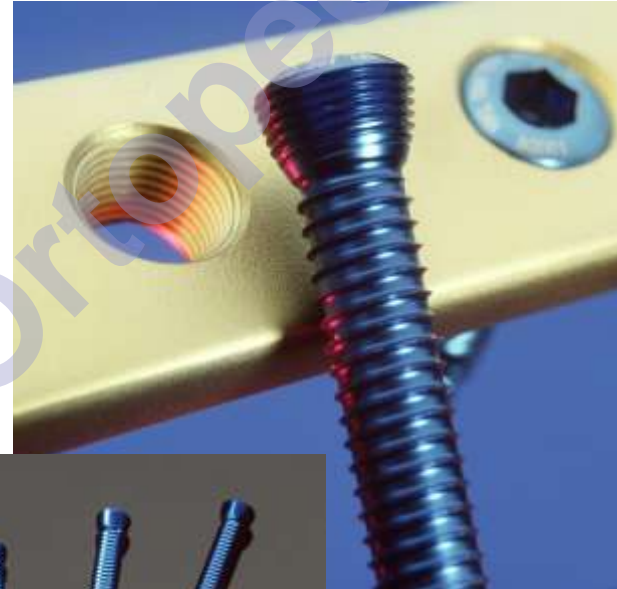
LISS - DF



LISS - PLT

LISS

- Locking head screw
- Self-drilling, self-tapping



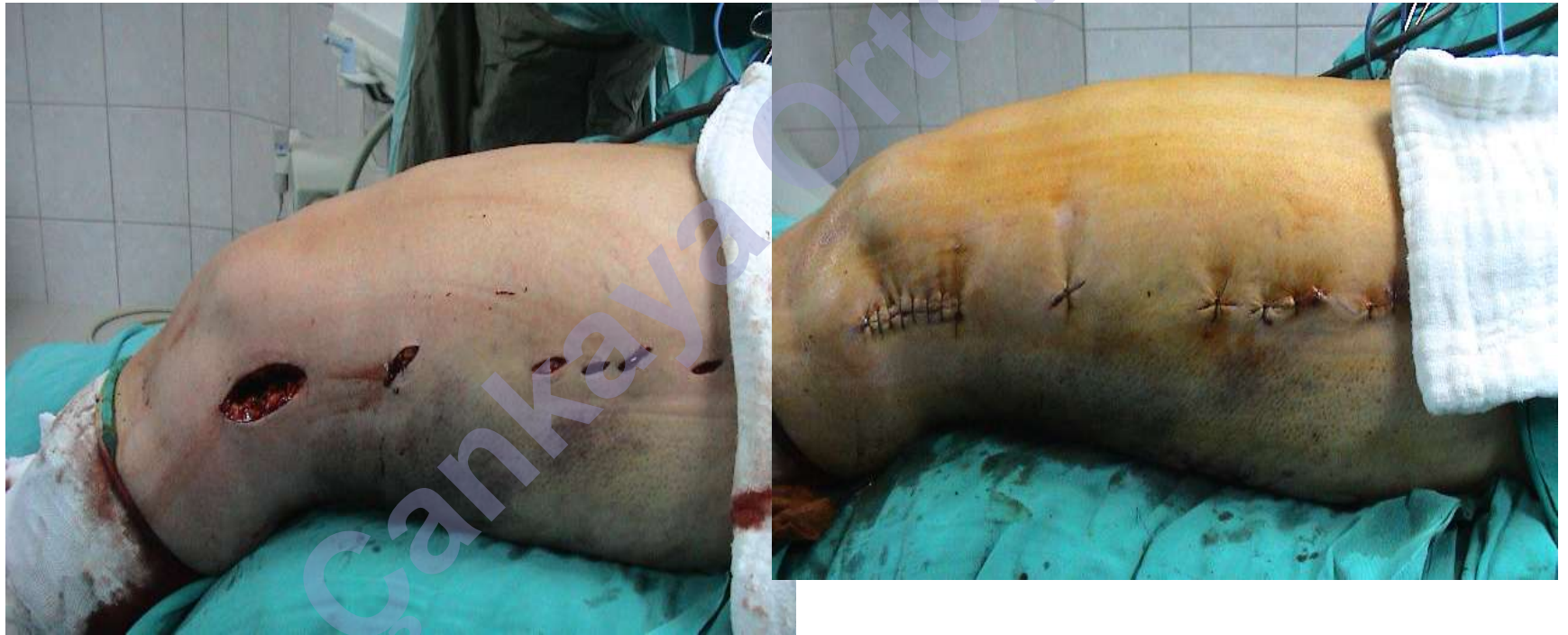
LISS - DF

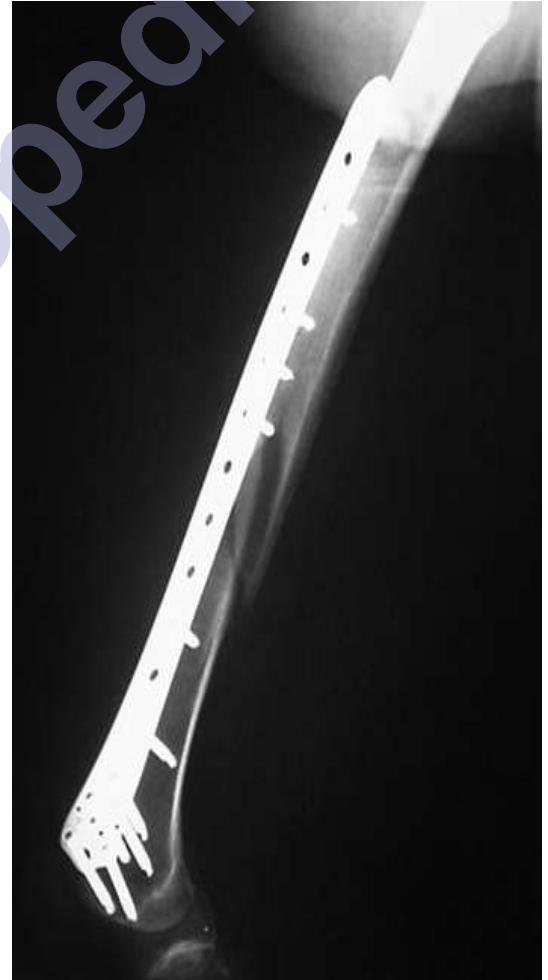


LISS - DF



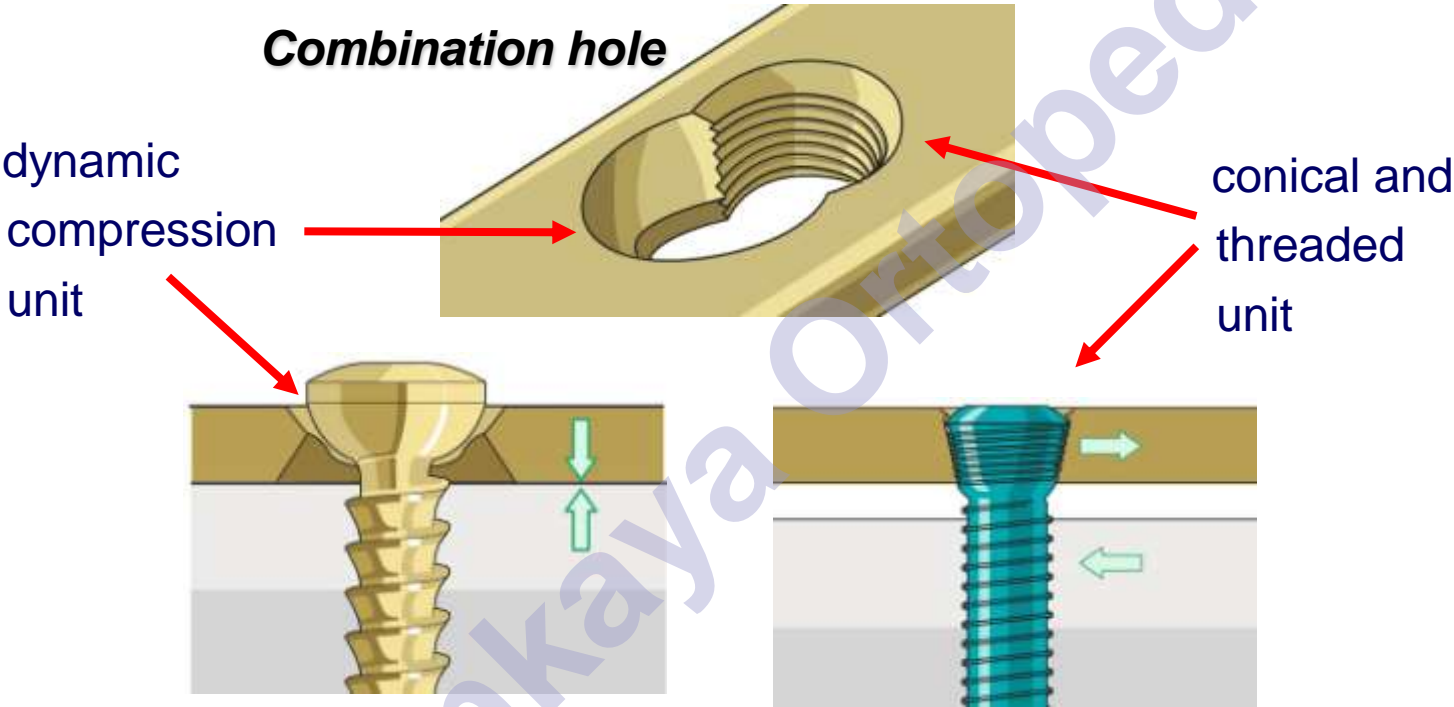
LISS - DF





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Locking Compression Plate (LCP)



Different types of screws

Conventional screws

Cortex screw (with or without shaft)

Cancellous bone screw (with or without shaft)



Locking head screws (LHS)

