Minimally Invasive Plating of Fractures:
Advantages, Techniques and Trade-offs

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OUTLINE

• Principles of fracture management
• The importance of vascular supply
• Equipment and reduction techniques
• Examples of minimally invasive plating
• Advantages and outcomes of minimally invasive plating
• Disadvantages of minimally invasive plating
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• Principles of fracture management
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1. Restoration of anatomic relationships:
   – Malalignment leads to limited function of limb
   – Limp leads to increased physiologic demand
   – Either can lead to chronic disability and an unsatisfied patient
PRINCIPLES OF FRACTURE MANAGEMENT

2. Preservation of osseous blood supply:

- Bone has two primary blood supplies:
  - Endosteal—high pressure, inner 2/3
  - Periosteal—low pressure, outer 1/3
- Loss of blood supply limits healing
PRINCIPLES OF FRACTURE MANAGEMENT

2. Preservation of osseous blood supply:

- An intact blood supply is necessary for fracture healing.
3. Stable fixation until union:
   – Surgical implants share or bear physiologic loads until healing:
     • Absolute stability for anatomic reduction and primary bone healing
     • Relative stability for bridging construct, callus formation and secondary bone healing
PRINCIPLES OF FRACTURE MANAGEMENT

4. Early and safe mobility:

– Limits risk of morbidity that is associated with immobilization
  • Pneumonia
  • Venous thromboembolism
  • Bedsores/skin breakdown

– Helps restore joint range of motion and prevent contractures
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Importance of Vascular Supply
Importance of Vascular Supply

• All fractures are associated with soft tissue disruption of some extent:
  – Vascular tearing, laceration or occlusion
  – Periosteal stripping

• Soft tissue damage is typically related to mechanism of injury:
  – Rotation = low energy with limited soft tissue damage
  – Blunt trauma = high energy with potential for extensive stripping
Importance of Vascular Supply

- Early ORIF results were discouraging:
  - Over dissection of distal femur resulted in unacceptably high rates of non-union, malunion, infection and need for bone graft

Neer et al., Injury 1975
Schatzker and Lambert, Clin Orthop 1979
Importance of Vascular Supply

The Effects of Extraperiosteal and Subperiosteal Dissection

II. On Fracture Healing*

BY LEO A. WHITESIDE, M.D.†, AND PEGGY A. LESKER, B.S.‡,

Whitesides and Lesker, JBJS 1978

• Rabbit Model:
  – Healing was significantly retarded with muscle and periosteal injury
  – Healing potential was inversely proportional to amount of soft tissue stripping
10 fresh cadaveric specimens underwent conventional open plating and minimally invasive plating.

Each cadaver was injected with silicone dye and vascularity was assessed.

Results:

- MIPO demonstrated improved extramedullary and intramedullary perfusion
Importance of Vascular Supply

Periosteal perfusion after MIPO (A) and conventional plating (B)

Farouk et al., JOT 1999
Importance of Vascular Supply

Medullary perfusion after MIPO (A) and conventional plating (B)

Farouk et al., JOT 1999
Importance of Vascular Supply

- “…the extensive operative exposure require to achieve an anatomic reduction often results in devitalization of the bone and surrounding tissues as well as evacuation of the fracture hematoma, which has osteogenic potential.”

Collinge et al., JAAOS 2000
Importance of Vascular Supply

• “Biologic Fixation”:  
  – Surgical techniques designed to limit biological damage at the time of surgery.  
    • Avoids the need for precise reduction by using bridging construct and indirect reduction techniques.  
    • Minimizes soft tissue trauma and damage to the remaining vascular supply.  
    • Can be achieved with plating or intramedullary rodding.  

Moore et al., J Trauma 1987  
Perran et al., JBJS (Br) 2002
Importance of Vascular Supply

• Surgeon’s responsibility:
  – Limit iatrogenic soft tissue damage
  – Limit further damage to periosteal and/or endosteal blood supply
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MIPO Reduction Techniques

• Minimally invasive plating relies on indirect reduction techniques.

• Required Equipment:
  – Radiolucent Table
  – C-arm/Fluoroscopy
  – Total Paralysis
MIPO Reduction Techniques

• Required Equipment Continued:
  – Length and Coronal Plane Alignment:
    • Traction pin:
      – Can often help with pulling femur to length, especially for extra-articular fractures
        » May actually be harmful if attempting joint reduction as it tensions surrounding soft tissues
      – May be placed within the distal femur or proximal tibia depending on fracture pattern and planned fixation
MIPO Reduction Techniques

• Required Equipment Continued:
  – Length and Coronal Plane Alignment:
    • **Schantz Pins/T-Handle:**
      – Can be used to manipulate fracture fragments through small incisions
      – Place outside of footprint of plate
MIPO Reduction Techniques

