Minimally Invasive Plate Osteosynthesis

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Introduction

- Minimally Invasive Plate Osteosynthesis (MIPO)
  - A mechanism of achieving plate fixation of a fracture though limited soft tissue windows with a goal of preserving fracture site biology to improve healing

Objectives

- Understand the principles of minimally invasive plate osteosynthesis
- Understand the limitations of minimally invasive plate osteosynthesis
- Review specific fracture patterns where MIPO is safe and effective
- Learn technical strategies to achieve success with MIPO

AO Principles (2017)

- Early and safe mobilization and rehabilitation of the injured part and the patient as a whole
- Fracture reduction and fixation to restore anatomical relationships
- Fracture fixation providing absolute or relative stability as the "personality" of the fracture, the patient, and the injury requires
- Preservation of the blood supply to soft tissues and bone by gentle reduction techniques and careful handling

History

- Early fracture surgery often involved anatomic reduction with fixation of all fracture fragments
- At times this was accomplished with extensive exposure resulting in soft tissue stripping
- This evolved to more “biologically friendly” surgery and focus on preservation of periosteal blood flow
- Minimally invasive plating evolved from the concept of biologically friendly surgery

Evolution of Soft Tissue Handling

MIPO preserves vascularity

- Cadaveric vascularity study demonstrated marked improvement in periosteal blood flow with MIPO of the distal femur compared with conventional plating (CPO)

Approach:	CPO		MIPO	
Artery condition:	Intact	Interrupted	Intact	Interrupted
1st Perforating	5	5	10	0
2nd Perforating	0	10	10	0
3rd Perforating	0	10	10	0
4th Perforating	6	4	10	0
Total	11	29	40	0
Percentage	27.5%	72.5%	100%	0%

CPO, conventional plate osteosynthesis; MIPO, minimally invasive plate osteosynthesis.

Farouk O, Krettek C, Miclau T, Schandelmaier P, Guy P, Tscherne H. Minimally invasive plate osteosynthesis: does percutaneous plating disrupt femoral blood supply less than the traditional technique? J Orthop Trauma. 1999 Aug;13(6):401-406. jorthotrauma.com

MIPO is:

- A method of applying an implant in a soft tissue friendly manner through limited incisions
- A technique to be used as part of a complete surgical plan

MIPO isn't:

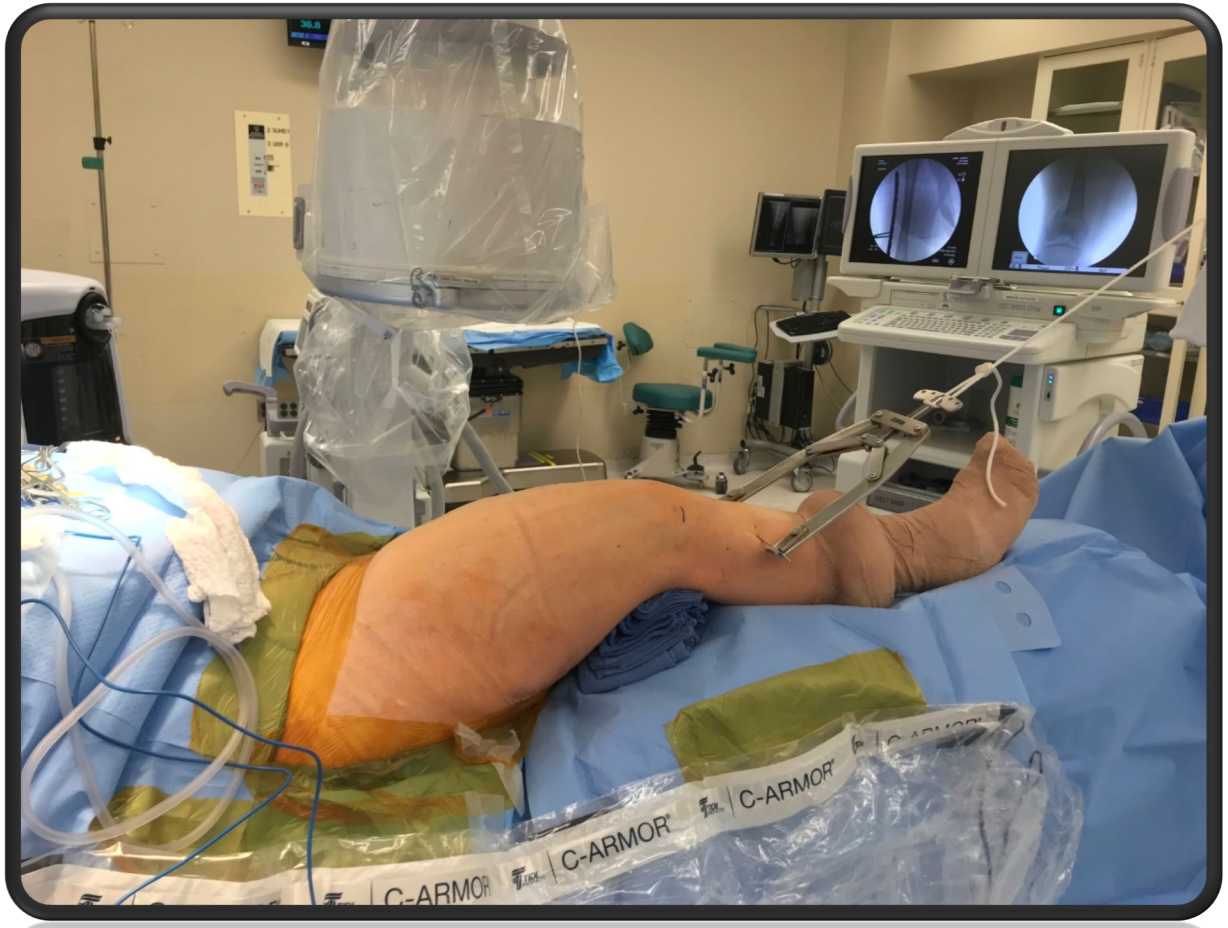
- Always the answer
- Necessarily a reduction strategy
- Always safe

Minimally Invasive Reduction Techniques

- As always, you still need to achieve fracture reduction
- MIPO can be combined with open and minimally invasive or indirect reduction techniques

Reduction Techniques: Indirect

- Indirect reduction with traction
  - Intraoperative application of skeletal traction
- Bump under the knee to correct sagittal plane deformity



