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# Minimally invasive plate osteosynthesis versus conventional open insertion techniques for osteosynthesis

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ABSTRACT

Osteosynthesis has evolved theoretically and practically throughout its evolution. Similar to trends in other surgical fields, surgical techniques in fracture fixation, such as minimally invasive plate osteosynthesis (MIPO), have moved from large dissections to more tissue sparing methods. These plating techniques have been developed for a variety of bones, but more universal clinical adoption will rely upon improved clinical outcomes. The current review will describe minimally invasive techniques, evaluate their rationale, and summarize evidence for their efficacy.



## Introduction

Compared to majority of the medical field, the history of osteosynthesis is relatively brief. While there are reports of use of sutures and wires for fixation of fractures as early as the 1770s, modern osteosynthesis techniques did not appear until the beginning of the twentieth century. Albin Lambotte, the often-suggested father of osteosynthesis, made his first report of 35 patients treated with internal fixation in 1908, followed by the publication of his classic text in 1913. Arguably the next great advance did not occur until the founding of the AO group (Arbeitsgemeinschaft fur Osteosynthesefragen) in 1958 by Muller, Willenegger, Schneider, and Allgower; this marked the first rigorous attempts at the scientific investigation of fracture treatment and the education of those who undertook it [1].

There has been exponential growth in the surgical techniques and understanding of fracture treatment over the last 60 years. The fundamental advances can be highlighted by comparing Robert Danis' original principles of osteosynthesis [2] to those currently promoted by the AO [3] (Table 1).

While Danis emphasized the strict anatomic restoration of bone and absolute stability, current theory allows for the restoration of anatomic relationships (length, alignment, and rotation) distant from articular surfaces; accepts relative stability and callus formation; and emphasizes the importance of judicious soft tissue handling. These are some of the differences that separate traditional and minimally invasive plating techniques.

**Table 1**
Principles of osteosynthesis

| Robert Danis, 1949 [2] | AO, 2017 [3] |
|---|---|
| 1) Immediate and active mobilization of the muscles of the region and of the neighboring joints | 1) Early and safe mobilization and rehabilitation of the injured part and the patient as a whole |
| 2) Complete restoration of the bone to its original form | 2) Fracture reduction and fixation to restore anatomical relationships |
| 3) The primary bone healing of the bony fragments without the formation of apparent callus | 3) Fracture fixation providing absolute or relative stability as the "personality" of the fracture, the patient, and the injury requires |
| | 4) Preservation of the blood supply to soft tissues and bone by gentle reduction techniques and careful handling |

The purpose of this review is to discuss the rationale and summarize the evidence for minimally invasive plating techniques (MIPO).

## Minimally invasive surgical techniques

Prior authors have described the use of minimally invasive plating techniques in different extremities. Fractures of the clavicle, humerus, distal radius, femur, tibia, fibula and calcaneus have all been treated in this manner. While each region requires a commanding knowledge of anatomy and unique technical aspects to ease reduction and fixation, the surgical goals and general approach remain the same.

The majority of these techniques involve minimally invasive plate osteosynthesis (MIPO), as described below.

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*Minimally invasive plate osteosynthesis (MIPO)*

Minimally invasive plate osteosynthesis is a surgical technique that can be used throughout the upper and lower extremities, which emphasizes minimal soft tissue dissection, indirect reduction techniques to restore anatomic alignment, and bridge plate fixation of metaphyseal and diaphyseal fractures. MIPO does not preclude anatomic reduction and absolute stable fixation of associate articular fractures, which can be done in conjunction. Such procedures are generally done in the following sequence:

1. Surgical exposure limited to the articular portion of a fracture (metaphyseal and/or diaphyseal areas are not exposed);
2. Articular components are anatomically reduced, and fixation is obtained with absolute stability;
3. Indirect reduction (length, alignment, rotation) of the metaphyseal and/or diaphyseal portion of the fracture is performed, provisionally secured with manual traction, external fixation, or other methods, and confirmed using fluoroscopy;
4. Plate length determination, contouring, and submuscular insertion spanning the remaining metaphseal and/or diaphyseal fracture;
5. Reduction of the plate to bone (clamps, non-locking screws) and finalization of the metaphyseal and/or diaphyseal reduction;
6. Proximal and distal fixation (locking for osteoporotic bone or short segments, non-locking for long, cortical segments) to bridge the metaphyseal and/or diaphyseal fracture. Fixation of the articular block is generally performed through the open exposure, while fixation of the metaphysis/diaphysis away from the articular block is accomplished through a series of small (~1 cm) incisions only large enough for placement of the screws.