• Required Equipment Continued:
  – Length and Coronal Plane Alignment:
    • Universal AO Distractor or External fixator:
      – Can be used for both length and coronal plane alignment
      – Hold preliminary reduction while assessing alignment/rotation and while placing definitive fixation
      – Multiplanar external fixation can assist with correction of deformity in multiple planes
MIPO Reduction Techniques

- Universal AO Distractor:
MIPO Reduction Techniques
MIPO Reduction Techniques

• Required Equipment Continued:
  – Sagittal Alignment:
    • Towel Bumps: for under the leg to correct apex anterior/posterior
MIPO Reduction Techniques

Bump adjustment to restore anterior bow
MIPO Reduction Techniques

External Fixator for length and varus/valgus

Bump to push distal fragment anteriorly
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Pediatric Femoral Shaft Fracture
Submuscular Plating

MIPO Examples
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating
  - Patient positioning can help with reduction and ensure easy access to plate insertion site
MIPO Examples: Femoral Shaft

• Pediatric Femoral Shaft Fracture—Submuscular Plating
  – Marking osseous landmarks is essential to making accurate incisions.
  – Use fluoroscopy if necessary.
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating
  - The plate is used for submuscular dissection.
  - Insertion handles make insertion easier
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating
  - Suture tied to the screw head prevents the screw from being lost in a large soft tissue envelope
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating

- Antiglide Screw on Concavity of Fracture and Plate for reduction

- Pre-bent Plate
MIPO Examples: Femoral Shaft

- Pediatric Femoral Shaft Fracture—Submuscular Plating
MIPO Examples

Intra-articular Distal Femur Fracture
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Lateral or lateral parapatellar incision permits access to articular surface
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Lateral parapatellar incision
MIPO Examples: Distal Femur
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Absolute articular stability with lag screws
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Submuscular plate insertion (Lateral Incision)
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Submuscular plate insertion (Lateral incision)
MIPO Examples: Distal Femur

- Intra-articular Distal Femur Fracture:
  - Lateral incision with plate in place
MIPO Examples: Distal Femur

• Intra-articular Distal Femur Fracture:
  – Lateral parapatellar closure
MIPO Examples

Extra-articular Distal Femur Fracture
MIPO Examples: Distal Femur

• Extra-articular Distal Femur Fracture:
MIPO Examples: Distal Femur

• Extra-articular Distal Femur Fracture:
  – Traction and bump improves alignment
MIPO Examples: Distal Femur

• Extra-articular Distal Femur Fracture:
  – Femoral distractor to hold reduction and length
MIPO Examples: Distal Femur
MIPO Examples: Distal Femur
MIPO Examples

Intra-articular Proximal Tibial Shaft
MIPO Examples: Proximal Tibia
MIPO Examples: Proximal Tibia

- Intra-articular Proximal Tibial Shaft Fracture:
  - Restore anatomic articular surface and hold reduction
MIPO Examples: Proximal Tibia

- Intra-articular Proximal Tibial Shaft Fracture:
  - Reduce shaft component percutaneously
MIPO Examples: Proximal Tibia

• Intra-articular Proximal Tibial Shaft Fracture:
  – Lag screw fixation into shaft component
MIPO Examples: Proximal Tibia

• Intra-articular Proximal Tibial Shaft Fracture:
MIPO Examples: Proximal Tibia

• Intra-articular Proximal Tibial Shaft Fracture:
MIPO Examples: Proximal Tibia
MIPO Examples

Tibial Shaft Fracture
MIPO Examples: Tibial Shaft

- Tibial Shaft Fracture below TKA with prior saphenous vein graft
MIPO Examples: Tibial Shaft

- Select appropriate plate length and incision location
MIPO Examples: Tibial Shaft
MIPO Examples: Tibial Shaft
MIPO Examples

Extra-Articular Distal Tibial Shaft Fracture
MIPO Examples: Distal Tibia

• Extra-articular Distal Tibial Shaft Fracture:
MIPO Examples: Distal Tibia

• Extra-articular Distal Tibial Shaft Fracture:

  Bumps assist with reduction
MIPO Examples: Distal Tibia

- Extra-articular Distal Tibial Shaft Fracture:
MIPO Examples: Distal Tibia
MIPO Examples

Extra-Articular Distal Tibia Fracture:
Anterior wounds prevent conventional approach
MIPO Examples: Distal Tibia
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Minimally Invasive Plating Outcomes

- Indirect reduction and preservation of soft tissues resulted in improved outcomes:
  - Distal Femur:
    - 0-10% non-union
    - 2% infection
    - 2% malunion

Riemer et al, Orthopaedics 1992
Bolhofner et al, JOT 1996
Ostrum and Geel, JOT 1995
Schatzker et al., CORR 1998
Minimally Invasive Plating Outcomes

• Newer studies with larger cohorts better demonstrate risks, complications and clinical outcomes
Minimally Invasive Plating Outcomes

Clinical outcomes of locked plating of distal femoral fractures in a retrospective cohort

Martin F Hoffmann, Clifford B Jones, Debra L Sietsema, Paul Tornetta III, and Scott J Koenig