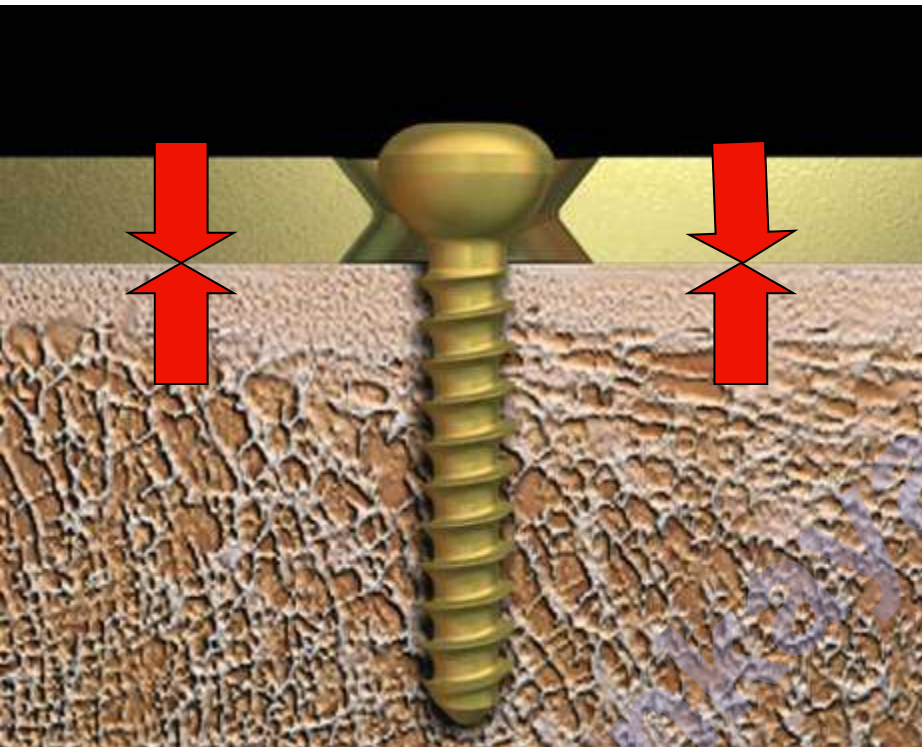
Self-tapping LHS

Self-drilling, self-tapping LHS



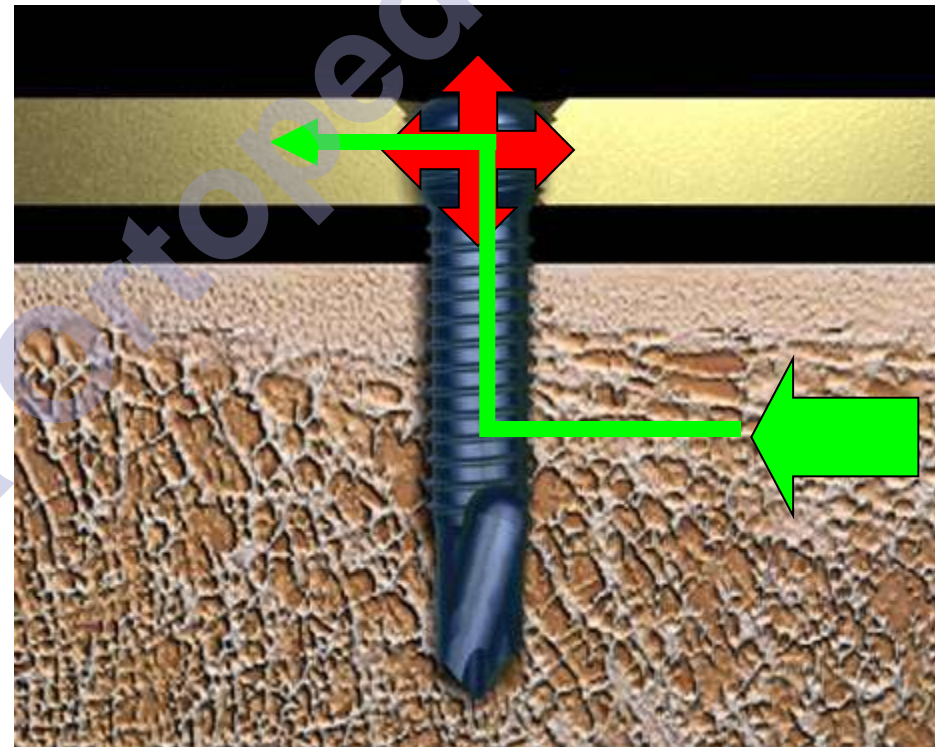
Difference of Function

Compression plate



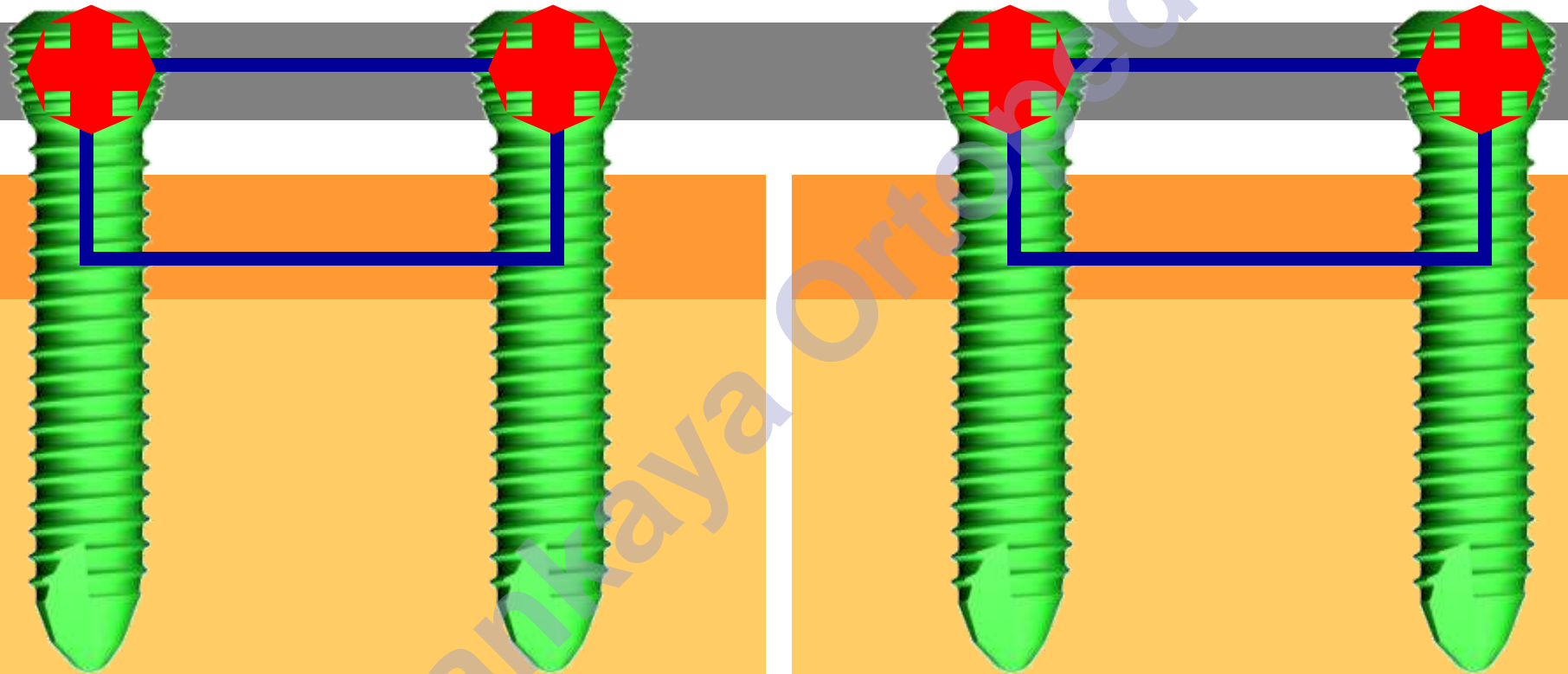
Force Transmission by
Bone to Plate Friction

Locked plate



Force Transmission through
Locking Head Screw

Non-contact Plate

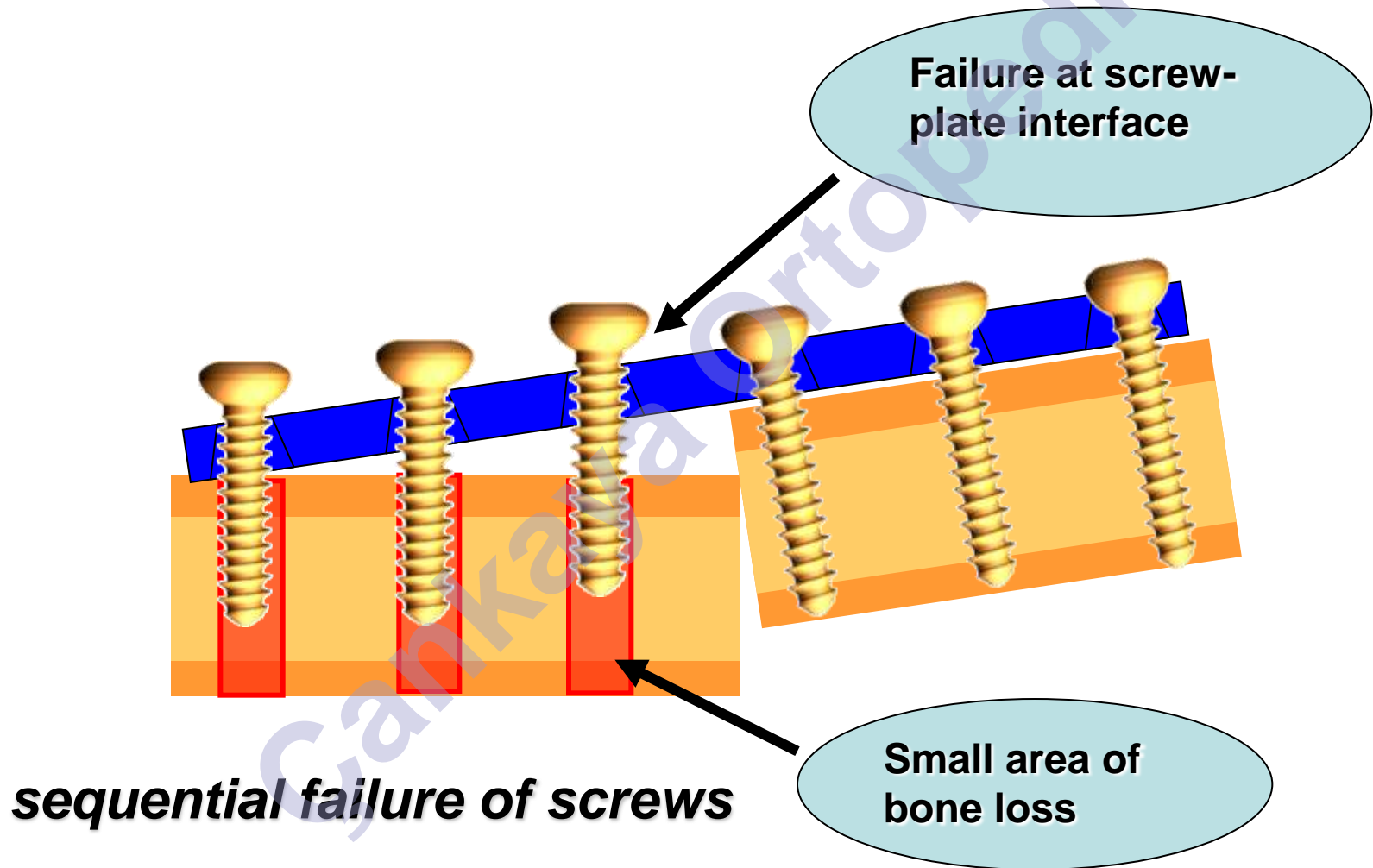


Locked plate does not compress underlying bone !!