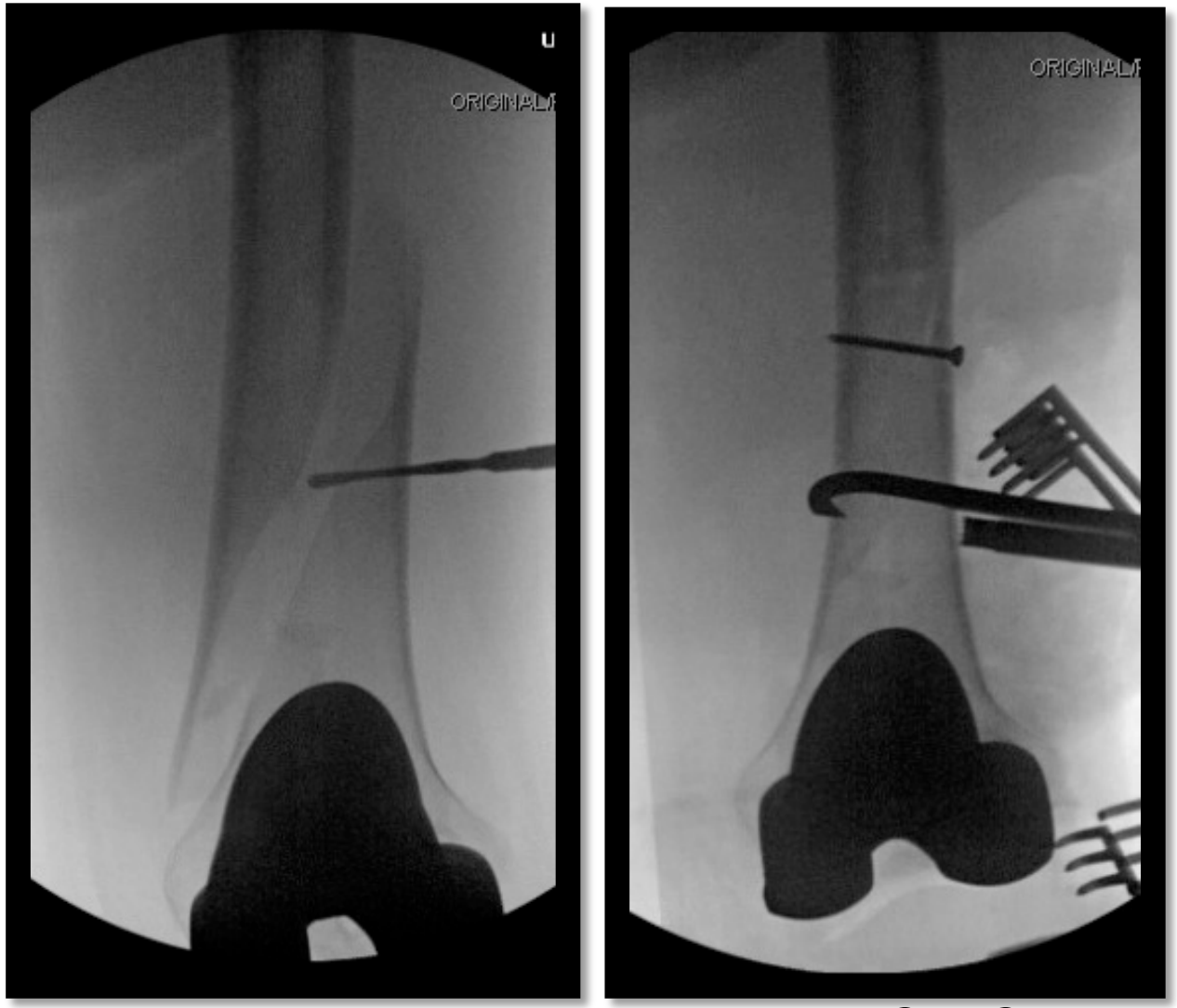
Reduction Techniques: Indirect

- Intraoperative use of femoral distractor to regain length

Rockwood and Green Figure 53-15
Tornetta P, Ricci WM, eds. Rockwood and Green's Fractures in Adults, 9e. Philadelphia, PA. Wolters Kluwer Health, Inc; 2019.

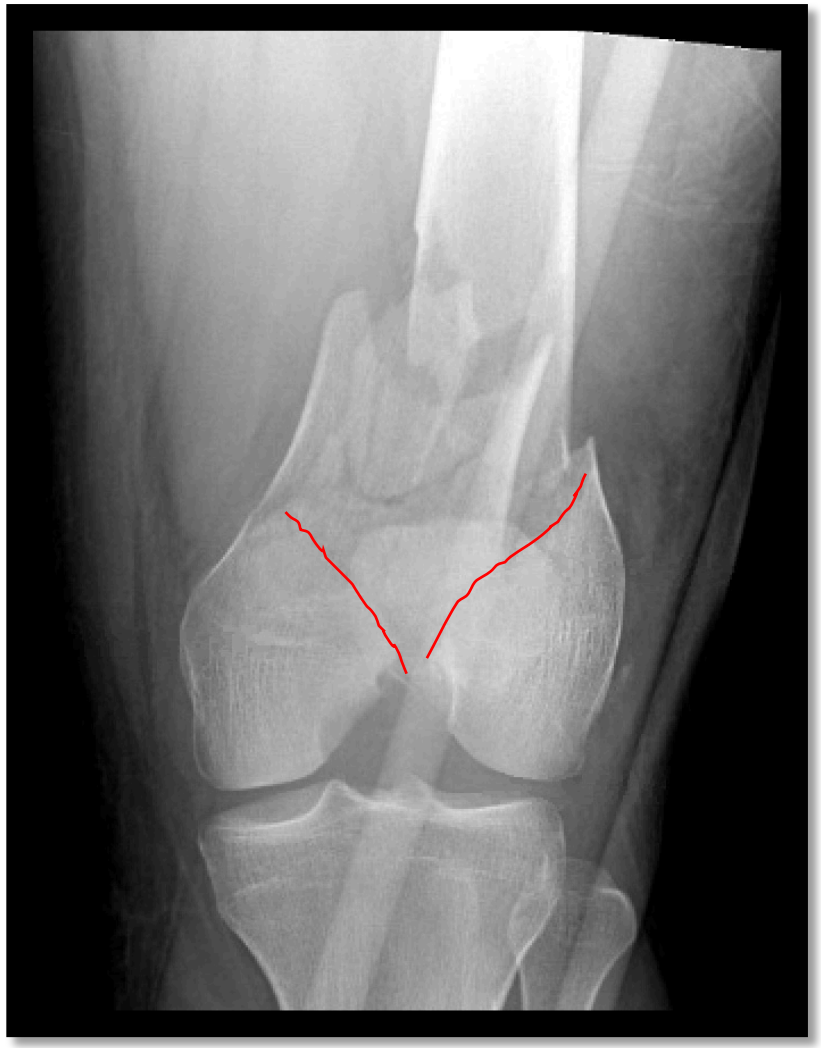
Reduction Techniques: Direct

- Simple fracture patterns warrant direct anatomic reduction and compression
- Colinear clamp
- Pointed reduction clamps
- Periarticular reduction clamps



Reduction Techniques: Combined

- Can use direct reduction techniques for articular surface reconstruction and minimally invasive techniques to bridge the metaphyseal component