- 111 fracture treated with locked plating
  - 18% non-union rate:
    • Risks = Open fracture and severity of open injury (Type III > Type I or II)
  - 10% implant failure
  - TKA = risk of implant failure and poor outcome
Minimally Invasive Plating Outcomes

Early Mechanical Failures of the Synthes Variable Angle Locking Distal Femur Plate

Jason C. Tank, MD, Prism S. Schneider, MD, PhD, Elizabeth Davis, BS, Matthew Galpin, Mark L. Prasarn, MD, Andrew M. Choo, MD, John W. Munz, MD, Timothy S. Achor, MD, James F. Kellam, MD, and Joshua L. Gary, MD

J Ortho Trauma, 2016

- Up to 22% implant failure rate with VA implant compared to 14% and 0% for LISS and LCP plating.
- New technology does not always result in improved fixation/outcomes
Minimally Invasive Plating Outcomes

• Tibial fractures, clinical results:
  – Proximal tibia:
    • 3-9% malalignment
    • 3% non-union
    • 0-4% infection

Cole et al., JOT 2004
Ricci et al., JOT 2004
Sitnik et al. CORR 2013
Minimally Invasive Plating Outcomes

- Tibial fractures, clinical results:
  - Distal Tibia:
    - 0-20% malunions
    - 0-4% nonunions
    - 0-5% infection

Helfet et al., Injury 1997
Borg et al. Injury 2004
Redfern et al. Injury 2004
Maffuli et al. Int Orthop 2004
Khoury et al. Foot Ankle Int 2002
Sitnik et al. CORR 2013
Paluvadi et al. J Ortho Trauma, 2014
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Disadvantages of Minimally Invasive Plate Fixation

- Restoration of fracture alignment is critical to gaining acceptable clinical outcomes

- Intraoperative assessment of length, alignment and rotation may be difficult with fluoroscopy

- Several techniques can be used to help assess and maintain alignment
Accurate plate placement is essential:
- Modern plates are designed to fit the femur anatomically, but not all patients are the same.
- A plate placed in the wrong location can lead to malalignment in the coronal or sagittal plane, malrotation, or translation.
- Avoid the “golf club deformity”—medialization and external rotation of the distal femoral articular surface.
  - Typically occurs when plate placed too posteriorly.

Disadvantages of Minimally Invasive Plate Fixation

“Pitfalls in the Application of Distal Femur Plates for Fractures”

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

J Ortho Trauma, 2011
Disadvantages of Minimally Invasive Plate Fixation

- Difficulty assessing length
Disadvantages of Minimally Invasive Plate Fixation

- Use intraoperative measurements from other leg
Disadvantages of Minimally Invasive Plate Fixation

• Unable to assess varus/valgus
Disadvantages of Minimally Invasive Plate Fixation

- Get intraoperative plain radiograph and measure on PACS
Disadvantages of Minimally Invasive Plate Fixation

- Other Disadvantages:
  - Indirect reduction can be technically difficult
  - Learning curve associated with use—may increase malreduction rate early on.
Minimally Invasive Plate Fixation

Future direction of MIPO:
Minimally Invasive Plate Fixation

Humeral Shaft Fractures?
Minimally Invasive Plate Fixation

Minimally Invasive Plating Osteosynthesis (MIPO) of Middle and Distal Third Humeral Shaft Fractures

An Zhiquan, MD, PhD, Zeng Bingfang, MD, Wang Yeming, MD, PhD, Zhang Chi, MD, and Huang Peiyian, MD

J Ortho Trauma, 2007
Minimally Invasive Plate Fixation

Minimally invasive percutaneous plating of proximal humeral shaft fractures with the Proximal Humerus Internal Locking System (PHILOS)

Alexander Brunner, MD, Sebastian Thormann, MD*, Reto Babst, MD

J Shoulder and Elbow, 2012
Minimally Invasive Plate Fixation

A Prospective Randomized Study of Operative Treatment for Noncomminuted Humeral Shaft Fractures: Conventional Open Plating Versus Minimal Invasive Plate Osteosynthesis

Ji Wan Kim, MD,* Chang-Wug Oh, MD,† Young-Soo Byun, MD,‡ Jung Jae Kim, MD,§ and Ki Chul Park, MD||

J Orthop Trauma, 2015
Minimally Invasive Plate Fixation

- Humeral Shaft Fractures:
  - More data on surgical techniques, complications and clinical outcomes is required
  - Complex neurovascular anatomy may limit utility of minimally invasive plating in this area
SUMMARY

• Fracture healing requires an intact soft tissue envelope and blood supply.

• Minimally invasive plating of fractures allows for the preservation of surrounding vasculature.
  – Improves union rates
  – Limits infection risk

• Achievement and maintenance of reduction can be technically demanding

• Must be overly critical of fracture alignment as malreduction and malunion is more common with minimally invasive techniques.
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