Advantages of LHS

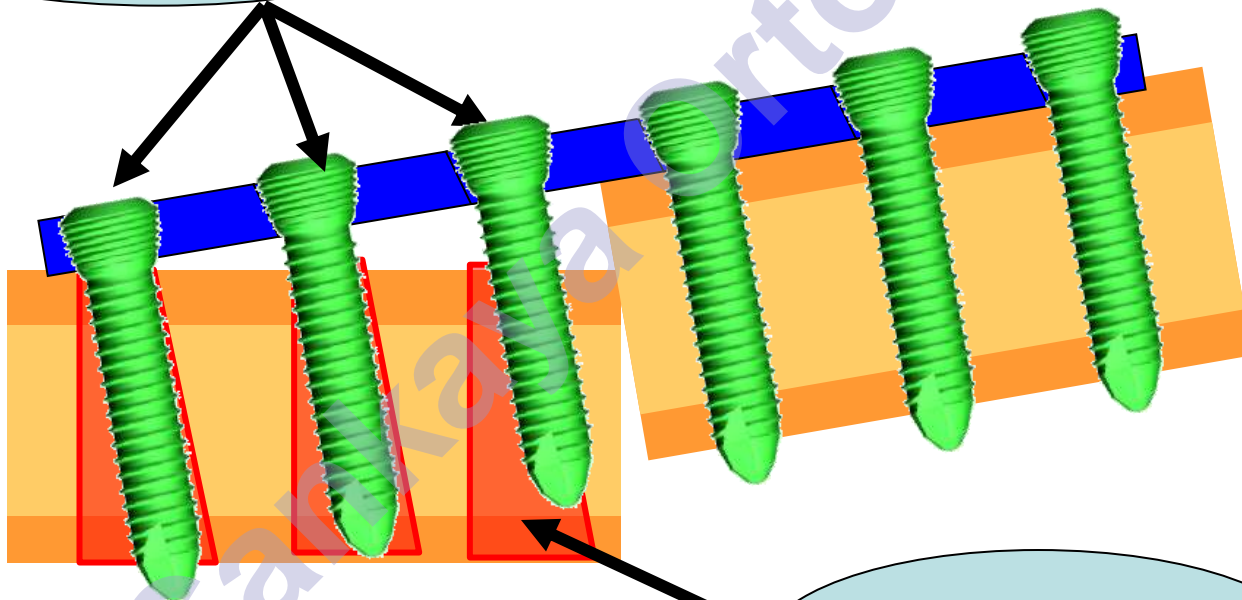
- **No compression of periosteum**
 - Protects blood supply
- **Angular stability**
- **Better anchorage in osteoporotic bone**
 - Less primary destruction of thread in the bone
 - Higher resistance against bending forces

Conventional Screws in Osteoporosis



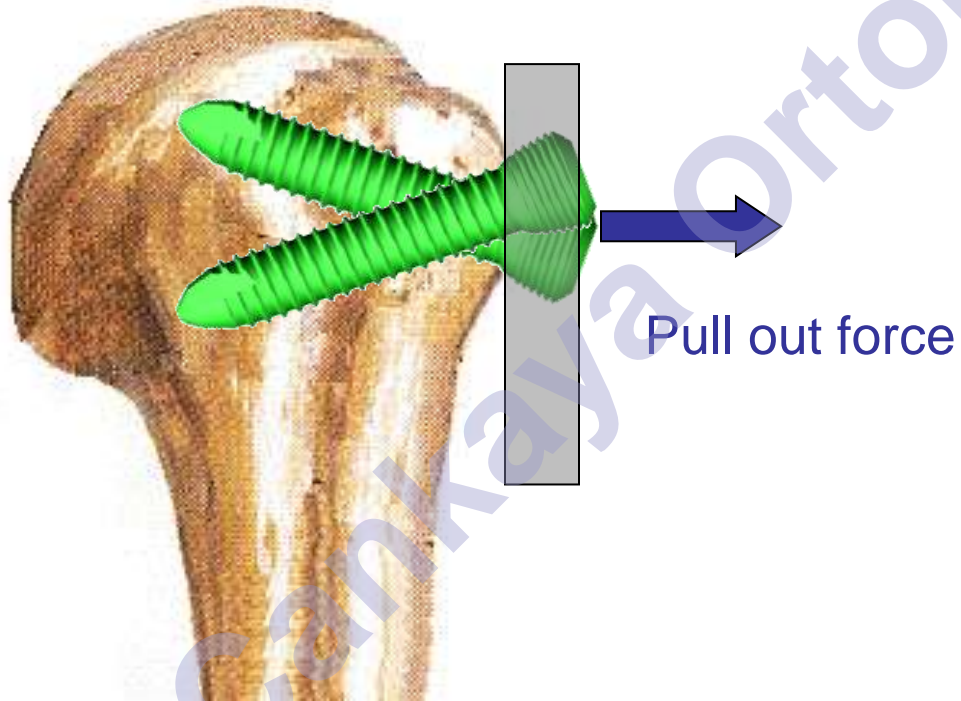
LHS in Osteoporosis

LHS and plate functions as one unit



Larger area of resistance

LHS-Plate Unit



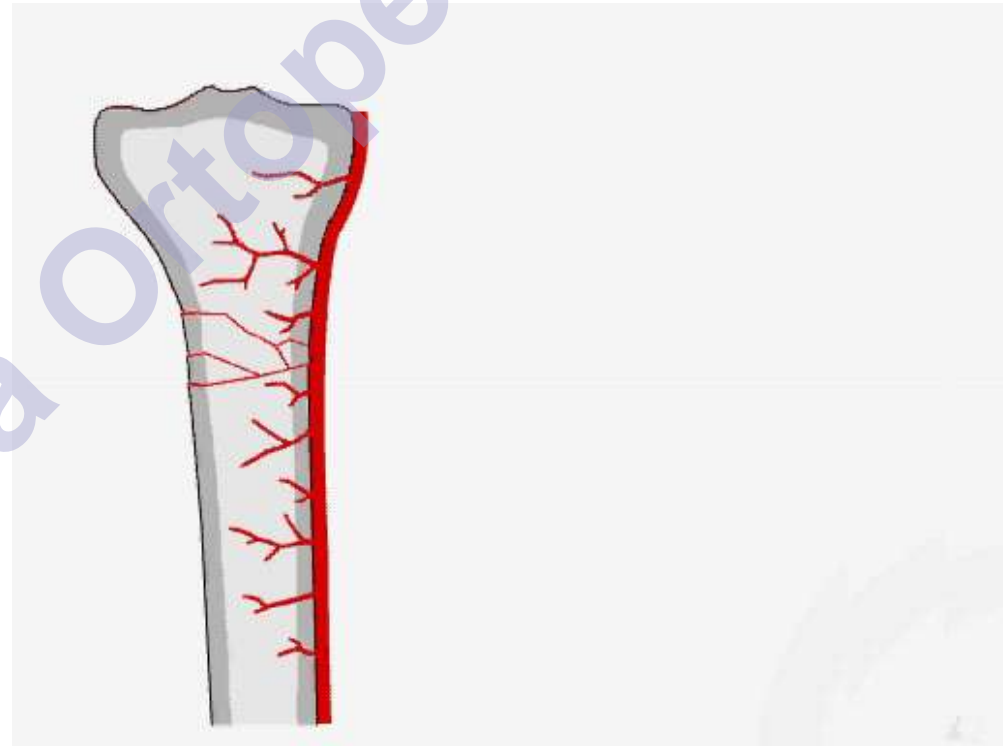
LHS-Plate Unit



Pull out strength ↑↑↑

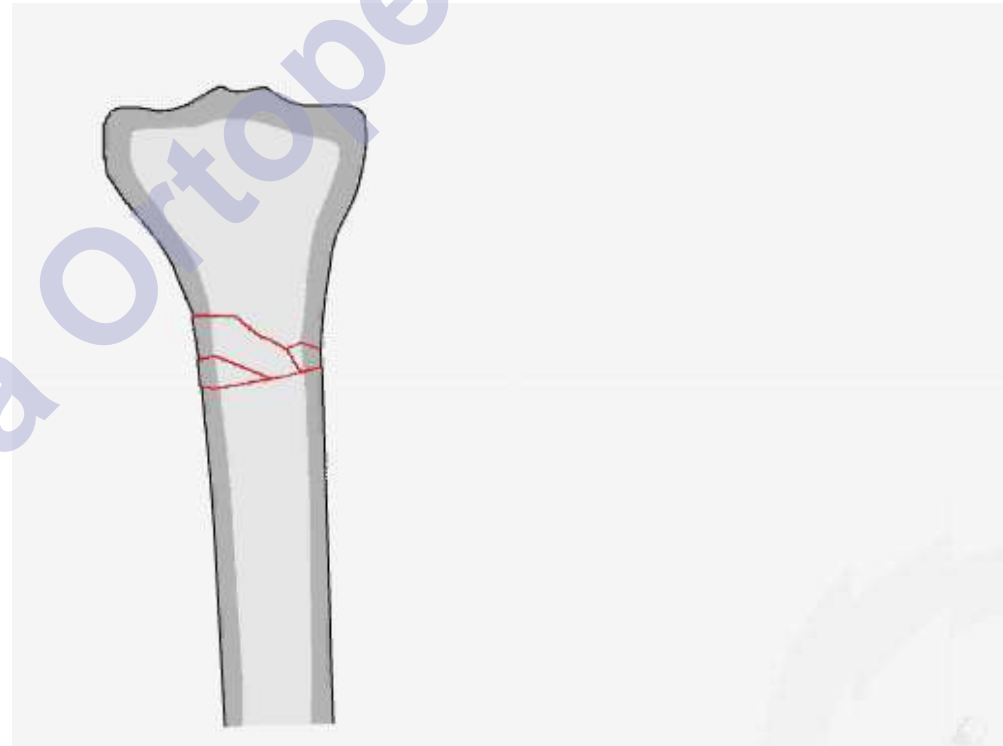
No Bony Contact

- Preserved periosteal circulation



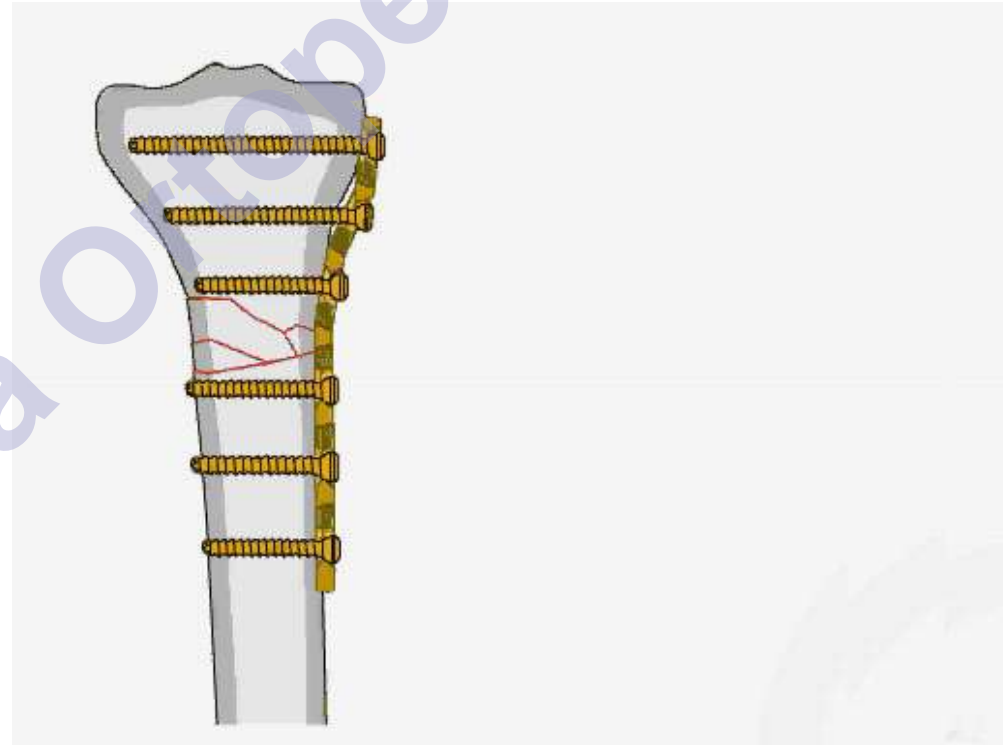
Primary Loss of Reduction

- No compression of the plate to the bone
- No contouring necessary in metaphyseal region
- Advantageous in MIPO



Secondary Loss of Reduction

- Angular stability
- Short epi-metaphyseal fragments
- Osteoporotic fractures



Application of LCP

- **When ?**
- **Where ?**
- **How ?**

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When ?