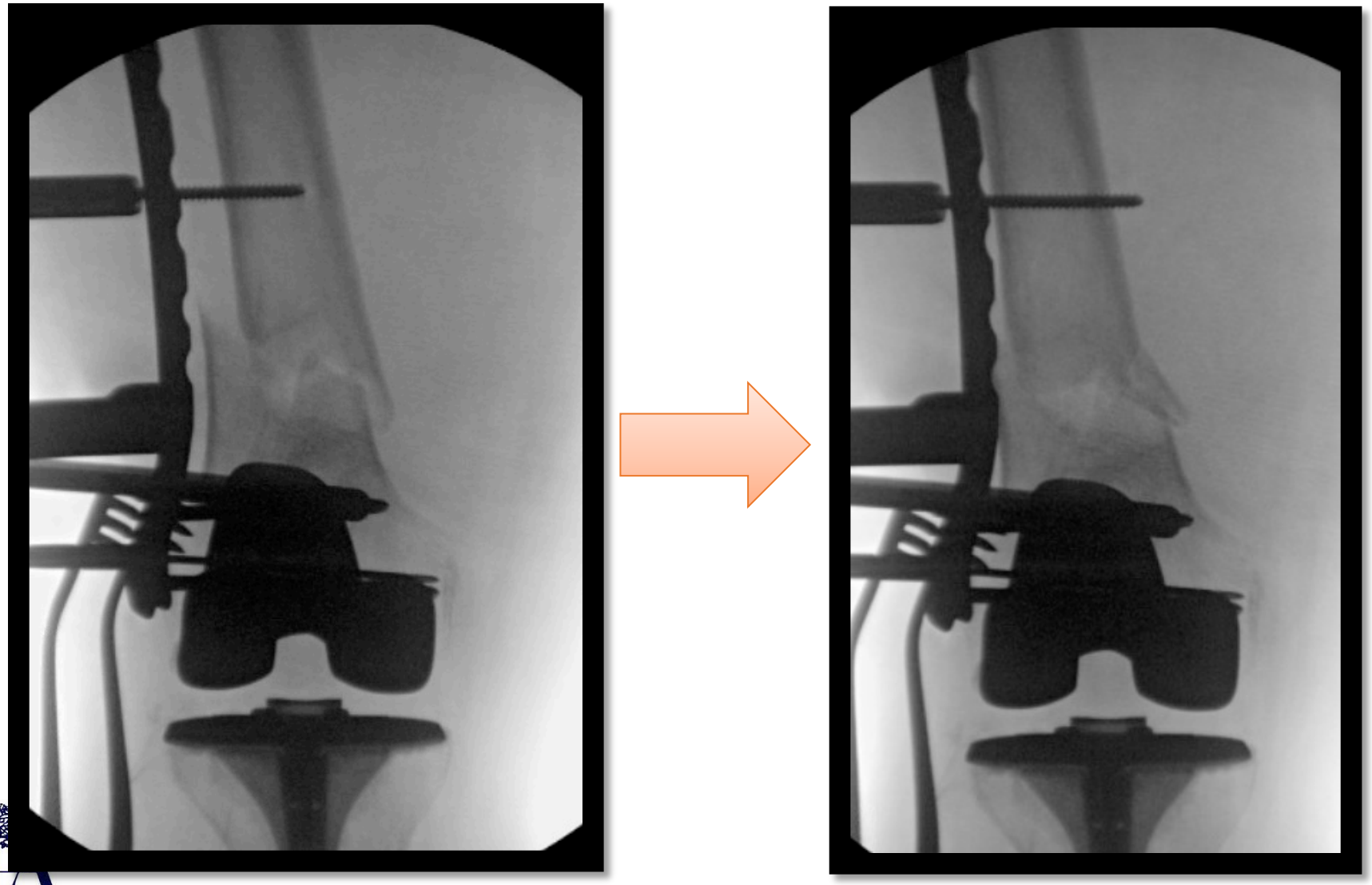
Direct reduction of articular surface

- Lateral parapatellar arthrotomy to visualize articular reduction
- Direct reduction utilizing shanz pins to control fracture fragments, colinear clamp to compress articular surface

Proximal screws inserted percutaneously

Bridge plating of metaphyseal component

Cortical Screw as a Reduction Tool



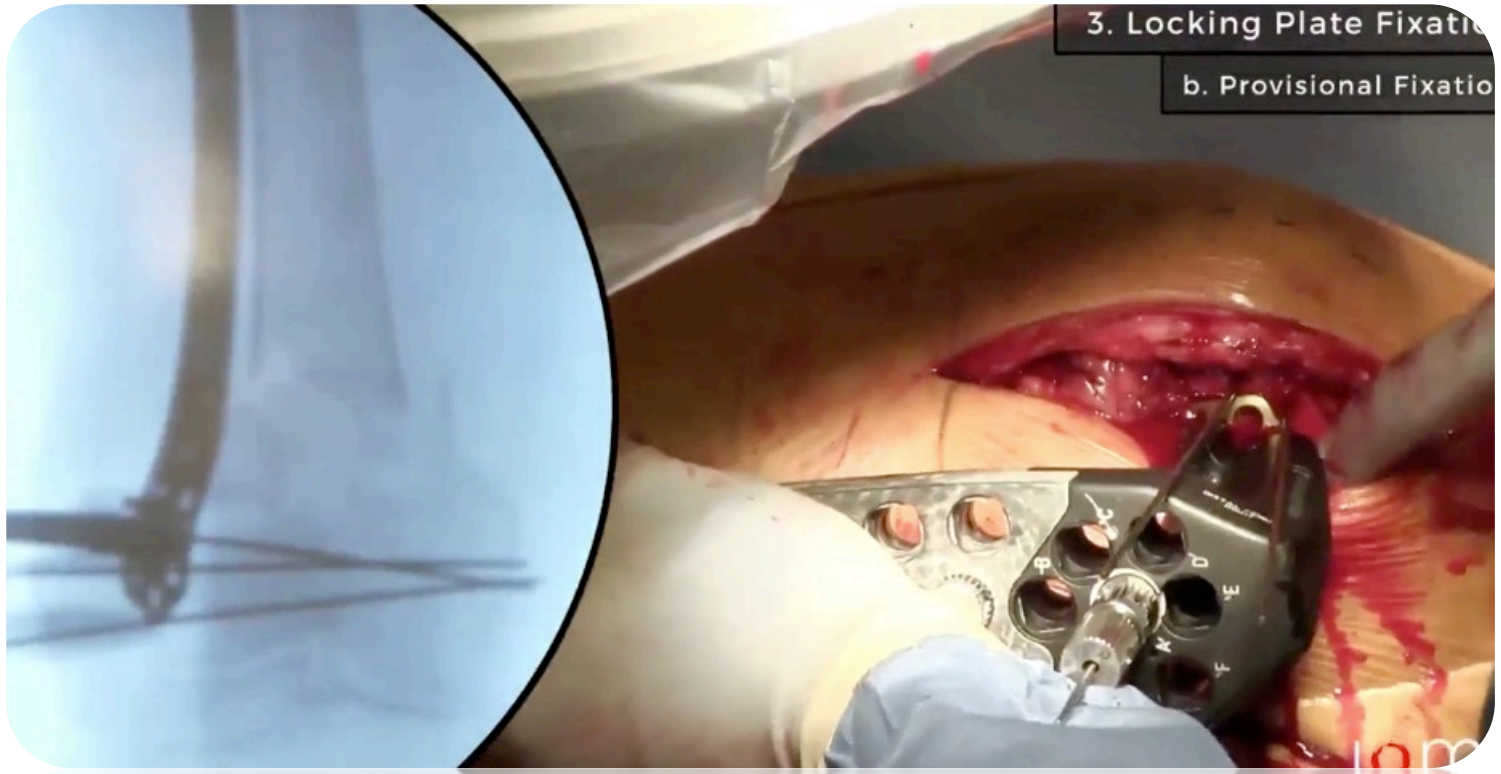
Cortical screw can be placed percutaneously and tightened to lateralize the shaft as needed.

Direct Reduction

- Neutralization plates can also be placed minimally invasively
- Open approach to allow for direct reduction and lag screw placement followed by MIPO proximally

MIPO Intraarticular Distal Femur – LISS plate

- https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731421/liss-system-for-stabilisation-of-a-distal-femur



MIPO Intraarticular Distal Femur

- https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/16731391/orif-with-submuscular-plating-of-an-intercondylar

Distal Femur: Anatomic Concerns

Superficial femoral artery averages 21 mm from the screw tips placed through a lateral plate but can be as close as 8mm. LISS plate (Less Invasive Stabilization System) holes 6-10 are highest risk.

Be cautious about plunging drill bits and screws which are too long

Injury 51 (2020) 452–456

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Identification of the lateral femoral safe zone for drilling during LISS plate fixation of distal femur fractures

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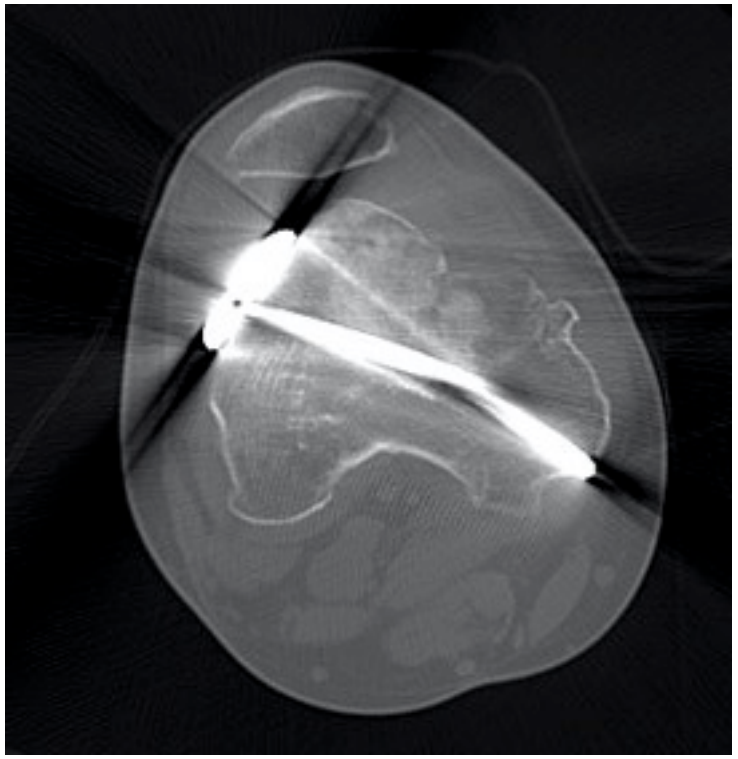
Distal Femur: Malreduction