Some fractures treated with this technique may have no articular involvement. In these cases, the incision only has to be large enough for plate insertion.

*Transarticular approach and retrograde plate osteosynthesis (TARPO)*

Fixation of complex intra-articular fractures of the distal femur has additionally been accomplished through a related technique with its own acronym: transarticular joint reconstruction and indirect plate osteosynthesis (TARPO).

Described for complex intra-articular fractures of the distal femur (AO 33C), the TARPO technique differs from the MIPO technique only in its exposure of the distal articular block. While classic MIPO exposures for the distal femur generally involve a lateral incision with limited exposure of the articular surface, particularly medially, TARPO exposes the joint through a midline skin incision and lateral parapatellar arthrotomy. This exposure significantly augments exposure of the articular surface, and therefore the surgeon's ability to reduce and fix complex intra-articular fractures. Once the articular block has been reconstructed, the sequence remains the same as for MIPO. However, since the joint has been formally entered, the plate must pass from within the arthrotomy, through a lateral portion of the capsule, and then submuscularly along the metaphysis and diaphysis of the femur.

## Rationale for minimally invasive techniques

Prior to the development of minimally invasive techniques, surgeons performing open reduction and internal fixation procedures used conventional exposures and implants. As described above with reference to Danis, this involved complete exposure of the fracture site with the inherent dissection and stripping of muscle and periosteum. Individual fragments were brought together to recreate a whole bone and compression was achieved ideally across all fracture sites via lag screws or compression plating. Such techniques restored all of the bone fragments anatomically to their initial alignment but came at the cost of reducing the blood supply to the fracture site. Cadaveric injection studies comparing conventional and minimally invasive plating techniques of the distal femur have clearly shown the reduction of both periosteal and medullary perfusion with conventional techniques [4]. Furthermore, clinical reports reveal outcomes with substantial room for improvement. Conventional plating of the distal femur resulted in good to excellent results only 75–80% of the time in most studies. Similar problems with infection, malunion, and nonunion have similarly been described for open approaches to the proximal tibia.

Paralleling the evolution of plating techniques was the development of intramedullary fixation of diaphyseal femur and tibial fractures. In distinct contrast to conventional plating, these techniques were performed with the use of small incisions and dissections remote from the site of injury. The restoration of length, alignment, and rotation were sought rather than the absolute reconstruction of the bone, and relative stability with callous formation rather than absolute stability was the goal for union. The gentle soft tissue handling and preservation of blood supply of these techniques generated remarkable clinical results almost immediately. Winquist's initial report of 520 femur fractures treated in this manner showed a remarkable >99% union rate and <1% infection rate [5]. Subsequent reports continued to demonstrate promising results for the femur, with union rates of 98% and infection rates of 2.4%, as demonstrated by Klemm [6]. Tibial shaft fractures managed with intramedullary nailing demonstrated higher, but still promising nonunion and infection rates approaching at most 10% in some studies [6–8]. These laudable results clearly demonstrated the benefits of minimally invasive exposures and fixation, albeit with intramedullary devices.

Although intramedullary fixation is associated with improved soft tissue and preservation of blood supply, the control of the fragments grows gradually more challenging the fracture moves closer to the articular surface, from the diaphysis to the metaphysis. As the space between the nail and the cortex increases, so does the opportunity for malreduction and malunion. This has been demonstrated most aptly in proximal third tibia fractures, where prior authors have shown malunion rates of 58–84% [9,10]. While multiple interlocking screws, blocking screws, and careful attention to nail start sights can all help reduce malunion, there remains a need for improvement in designing strategies for managing non-diaphyseal fractures. Particularly in the presence of osteoporosis, the metaphyseal bone surrounding the nail may not provide enough stability to prevent the metaphyseal segment from moving around the nail.

With the background of conventional plating, intramedullary nailing, and the advent of fixed angle locked plating comes the foundation for the rationale for minimally invasive plate osteosynthesis. Conventional plating has the inherent effect of reduced soft tissue health and bone perfusion. Intramedullary fixation preserves the blood supply to the area of injury but does not allow for adequate control of many meta-diaphyseal and metaphyseal fractures. MIPO ideally retains the benefits of minimally invasive intramedullary fixation, while allowing for better control of non-diaphyseal fractures.

## Evidence for minimally invasive plate osteosynthesis: upper extremity

For fractures of the upper extremity, MIPO has been described primarily for the humerus, clavicle, and distal radius, with the majority of the literature focusing on fractures of the humeral shaft. As with femoral fractures, MIPO techniques in the humerus have been shown in a cadaveric study to result in a smaller vascular insult compared with an open reduction and plating technique [11].