- **Anatomical region** → **Periarticular / metaphyseal fx**
 - *Not suitable for IM nail*
- **Fracture pattern** → **Comminuted fx**
 - *Bridge plating → relative stability*
- **Bone quality** → **Osteoporosis**
 - *Angular stability*
- **Surgical technique** → **MIPO**
 - *No 1^o loss of reduction*
- **Special situations** → **Periprosthetic fx**
 - *Monocortical screw*

Do not mix things up!

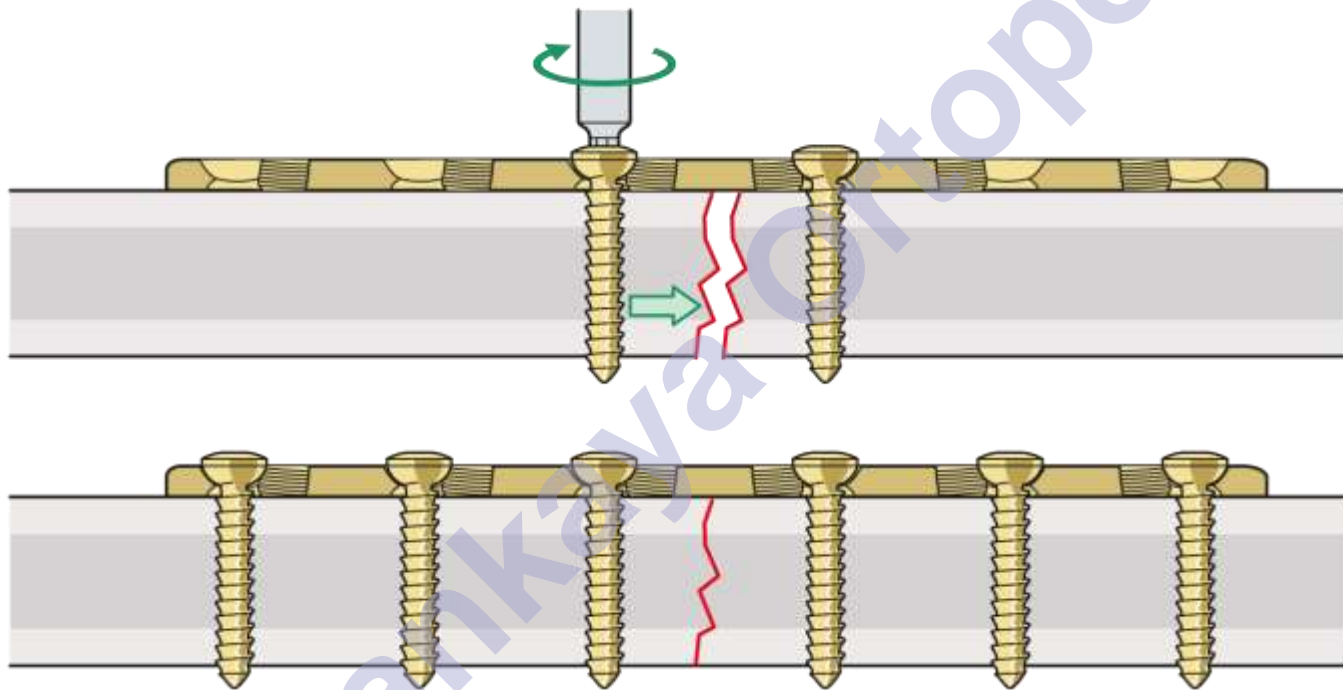
Implants

Surgical technique

Biomechanical principles

LCP for Absolute Stability

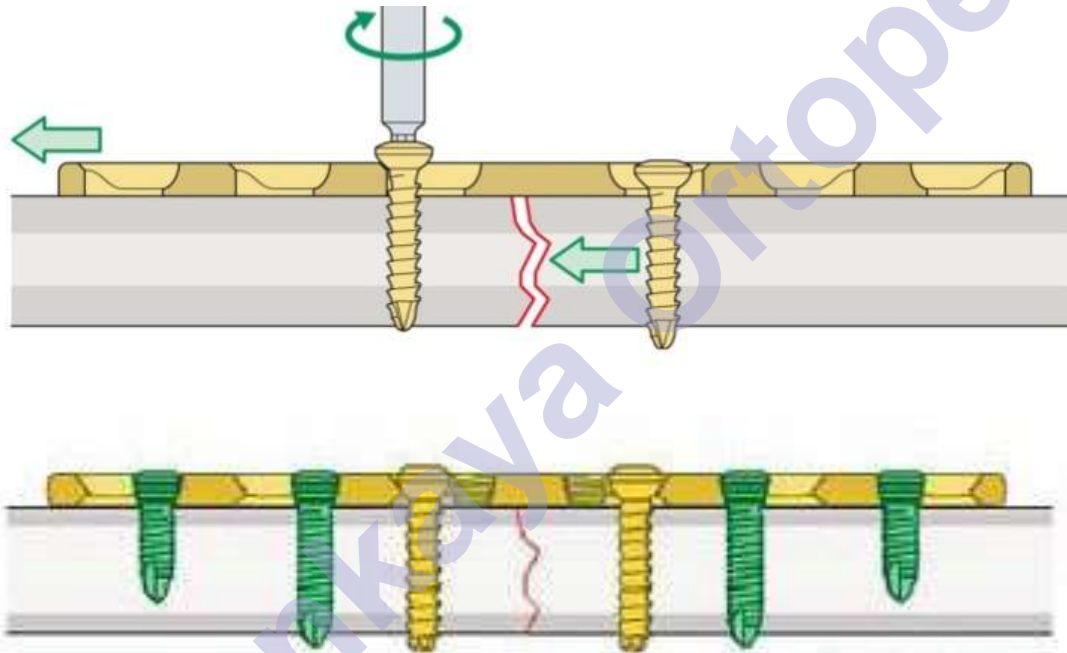
As a conventional plate, using conventional screws



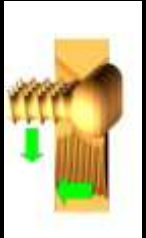
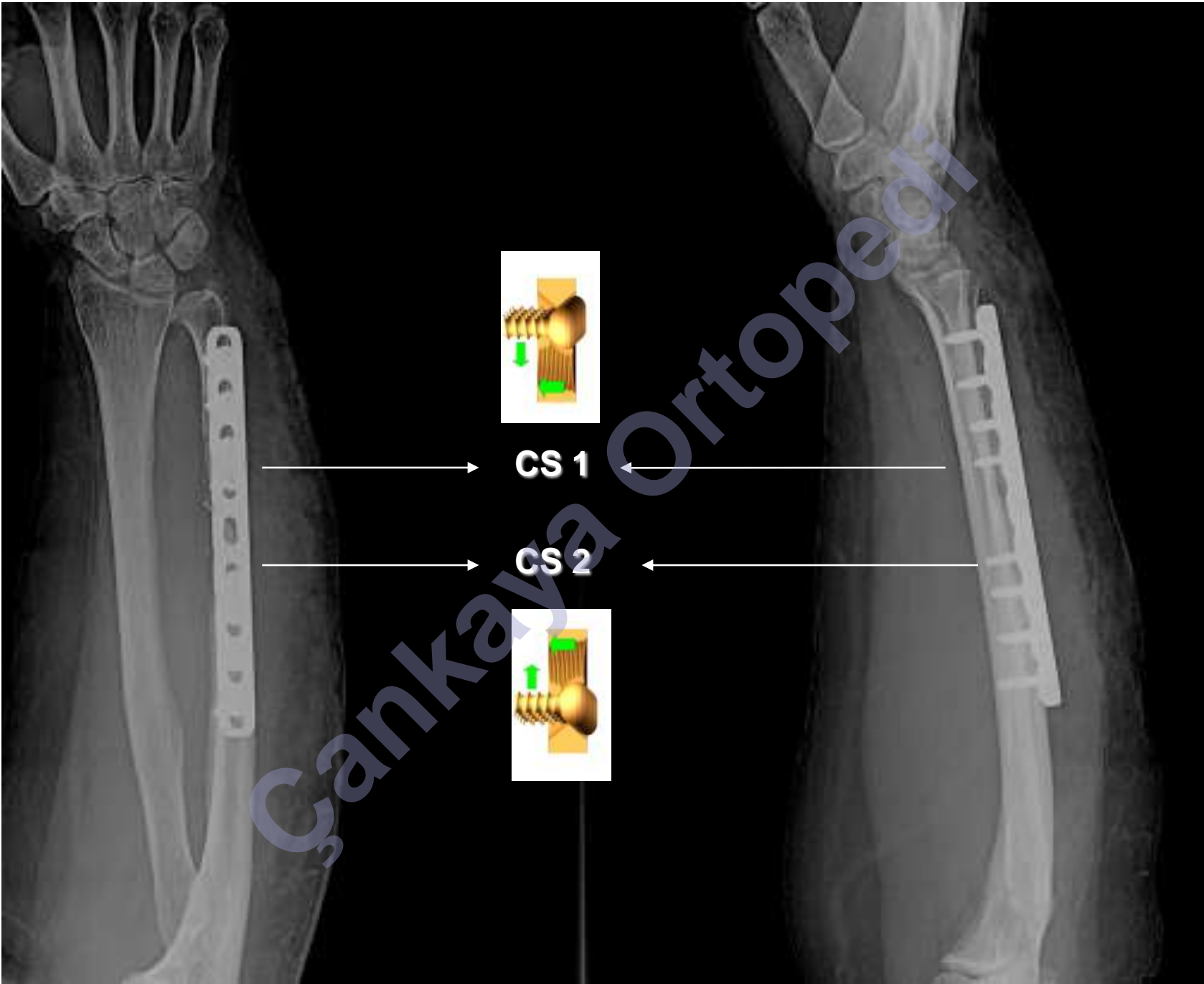
Good bone quality