- MIPO distal femur can result in satisfactory coronal and sagittal plane alignment > 96% of the time
- High risk of rotational malreduction ~50%
- Potential for limb length inequality ~8%



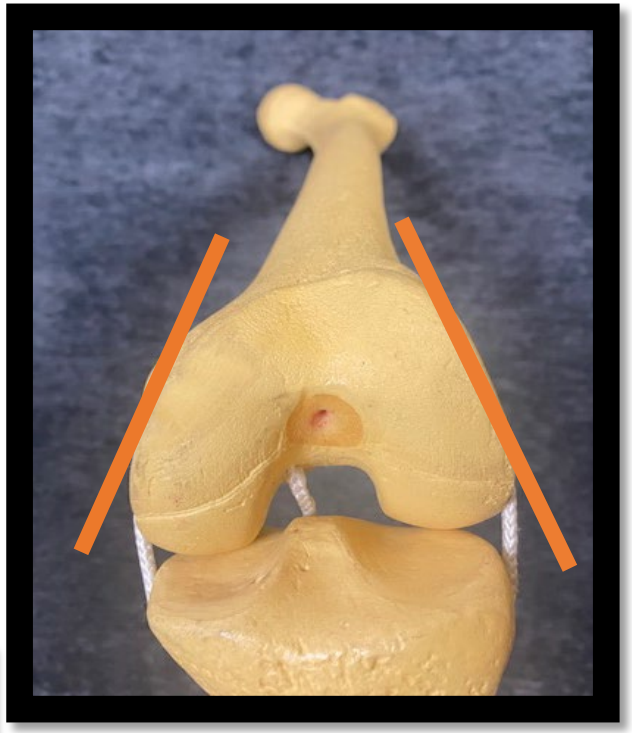
Note lateral subluxation of the patella secondary to rotational malunion of the distal femur

Kim JW et al Injury 2017

Image courtesy of G. Moloney

Distal Femur: Malreduction

- When viewed end on the distal femur is a trapezoid
- Placement of the plate too posterior or distal can cause medialization of the distal segment “golf club deformity”



Pitfalls in the Application of Distal Femur Plates for Fractures

Cory A. Collinge, MD, Michael J. Gardner, MD,† and Brett D. Crist, MD‡*

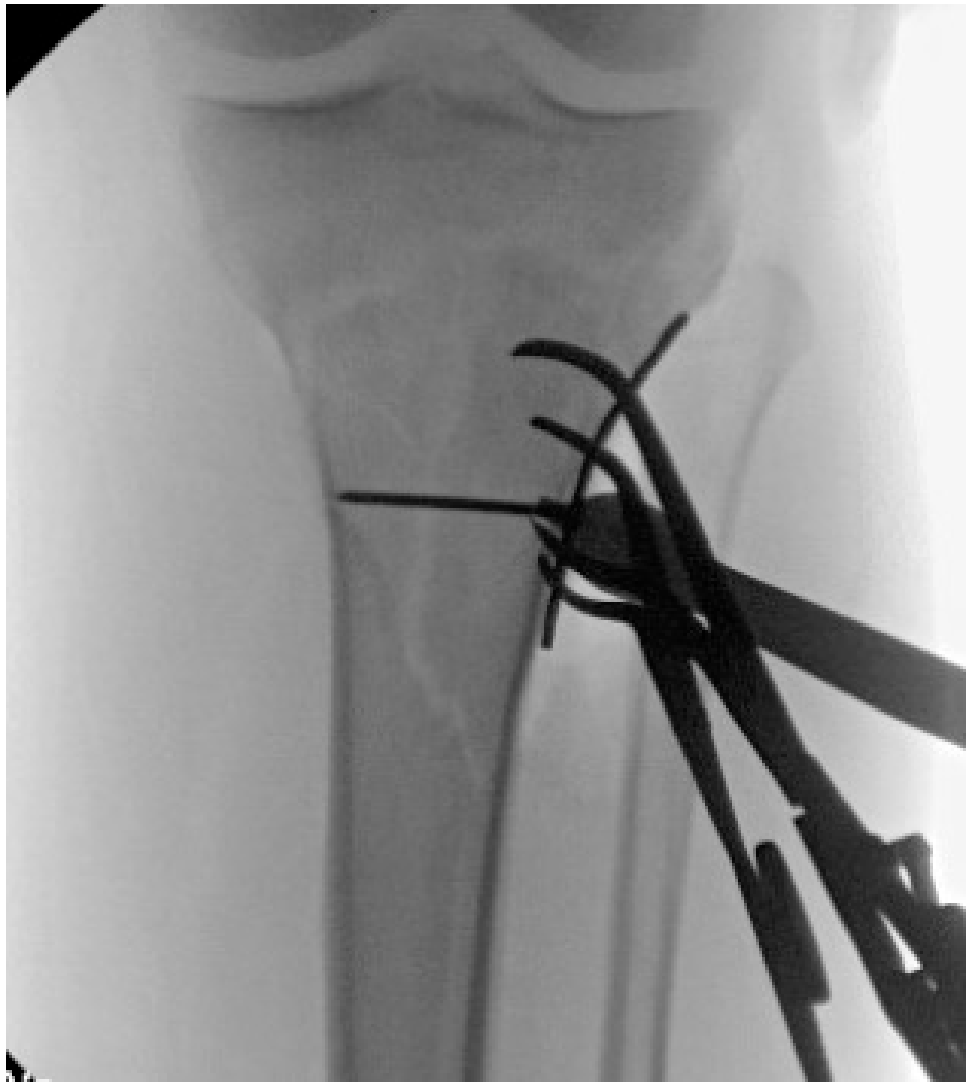
JOT 2011

Collinge CA, Gardner MJ, Crist BD. Pitfalls in the application of distal femur plates for fractures. J Orthop Trauma. 2011 Nov;25(11):695-706. jorthotrauma.com

Proximal Tibia

Plate can be slid in submuscular fashion along the anterolateral tibia with distal fixation placed percutaneously

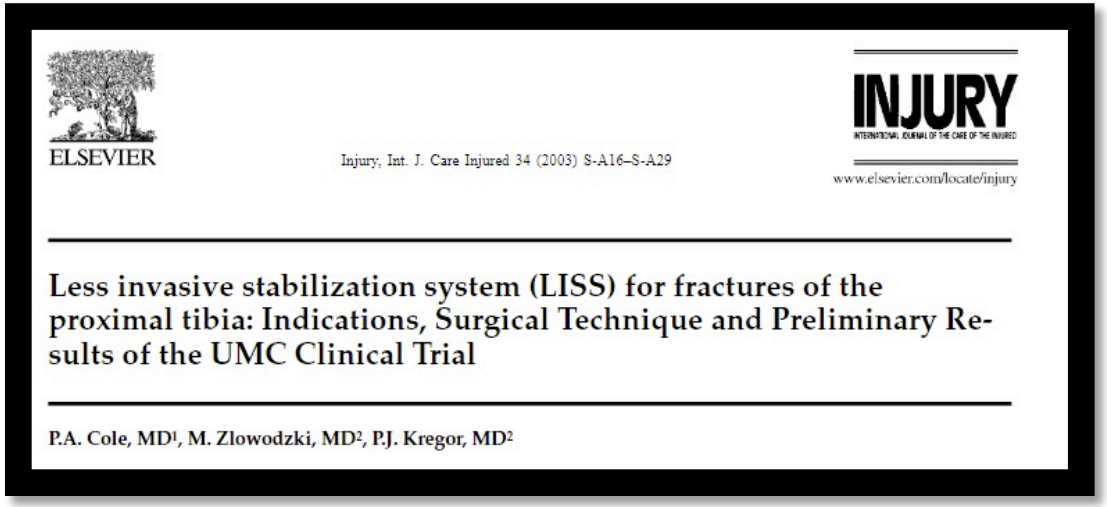
Limited incision with clamp and plate assisted reduction



Distal screws placed percutaneously

Less Invasive Stabilization System (LISS) Synthes

- Early MIPO system which allowed percutaneous plate insertion and use of a targeting arm to place screws
- Utilizes self drilling, self tapping, locked screws to create fixed angle construct “internal external fixator”



ELSEVIER

Injury, Int. J. Care Injured 34 (2003) S-A16–S-A29

INJURY

INTERNATIONAL JOURNAL OF THE CARE OF THE INJURED

www.elsevier.com/locate/injury

Less invasive stabilization system (LISS) for fractures of the proximal tibia: Indications, Surgical Technique and Preliminary Results of the UMC Clinical Trial

P.A. Cole, MD[1], M. Zlowodzki, MD[2], P.J. Kregor, MD[2]

LISS – utilized here for open fracture with proximal fracture extension

Technical Problems and Complications in the Removal of the Less Invasive Stabilization System

Takashi Suzuki, MD, Wade R. Smith, MD, Philip F. Stahel, MD, Steven J. Morgan, MD, Andrea J. Baron, MS, and David J. Hak, MD

- Difficulty removing screws secondary to cold welding of titanium screws to the plate is commonly encountered leading to lengthy and challenging hardware removal cases.
- Reported in almost 40% of cases!

