Minimally Invasive Plate Osteosynthesis

Gele B Moloney, MD
Assistant Professor of Orthopaedic Surgery
University of Pittsburgh Medical Center
Pittsburgh, PA
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

- Open Plating
- Open Plating with Meticulous Soft tissue handling
- Minimally Invasive Plating
MIPO preserves vascularity

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

<table>
<thead>
<tr>
<th>Approach: Artery condition</th>
<th>CPO Intact</th>
<th>CPO Interrupted</th>
<th>MIPO Intact</th>
<th>MIPO Interrupted</th>
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<td>72.5%</td>
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CPO, conventional plate osteosynthesis; MIPO, minimally invasive plate osteosynthesis.

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
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

MIPO Intraarticular Distal Femur

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.
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”

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”
LISS – utilized here for open fracture with proximal fracture extension
• 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!
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
MIPO Proximal Tibia

Distal Tibia

- 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.

• 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

Humerus

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

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

Apivatthakakul T et al Injury 2010
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%
  • Musculocutaneous 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


- 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
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

William L. Wang, MD1  Asif M. Ilyas, MD1

1Department of Orthopaedic Surgery, Thomas Jefferson University and the Rothman Institute, Philadelphia, Pennsylvania

Address for correspondence: Asif M. Ilyas, MD, FACS, Department of Orthopaedic Surgery, Thomas Jefferson University and the Rothman Institute, 925 Chestnut Street, Philadelphia, PA 19107 (e-mail: asif.ilyas@rothmaninstitute.com).

Wang W et al J Wrist Surg 2020

Image courtesy of G. Moloney
Distal Radius: Dorsal Spanning Plate

- Limited Incision localized fluoroscopically
  - Centered between 2\textsuperscript{nd} and 3\textsuperscript{rd} metacarpal
  - Dorsal aspect of the radius
    - Deep exposure between 2\textsuperscript{nd} and 3\textsuperscript{rd} 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.
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