LCP for Absolute Stability

For poor bone quality

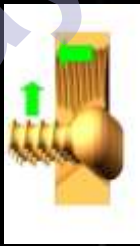


LHS for protection in osteoporotic bone especially in upper extremity



CS 1

CS 2



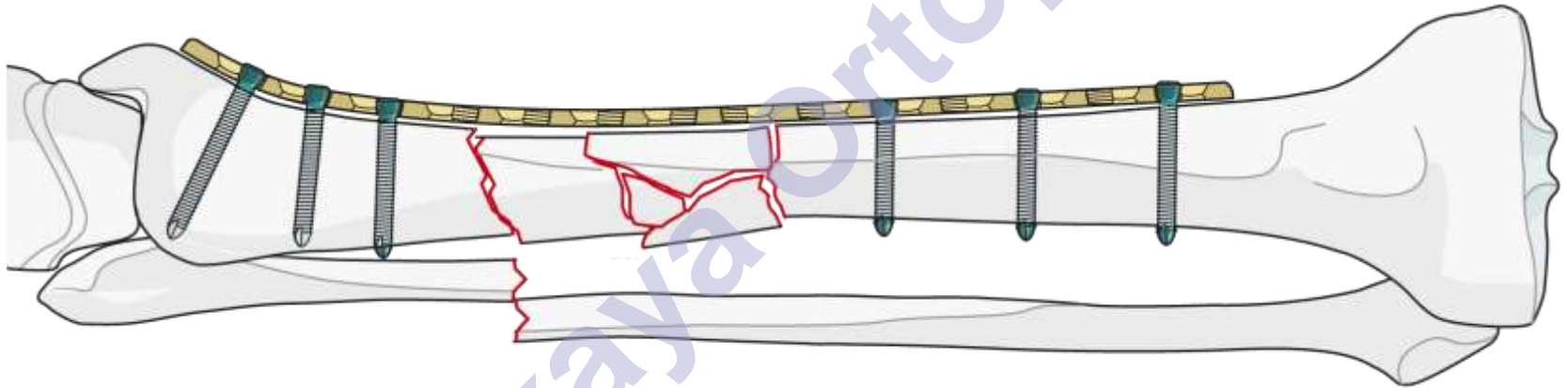
Neutralization

- **Free lag screws**
 - Absolute stability
- **Neutralization with locked plate**
 - Less periosteal compression
 - No plate contouring
 - Angular stability in poor bone



LCP for Relative Stability

Bridging plating



As an internal fixator, using locking head screws

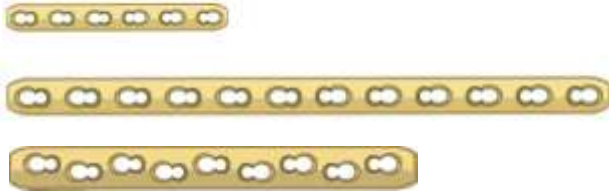
Where ?

- Proximal humerus
- Humeral shaft
- Distal humerus
- Distal radius
- Proximal femur
- Distal femur
- Proximal tibia
- Distal tibia
- Hand
- Foot

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Anatomically Preshaped Plates

Standard plates

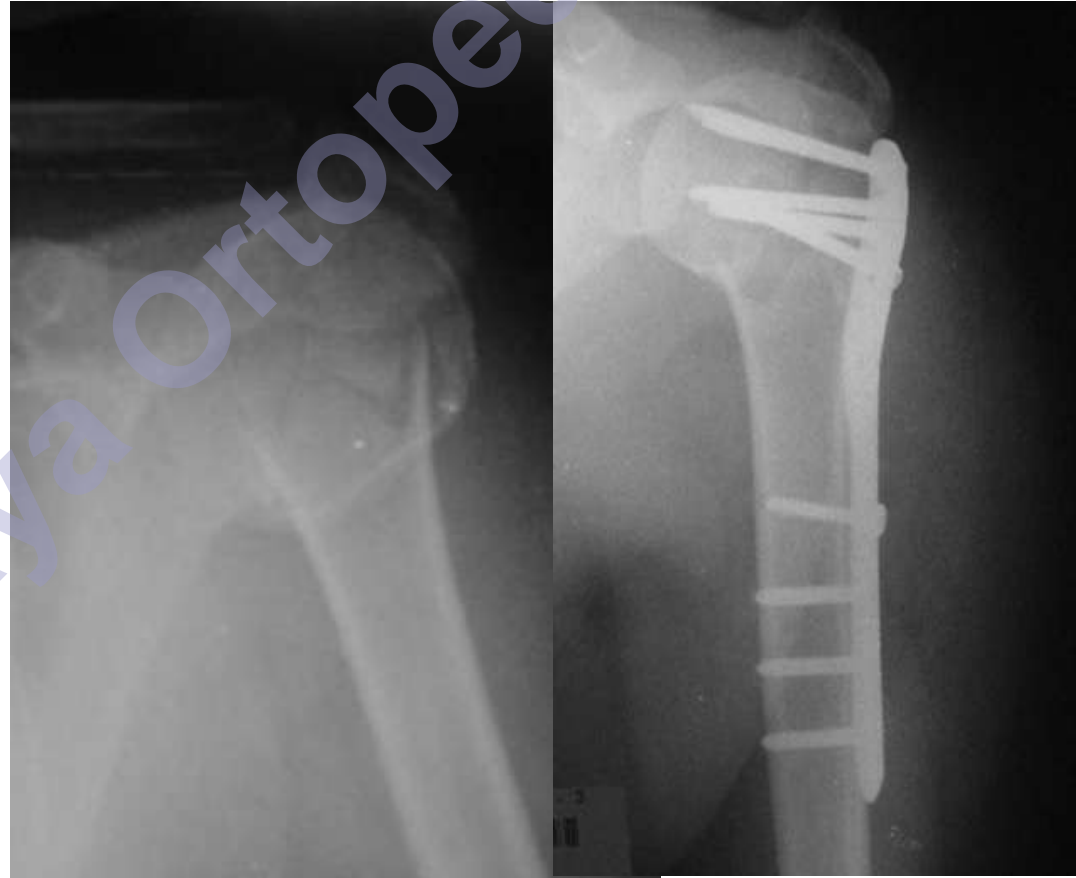


Special and anatomically preshaped plates



Proximal Humerus

- **Poor bone quality**
 - Angular stability
 - LHS in different directions
- **MIPO**



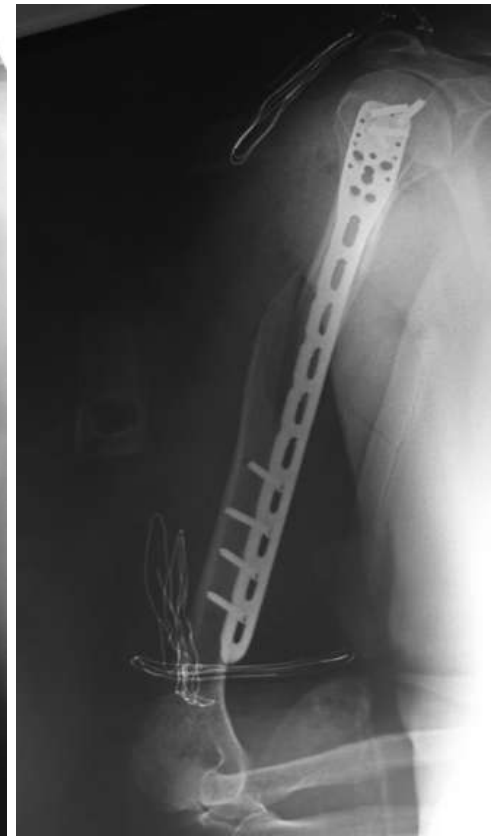
Proximal Humerus



MIPO technique

Humeral Shaft

- MIPO
- Rotational stability



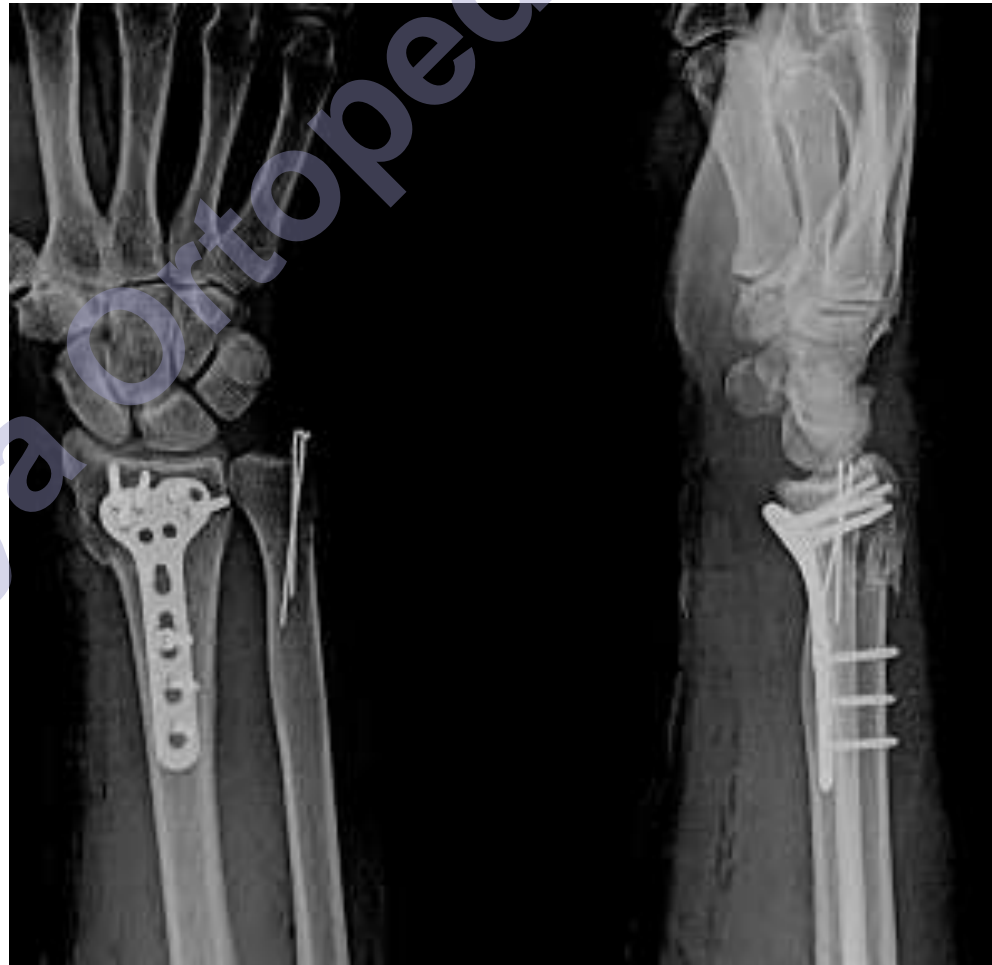
Distal Humerus

- Anatomically preshaped plates
- Short distal fragments
 - Angular stability



Distal Radius

- **Volar plating**
 - Short segment
 - Dorsal comminution
 - Osteoporosis



Lower Extremity

- **Periarticular / metaphyseal fx**
 - Short segment
 - Osteoporosis
 - Comminution
- **Bridging plating**
 - Relative stability
- **MIPO**