FIGURE 1. A 63-year-old woman who demonstrated nonunion of the femur. A, Anteroposterior view of preoperative radiographs. B, A plate levered off with 2 screws still attached. One distal screw and 1 proximal screw were stripped and conical extraction device was also stuck in the head of the distal screw head.

Suzuki T, Smith WR, Stahel PF, Morgan SJ, Baron AJ, Hak DJ. Technical problems and complications in the removal of the less invasive stabilization system. J Orthop Trauma. 2010 Jun;24(6):369-73. jorthotrauma.com

Proximal Tibia: Anatomic Concerns

- Superficial peroneal nerve at risk during percutaneous screw placement in holes 11 through 13 of LISS plate
- Equates to 26-30cm from the top and should be applied to all percutaneously placed screws
- Consider larger open approach at that level

Anatomy of the Superficial Peroneal Nerve in Relation to Fixation of Tibia Fractures With the Less Invasive Stabilization System

Joseph P. DeAngelis, MD, Nicola A. DeAngelis, MD, and Richard Anderson, MD

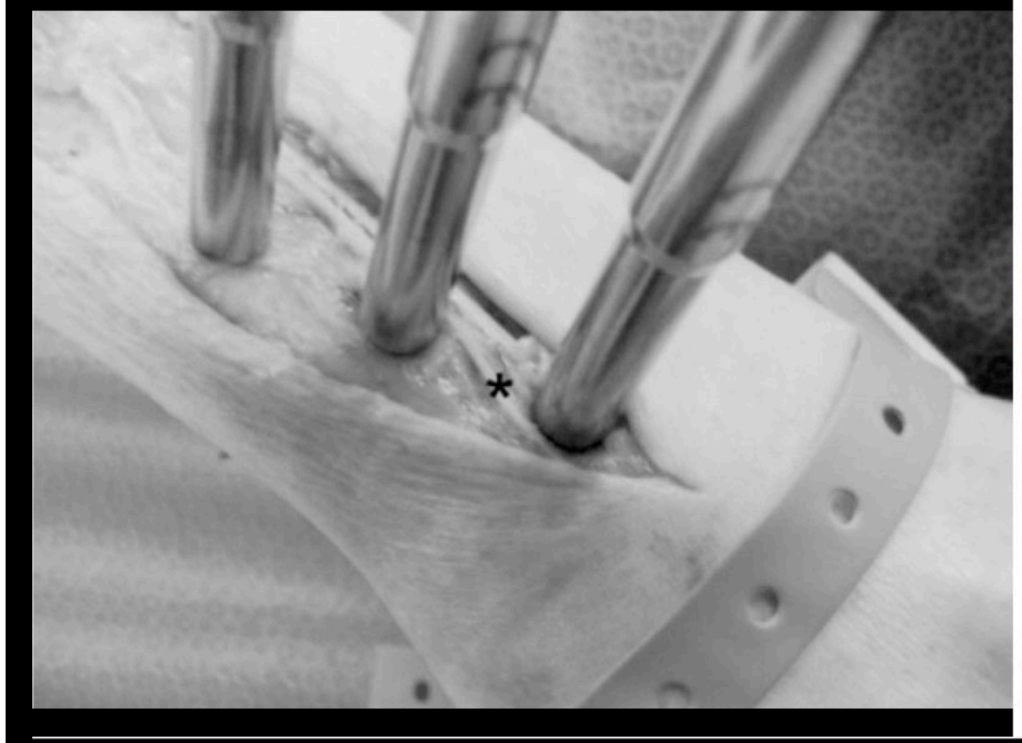


FIGURE 2.

The dissected superficial peroneal nerve (*) is seen crossing between holes 12 and 13 with insertion sleeves in holes 11 through 13. The nerve is seen running with its vascular pedicle.

Source

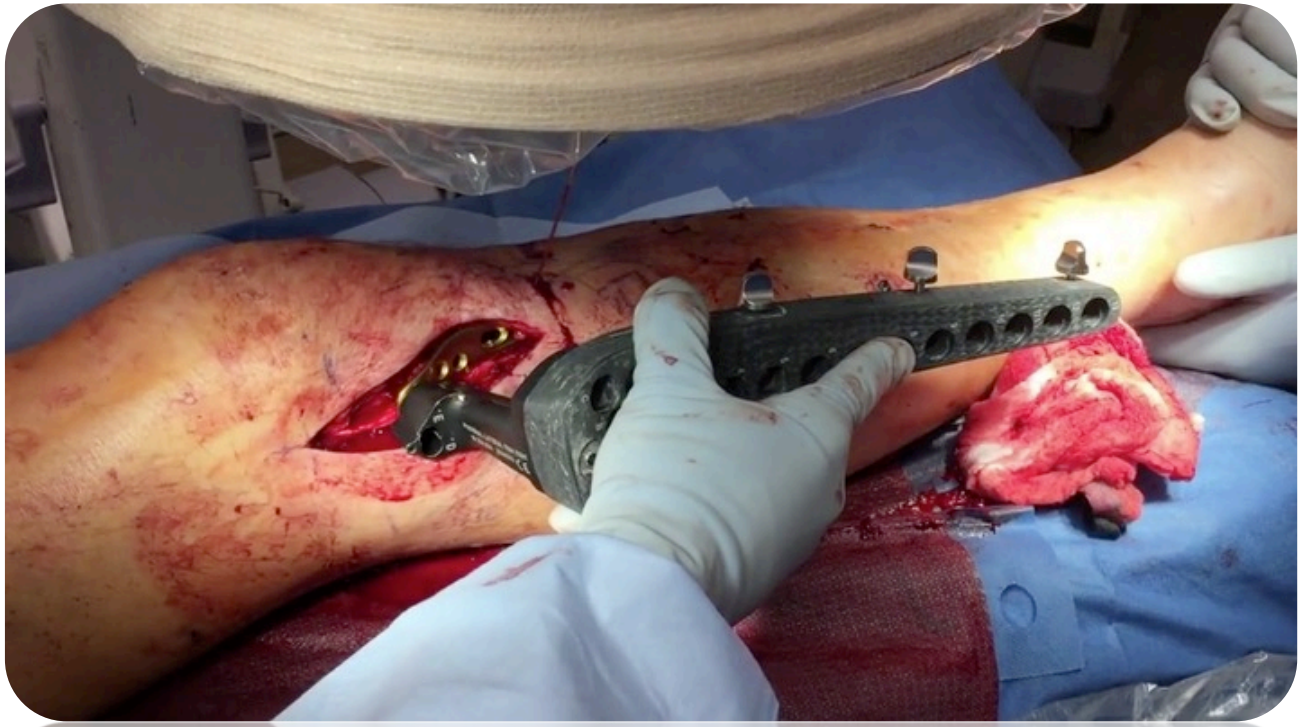
Anatomy of the Superficial Peroneal Nerve in Relation to Fixation of Tibia Fractures With the Less Invasive Stabilization System

Journal of Orthopaedic Trauma18 (8):536-539, September 2004.

JOT 2004

MIPO Proximal Tibia

https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/17165314/bridge-plating-of-proximal-tibia-metaphyseal



Distal Tibia

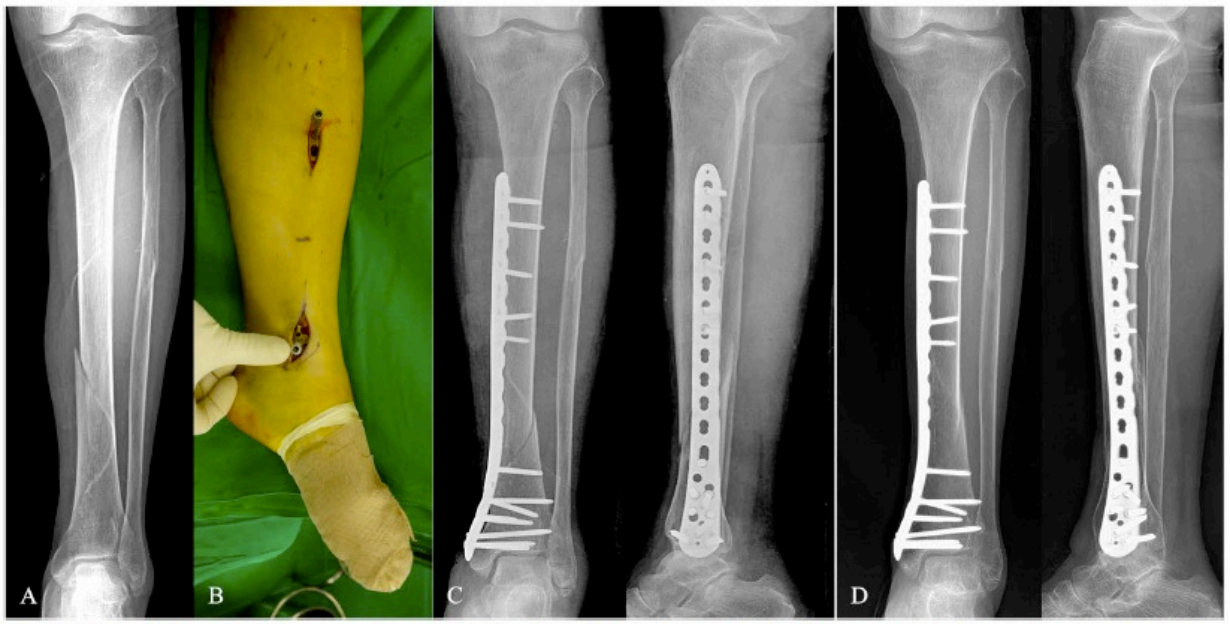


FIGURE 2. A, An 82-year-old woman who sustained a distal tibial shaft fracture (OTA/AO type 42 A1). B, The fracture was treated using minimally invasive plate osteosynthesis. C, Postoperative radiographs show acceptable alignment. D, The fracture healed with callus formation 16 weeks postsurgery.

- Can be performed using limited open reduction (separate from incisions used for plate insertion) as soft tissues allow without increasing complication rates.
- In this series adding open reduction to percutaneous techniques alone decreased fluoro time and improved coronal plane alignment

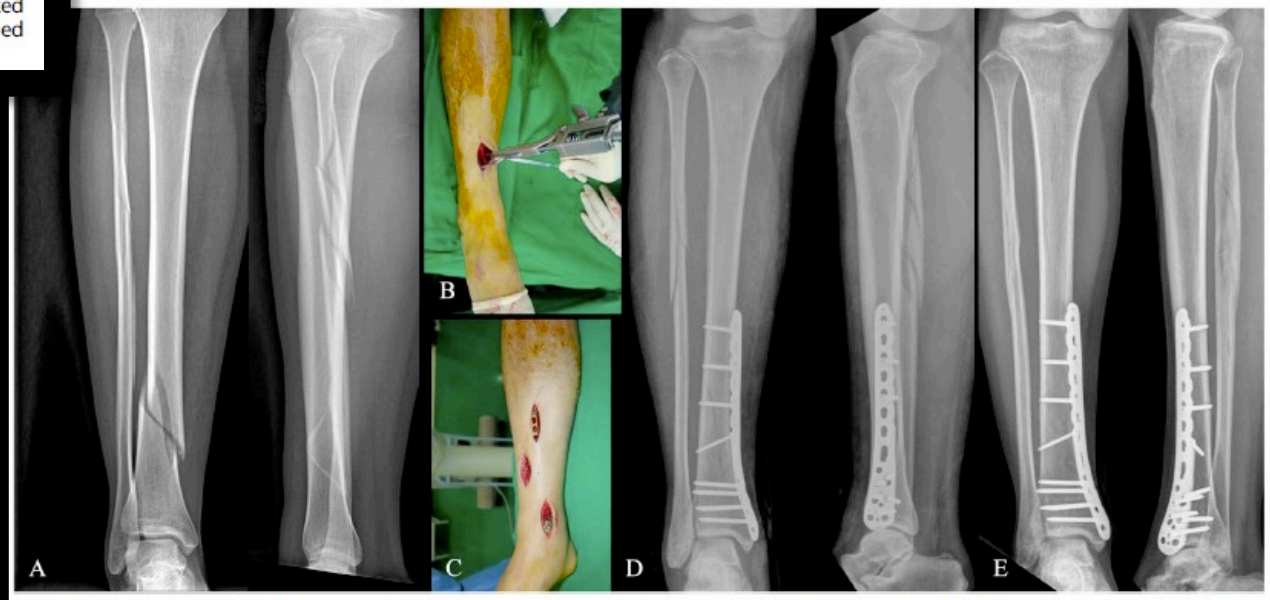


FIGURE 3. A, A 45-year-old man who sustained a distal tibial shaft fracture (OTA/AO type 42 A1). B, The fracture was reduced using minimal open reduction and internal fixation. C, A locking plate was placed medially, similar to the process in minimally invasive plate osteosynthesis. D, Postoperative radiographs show anatomical reduction. E, The fracture healed with a disappearing fracture line 15 weeks postsurgery.

Kim JW, Kim HU, Oh CW, Kim JW, Park KC. A prospective randomized study on operative treatment for simple distal tibial fractures-minimally invasive plate osteosynthesis versus minimal open reduction and internal fixation. J Orthop Trauma. 2018 Jan;32(1):e19-e24. jorthotrauma.com

- Risk of wound infection is primary concern given limited soft tissue envelope over the medial ankle
- May lead to plate removal, debridement, need for flap coverage

Distal Tibia

- Or you could nail it…
- Remember, MIPO is just one option

Humerus

- Multiple approaches described
- Technically demanding due to anatomic concerns
- Percutaneous screw placement unsafe over the majority of the length of the humerus

Humerus

- Two limited incisions
  - Proximal interval: deltoid/biceps
  - Brachialis split distally
  - Plate slid in submuscular fashion