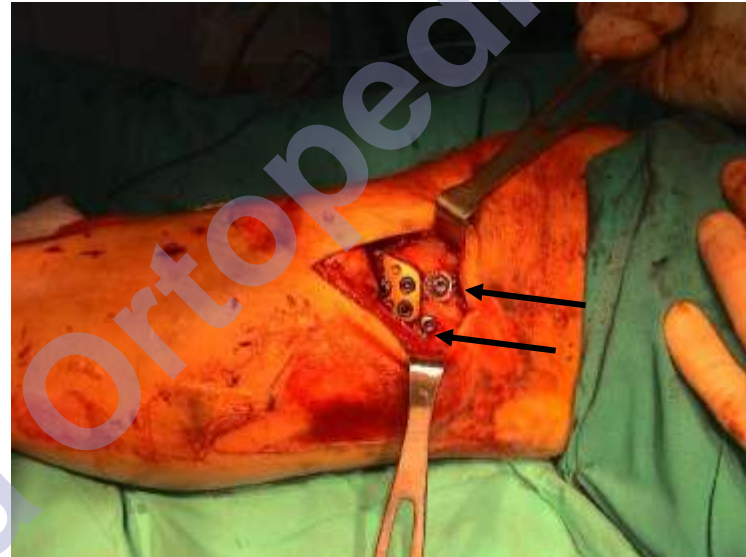


MIPO

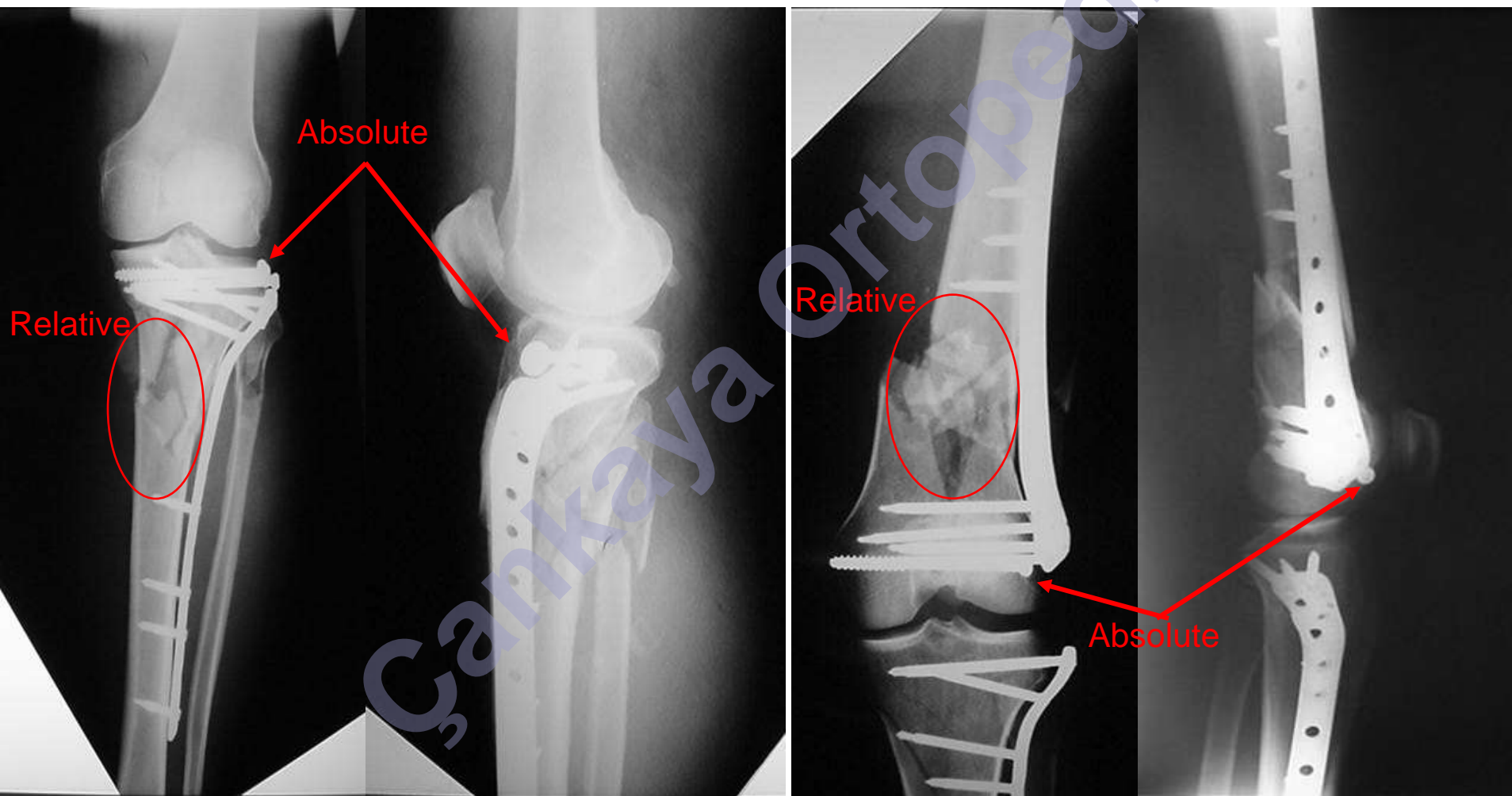


Intraarticular Involvement

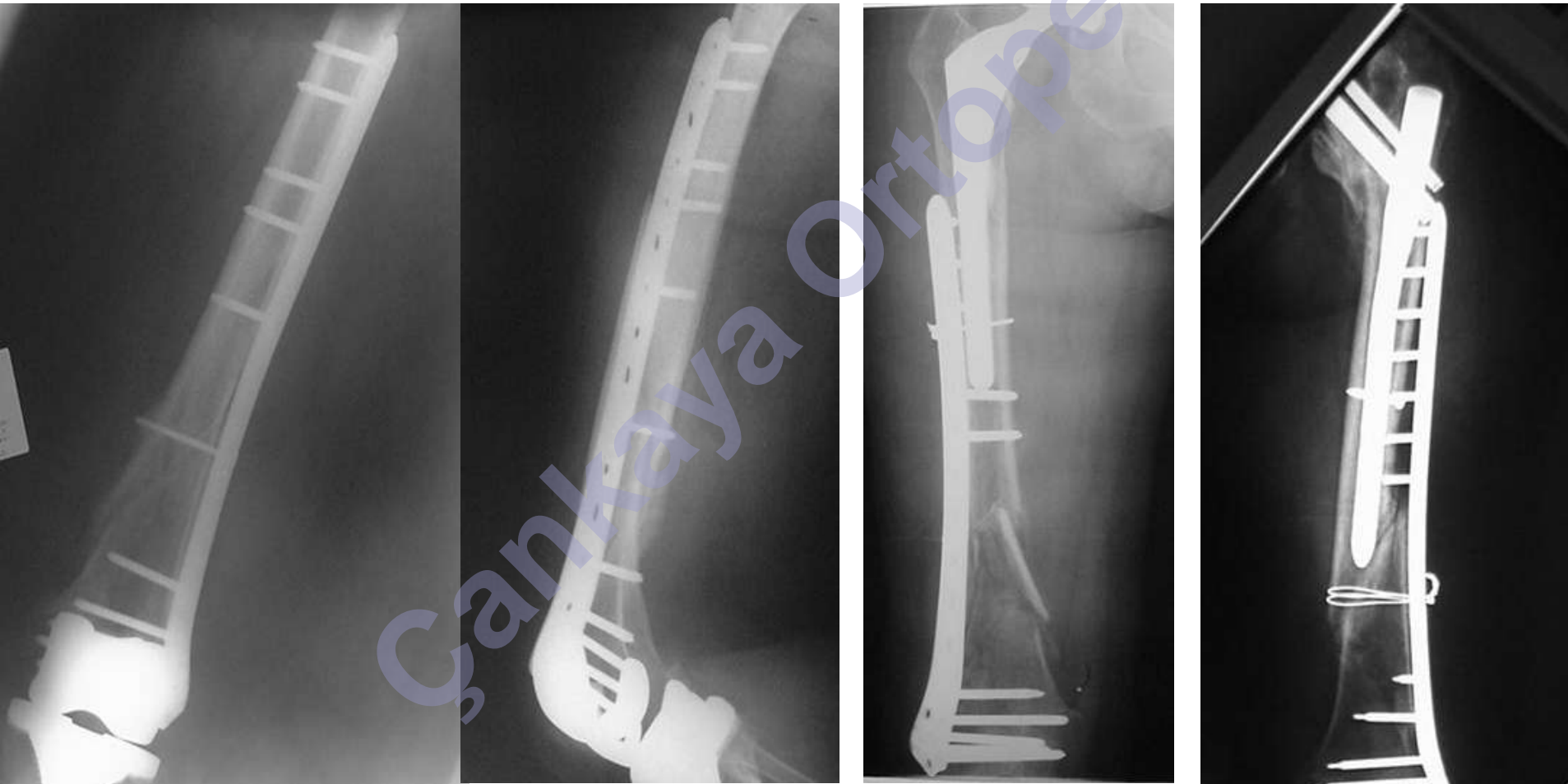
- **Intraarticular component**
 - Lag screw → absolute stability
- **Metaphyseal component**
 - Bridging → relative stability



Intraarticular Involvement



Periprosthetic Fractures



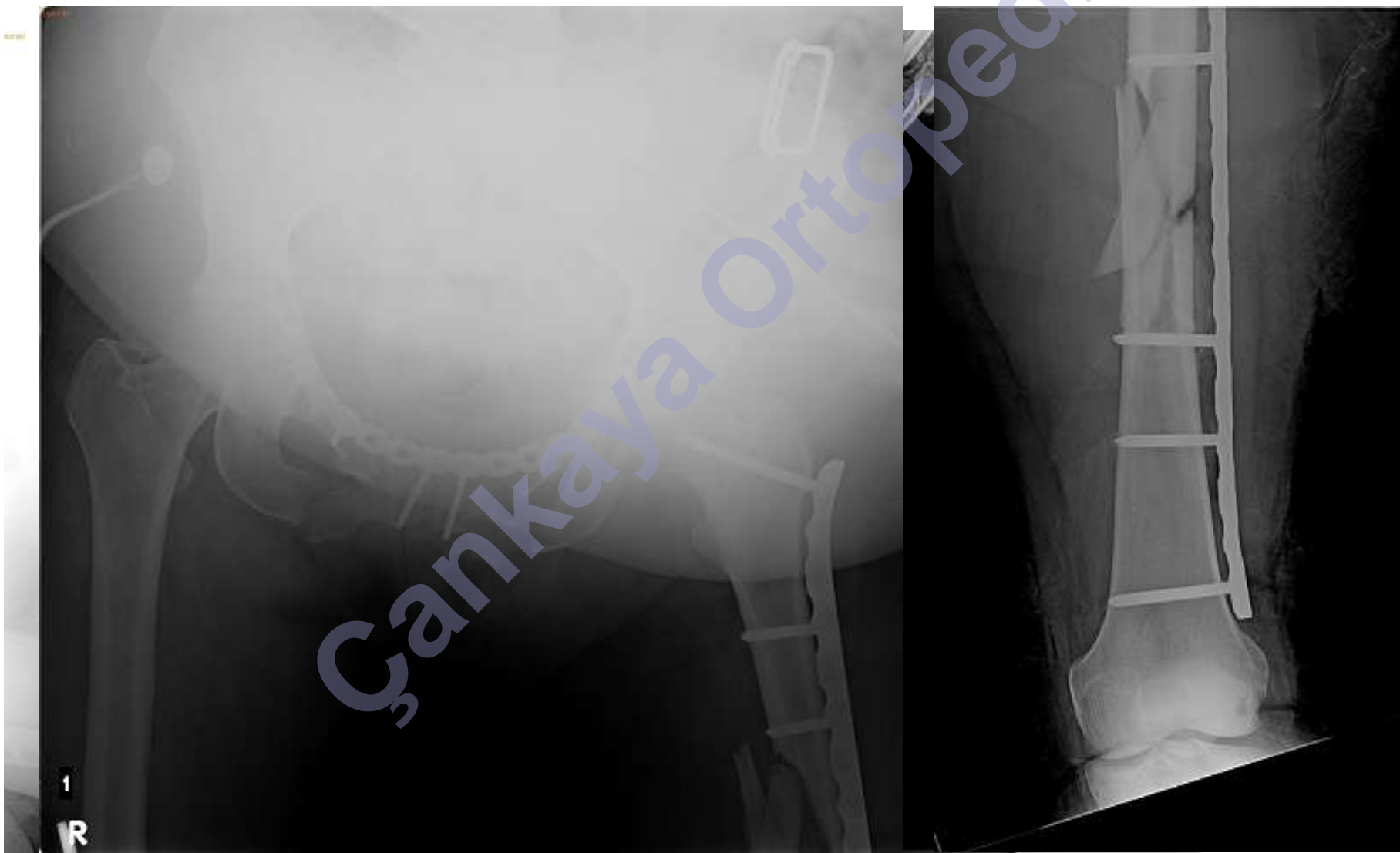
Diaphyseal Fractures

When you cannot use IM nailing

- Multiple injured patients
- Open physis
- Narrow canal

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Polytrauma



Pediatric



Narrow Canal



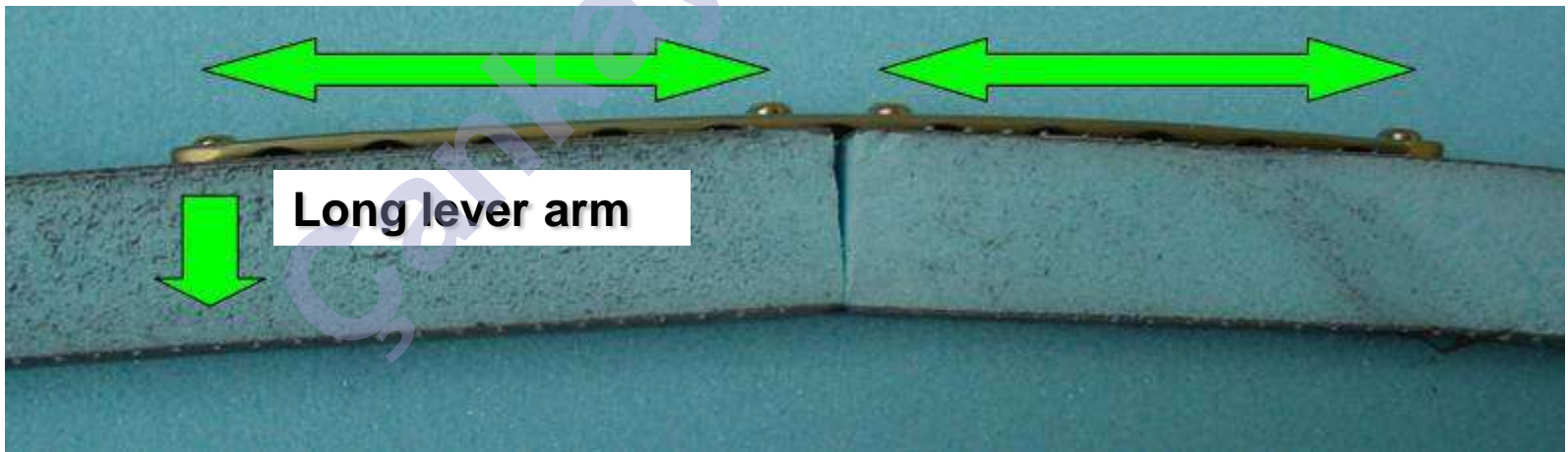
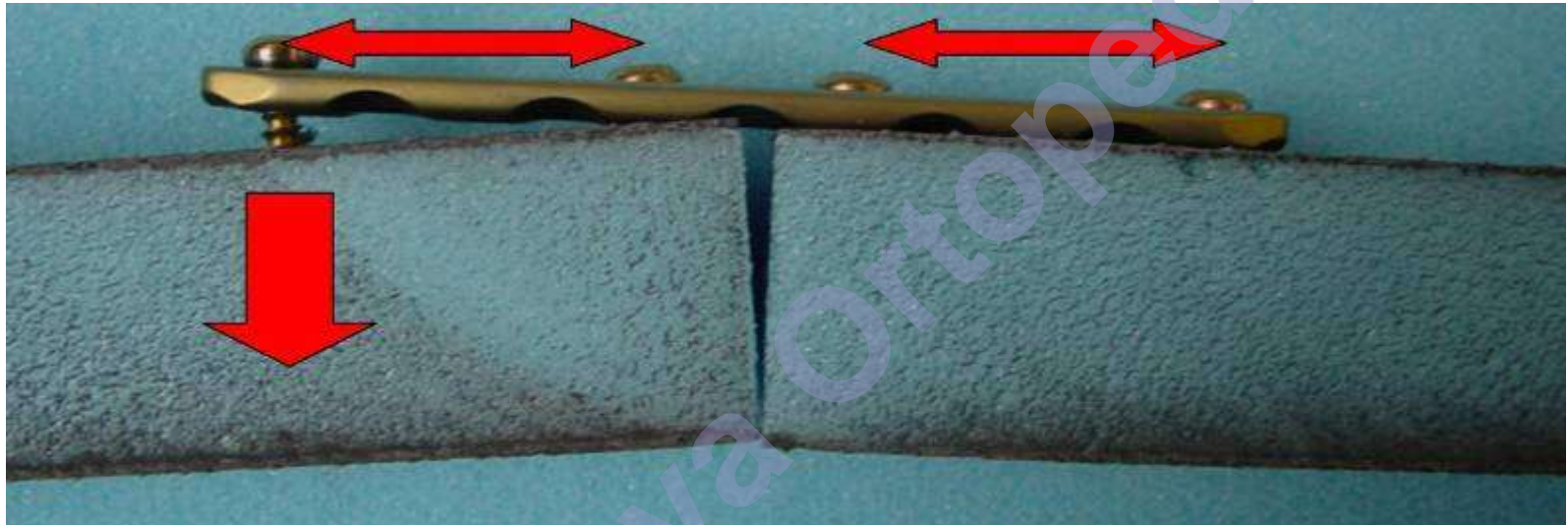
How ?

Pre-operative planning

- **Plate length**
- **Screw position**
- **Number of screws**
- **Screw length**

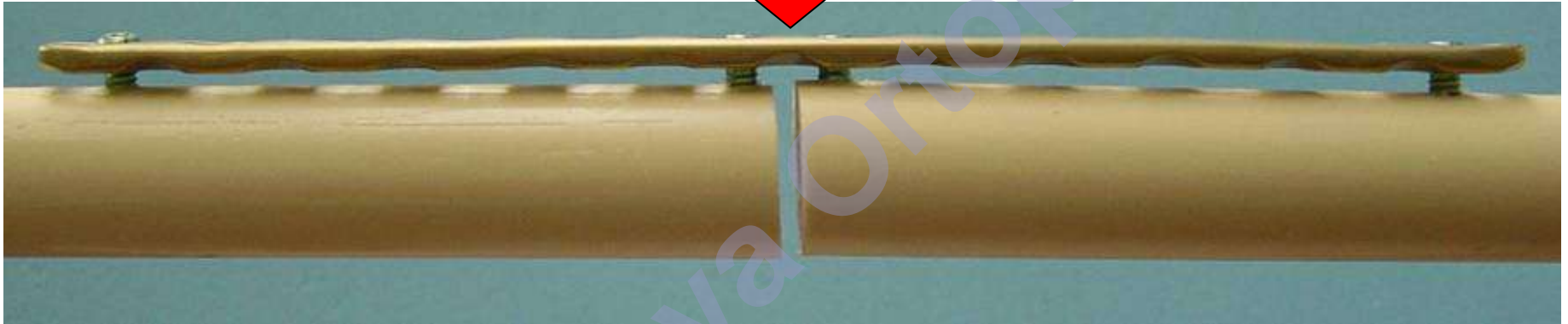
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Plate Length