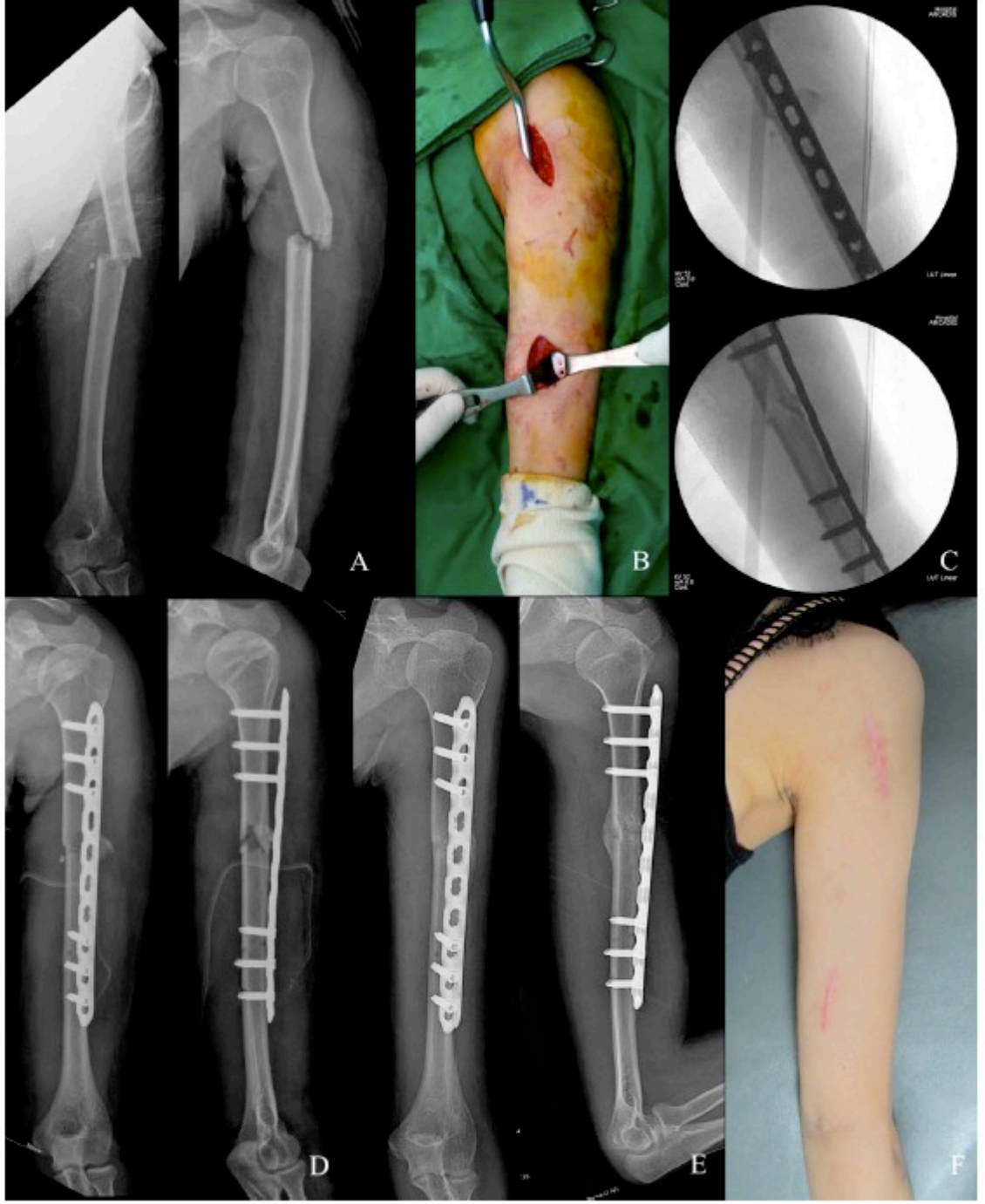
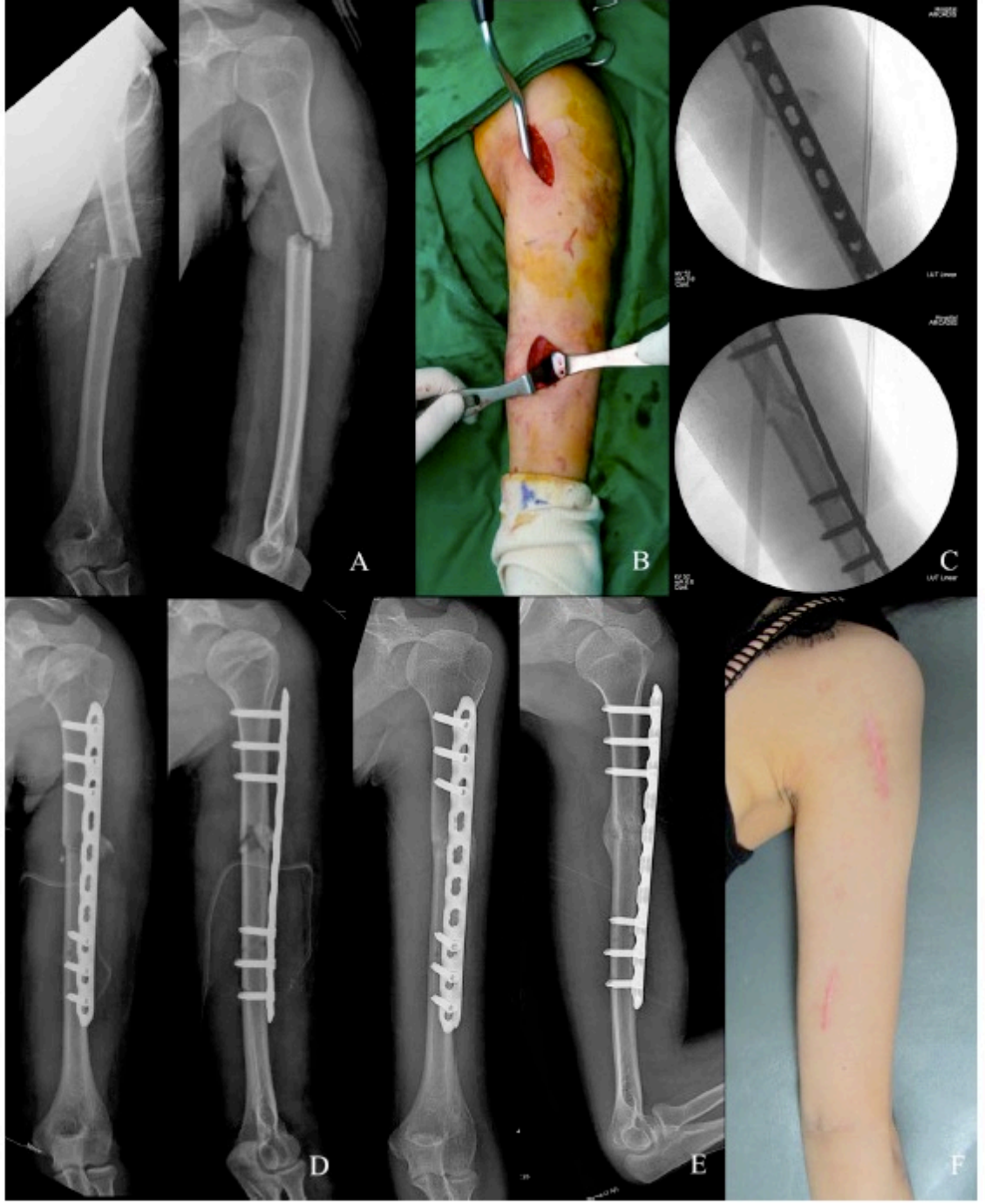


FIGURE 2. A, A 21-year-old woman sustained a fracture of the left humeral shaft (AO/OTA 12-A3) after a fall. B, The fracture was treated by MIPO. C, Under the image intensifier, the reduction state was verified. D, Post-operative radiographs show an acceptable alignment. E, The fracture was healed with callus formation 4 months after surgery, with a small incision scar and satisfactory function (F). **Editor's note:** A color image accompanies the online version of this article.

Kim JW, Kim HU, Oh CW, Kim JW, Park KC. A Prospective Randomized Study of Operative Treatment for Noncomminuted Humeral Shaft Fractures. J Orthop Trauma. 2015 Apr;29(4):189-194. jorthotrauma.com

Humerus

- RCT comparing conventional plating to MIPO
- Union rates and complications rates equivalent
- Increased fluoro time with MIPO
- Only experienced trauma surgeons included



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Kim JW et al JOT 2015

Humerus

- Two limited incisions
  - Delto-pectoral interval proximally
  - Brachialis split distally
- As a percentage of humeral length measured from the lateral epicondyle: nerves most at risk during anterior approach MIPO
  - Musculocutaneous: 18 – 42%
  - Radial: 36 – 60% →risk of A to P screws injuring the nerve

MIPO Humerus: Anteromedial approach

- Two incisions
  - Proximal interval: between biceps and deltoid
  - Distal interval: elevate brachialis from medial intramuscular septum
  - No percutaneous screws placed
- As a percentage of humeral length measured from the lateral epicondyle, structures most at risk during anteromedial approach MIPO
  - Brachial Artery: 20 – 62%
  - Median Nerve: 20 - 62%
  - Musculocutaneus nerve: 20 – 75%
- Note that these danger zones span nearly the entire humerus

Buranaphatthana T et al Injury 2019

MIPO Proximal humerus

- Described technique includes a limited anterolateral acromial approach/deltoid split to a point 5cm distal to the acromion (staying proximal to the axillary nerve) with percutaneous placement of distal screws using an aiming arm

- Would be wary of this approach as the axillary nerve crosses at the level of the calcar screws which must be placed for successful proximal humerus ORIF

MIPO Humerus – Posterior approach

- https://otaonline.org/video-library/45036/procedures-and-techniques/multimedia/18420128/posterior-mipo-humerus-plating
- Two limited incisions
  - Between long and lateral head of triceps proximally
  - Radial to triceps tendon distally
  - Can also add triceps split distally
  - Plate slid under radial nerve

MIPO Clavicle

While MIPO clavicle can result in shorter operative times and shorter incisions, time to union is related to fracture reduction which may be more difficult to obtain via MIPO

Randomized Controlled Trial > Orthopedics. 2018 Sep 1;41(5):e649-e654.

doi: 10.3928/01477447-20180711-05. Epub 2018 Jul 16.

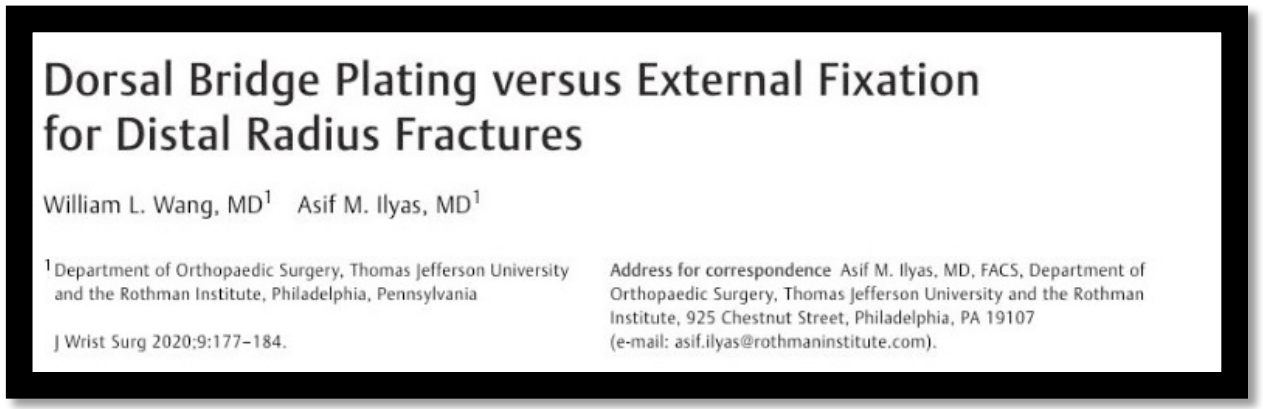
A Comparison of Clinical and Radiological Outcomes of Minimally Invasive and Conventional Plate Osteosynthesis for Midshaft Clavicle Fractures

Joon Yub Kim, Byung Chan Yoo, Jong Pil Yoon, Sung Jin Kang, Seok Won Chung

PMID: 30011053 DOI: 10.3928/01477447-20180711-05

Distal Radius: Dorsal Spanning Plate

- Compares favorably to external fixation of geriatric distal radius fractures with regard to patient outcomes, complex regional pain syndrome, and infection



Dorsal Bridge Plating versus External Fixation for Distal Radius Fractures

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J Wrist Surg 2020;9:177–184.

Image courtesy of G. Moloney

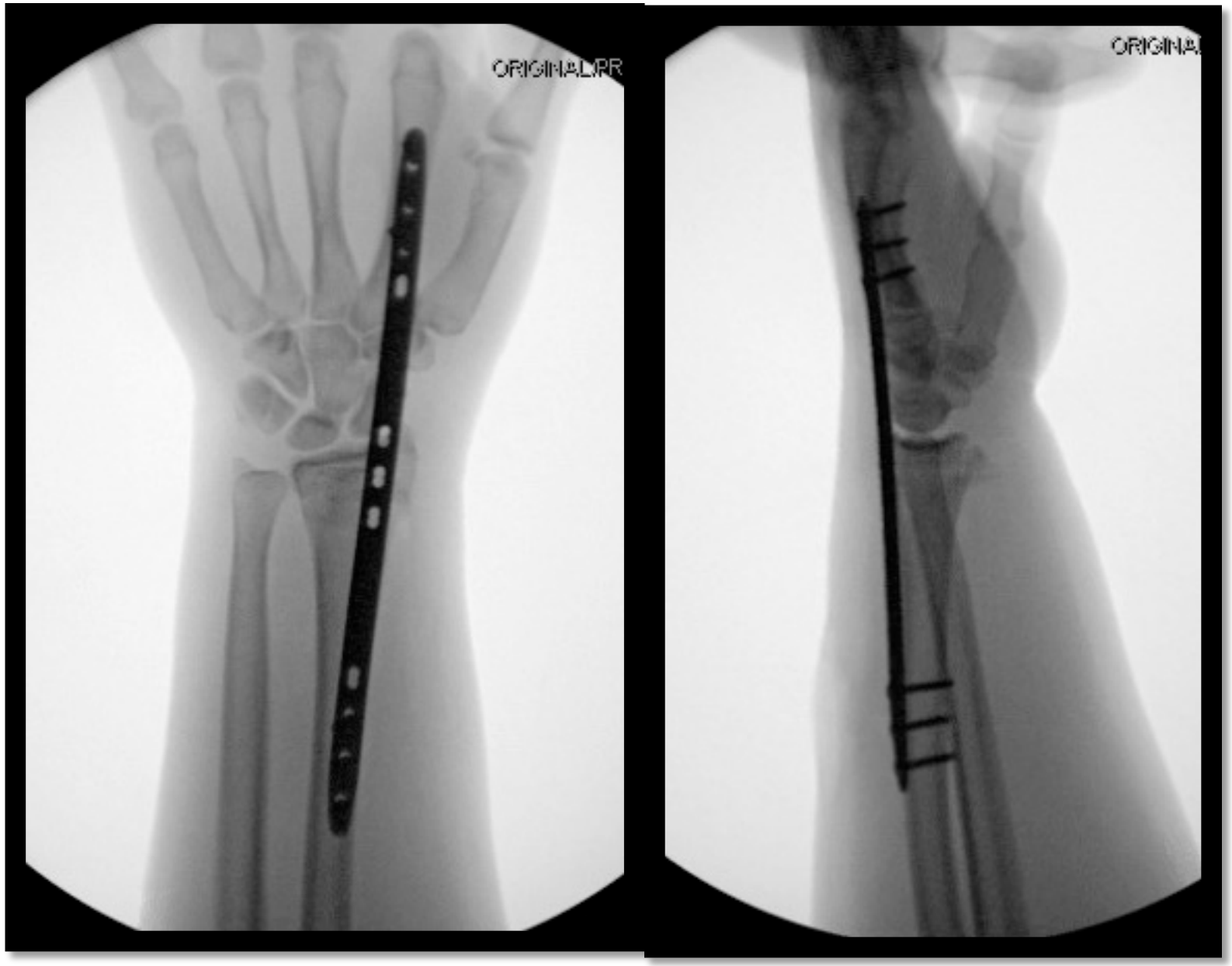
Wang W et al J Wrist Surg 2020

Distal Radius: Dorsal Spanning Plate

- Limited Incision localized fluoroscopically
  - Centered between 2nd and 3rd metacarpal
  - Dorsal aspect of the radius
    - Deep exposure between 2nd and 3rd compartments
    - Superficial Radial Nerve at risk
- Plate slid under the extensor retinaculum which is never exposed

Image courtesy of G. Moloney

- Plate can be placed on the 2nd or 3rd metacarpal
- 2nd metacarpal may assist in regaining radial height



- Plate can be attached to the metacarpal first and then used to regain length

Plate removal at 3 months if bony union and patient is physiologically appropriate and desires removal

Take Home

- MIPO allows insertion of plates with minimal disruption of soft tissues and can be done safely with appropriate awareness of anatomy
- MIPO is described for a wide variety of fractures
- The most widely accepted and safe locations are the distal femur, proximal tibia, and distal radius
- While there is literature to describe MIPO in other locations (humerus) anatomic concerns may mean the risks outweigh the potential benefits for most surgeons.

References

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