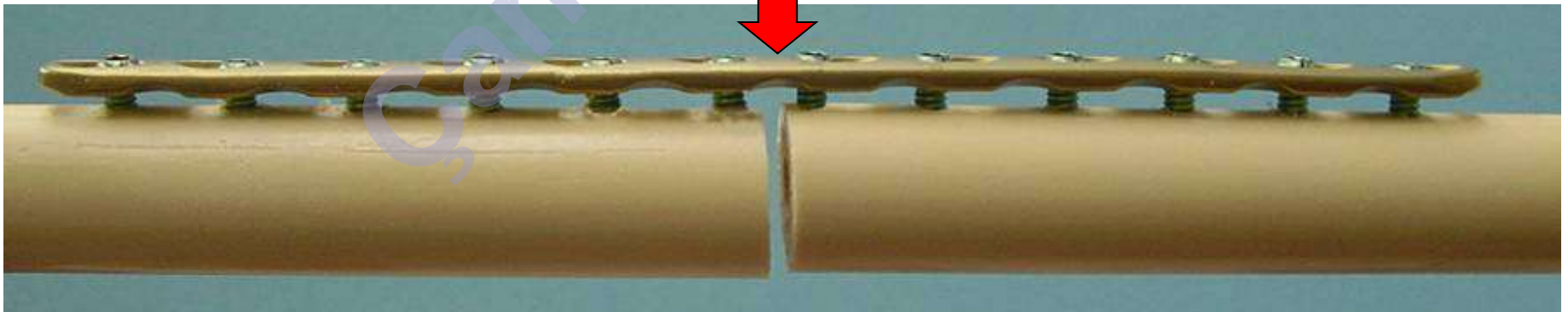


Screw Position

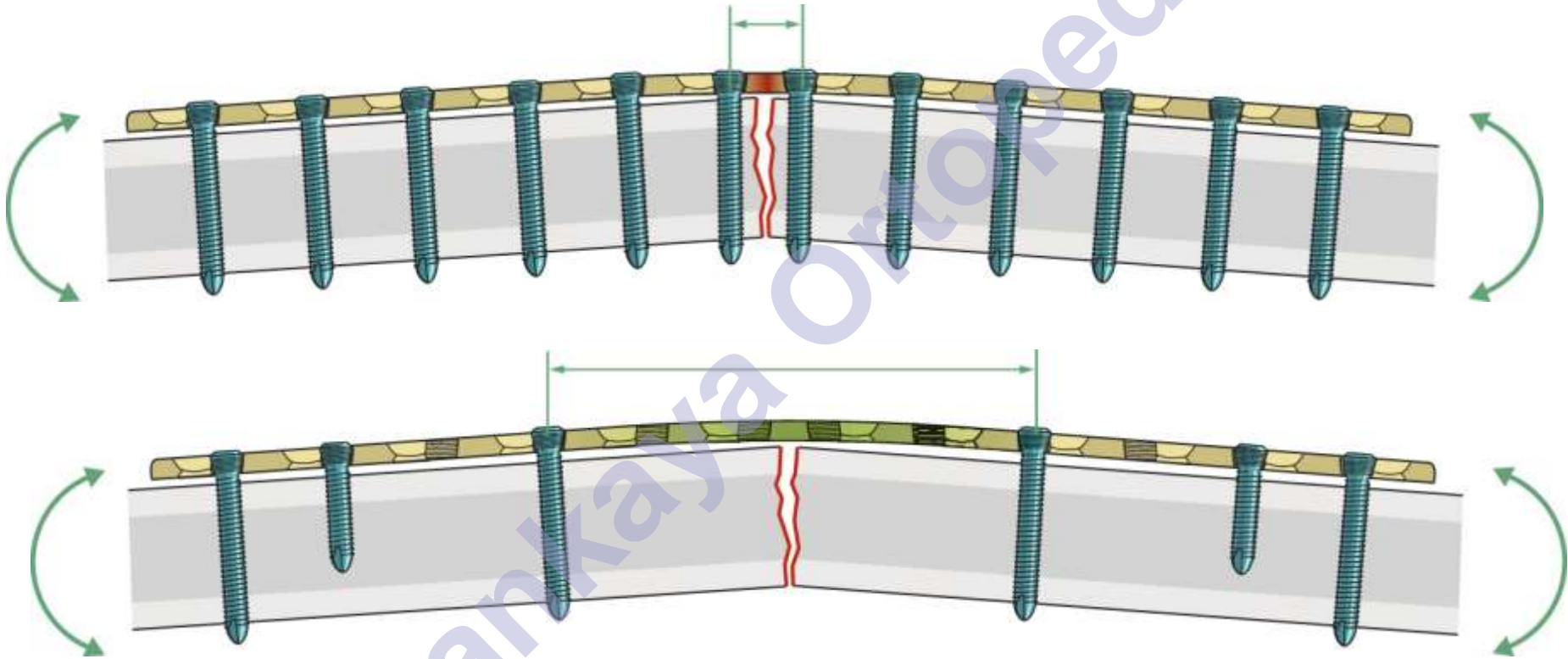
Higher stress



Maximum stress

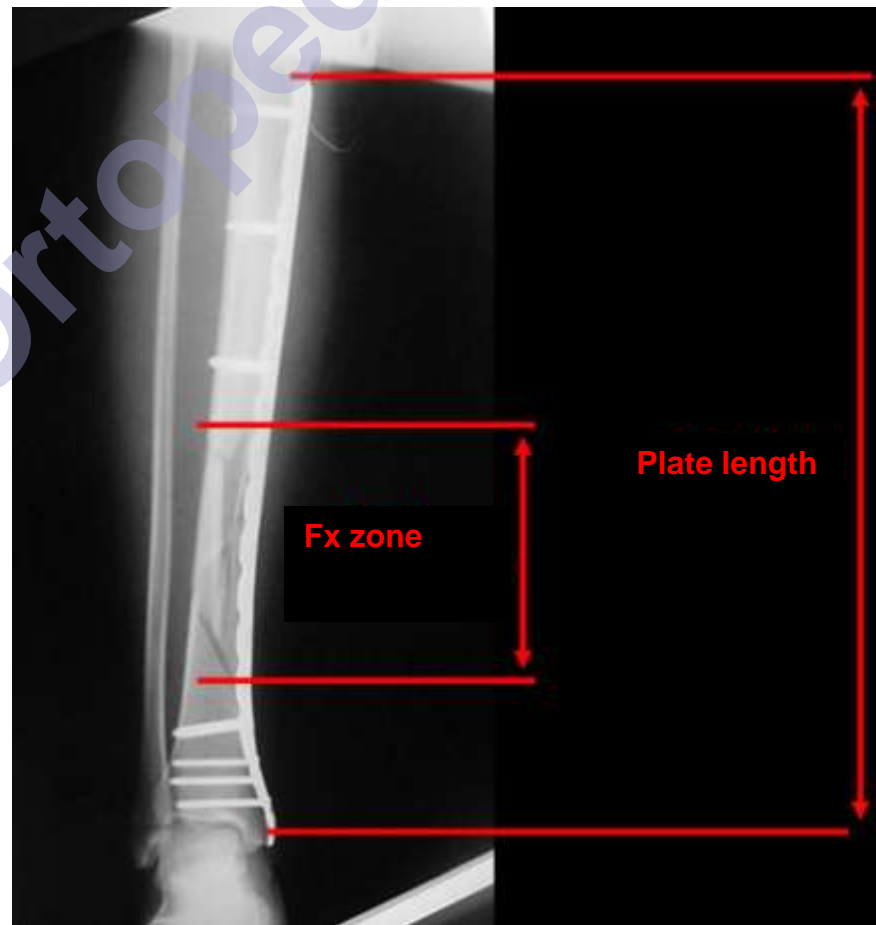


Avoid short “middle”



Implant Choice

- **Plate length**
 - Comminuted → 2 or 3 X fx length
 - Simple → 8 or 10 X fx length
- **3 - 4 empty holes**
- **Number of screws**
 - Lower ex. → 2 - 3 in each segment
 - Upper ex. → 3 - 4 in each segment
- **Plate-screw density 0.40**
- **Anatomical plates in metaphysis**

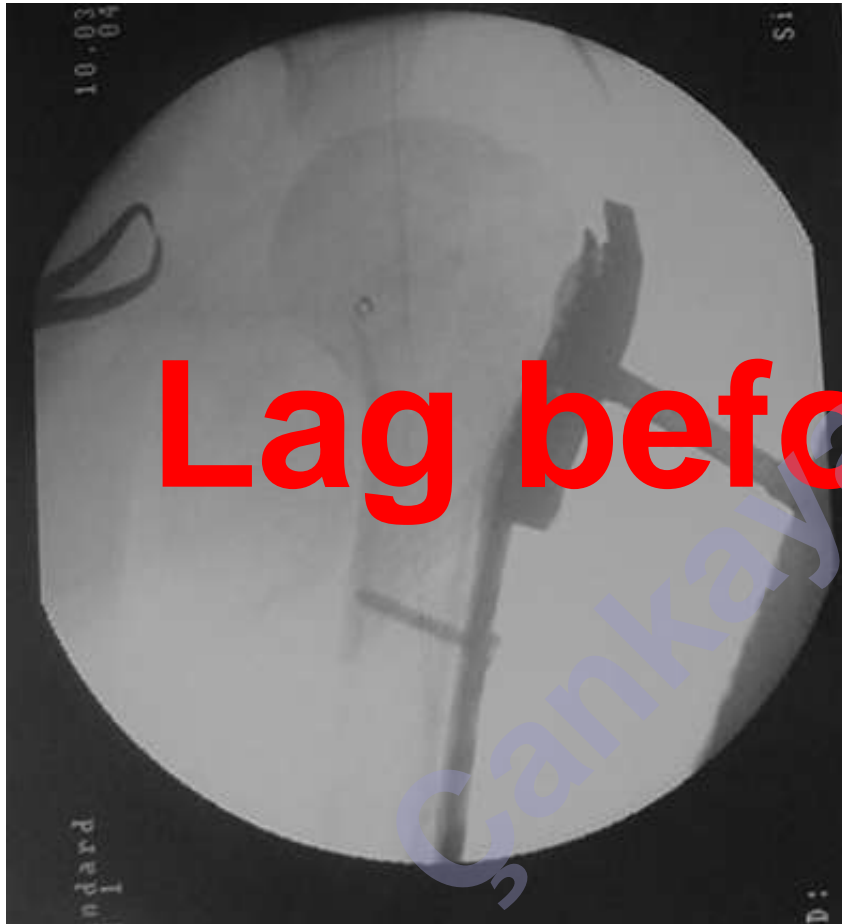


Hybrid use of screws

- **Intraarticular fractures**
 - Absolute stability
- **Reduction**
 - Anatomically preshaped plates
 - Big butterfly fragment
- **Articular orientation of fixed angled screw**



Hybrid use of screws



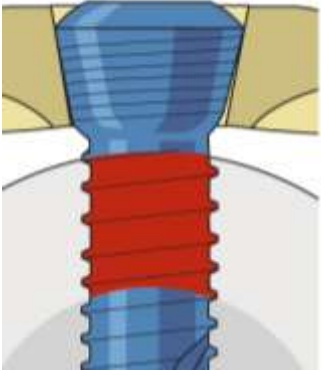
Lag before locked

Avoid monocortical screws

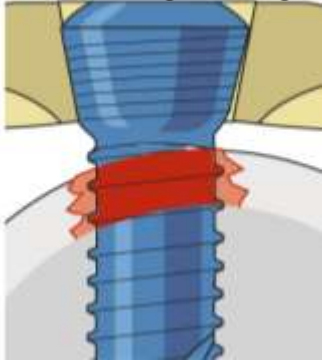


Working Length

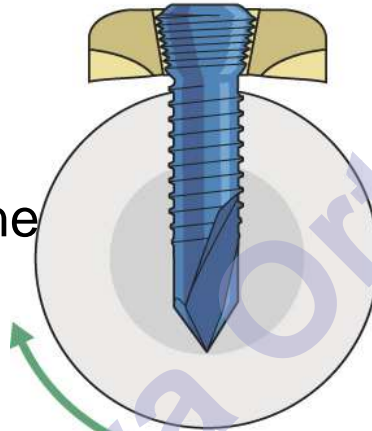
sufficient
working length



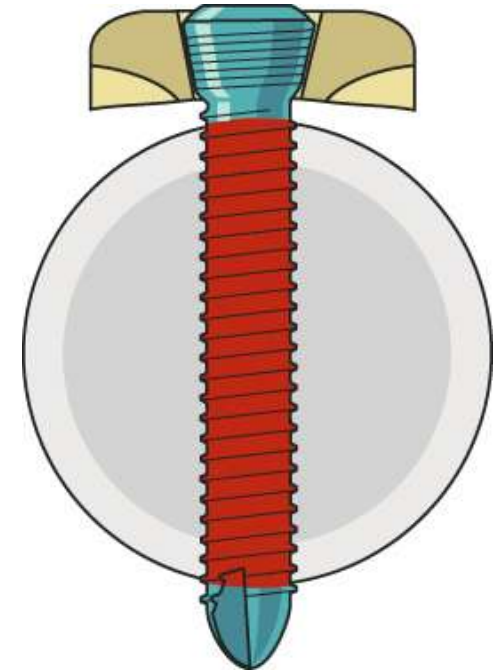
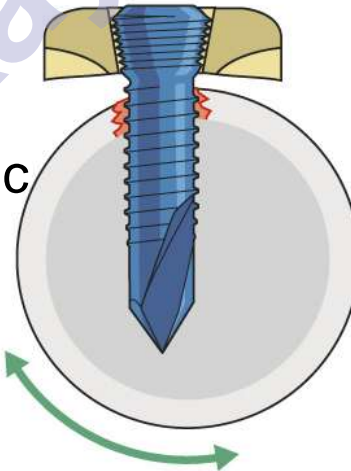
insufficient
working length



good bone
quality



osteoporotic
bone



Malreduction

- Locked plates don't help reduction !!
- Careful indirect reduction



Take home messages

- **Plate name \neq plate function**
- **Any plate can be used in many ways**
- **Plate function is dependent upon:**
 - Design
 - Method of application

Take home messages

- **Evolution of plates: mechanics → biology**
- **Comminuted fractures**
 - Bridging plating → biological fixation
- **Locked plating**
 - Osteoporosis; short metaphyseal segments
 - MIPO
- **Planning !!**
 - Understanding the principles
 - Good functional reduction
 - Correct choice of implant and application