MINIMALLY INVASIVE FRACTURE REPAIR

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The concept of biological internal fixation has been predicated for years with the goal of maximizing preservation of the blood supply to the fractured bone. This trend resulted in new implants and new techniques that allowed surgeons to approach fracture fixation with smaller, less invasive approaches. The principal concept is to gain access to the bone via small incisions away from the fracture zone, thus preserving blood supply to the fracture fragments. Minimally invasive surgical approaches reduce pain and minimize trauma to the soft tissues. The small incisions provide a means of inserting a bone plate and placing screws to achieve stabilization and osteosynthesis. Methods of fracture reduction are included using the technique of indirect fracture reduction.

Biological factors important for fracture healing are preserved, enhancing the body's ability for indirect bone healing. The technique can be used with all fracture types but is particularly useful for stabilization of comminuted fractures. This type of bone healing is also referred to as secondary bone healing, spontaneous bone healing and callus healing. Stabilization of fractures using the principles of biologic fracture management is performed with the same type of implant systems used with traditional fracture repair, including externally and internally applied devices. Bones amenable to minimally invasive fracture repair include the humerus, radius, femur and tibia.

Comminuted fractures of the extremities can be challenging. It is always a race between a fracture healing and an implant failing. The factors to consider with minimally invasive fracture repair include:

1. minimally invasive surgical approach
2. preservation of soft tissue attachments to bone fragments
3. use of cancellous bone grafts
4. rigid method of fracture stabilization
5. early return to function

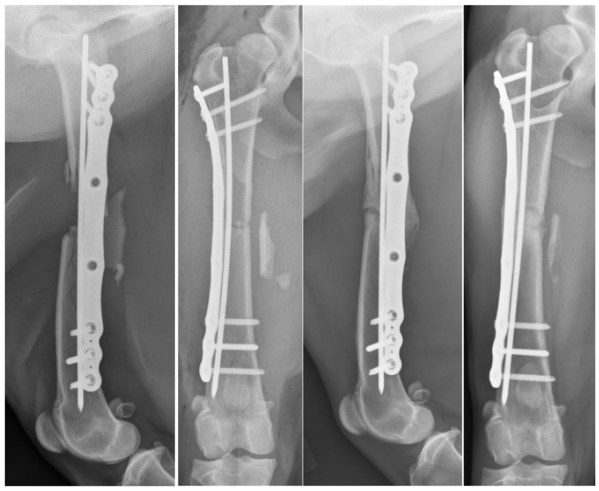
MINIMALLY INVASIVE PLATE OSTEOSYNTHESES TECHNIQUE

The technique of minimally invasive plate osteosynthesis (MIPO) describes the stabilization of a fractured bone with a bone plate and screws which are applied without performing an extensive open surgical approach to directly expose, reduce and stabilize the fracture. When MIPO is performed, the fracture segments are aligned using indirect reduction techniques in a closed fashion. Small plate insertion incisions are made over the anticipated (intended) locations of the proximal and distal ends of the bone plate. A tunnel is developed adjacent to the fractured bone, beneath the overlying soft tissues. The epiperiosteal tunnel extends from one plate insertion incision to the other, spanning the fracture site. The plate is inserted through the tunnel and fixed in place with bone screws inserted through the plate insertion incisions. Small stab incisions can be made over unexposed plate holes to facilitate additional screw insertion if necessary. MIPO techniques can result in superior preservation of blood supply to the fracture site, less disruption of supporting soft tissue structures, and potentially a faster return to function and more rapid bone healing than would be achieved with an open surgical approach to facilitate bone plating.

IMPLANT SYSTEMS

External and internal implant systems can be used to achieve bone healing using biological fracture management. Examples of external devices when used in an appropriate manner include casts, splints, linear external fixators and circular fixators. Internal devices commonly used for this application include the plate-rod system, interlocking nail and bone plates. Other implant systems can also be used for biologic fracture management as long as the soft tissue envelope is preserved at the fracture site. Whatever implant system is used, its application must be possible with minimal or no handling of the comminuted fracture fragments.

Locking plates are ideal for minimally invasive fracture repair for several reasons. Blood supply to the bone is preserved because the plate is not pressed tightly against the bone. The plate does not require perfect anatomic contouring because the displacement of the plate will not occur as the screw is tightened into the hole of the plate. Accurate contouring is difficult with a minimally invasive approach due to the minimal exposure to the shaft of the bone. Lastly, locking screws give fixed angle support to the non-reduced fracture, increasing stability and less chance of collapse and instability at the fracture gap.



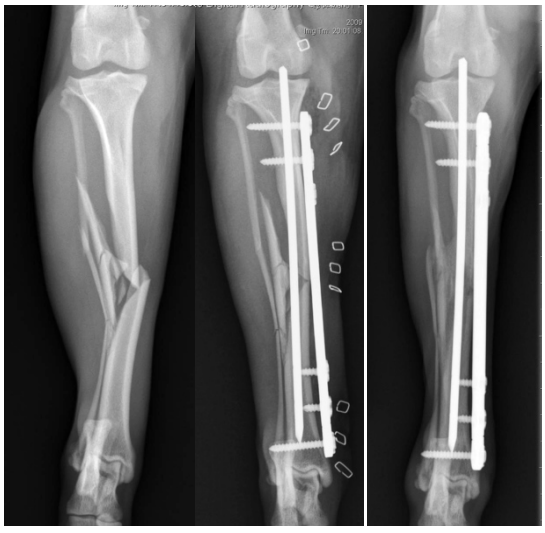
A percutaneous IM pin was first placed to assist fracture reduction and restore axial alignment. A locking plate was placed laterally to provide additional stability

FRACTURE REDUCTION

Fracture reduction is accomplished using a combination of limb distraction, limb manipulation, surgical instruments and placement of surgical implants. Limb distraction pre-op and intra-op fatigues muscles allowing easier reduction of the fractures. Distraction helps preserve limb length. Distraction also returns muscles to their original length. This is advantageous because comminuted bone fragm ents typically maintain a soft tissue attachment. As the muscle is stretched to its original length the comminuted bone fragments are pulled closer to their original location in the fracture zone. Manipulation of the limb by bending, rotation and translation can also help reduction of the fracture. Percutaneous placement of bone forceps can be used to reposition and align bone segments. Lastly, implants can be used to assist with fracture reduction. The intramedullary pin used fo r a plate-rod construct provide axial alignment and returns the limb to a more normal limb length. The pin also provides stability making bone plate placement easier. Pre-bending a plate to match the opposite normal bone is a very useful technique that simplifies fracture repair and improves outcome. This technique requires radiographic and surgical planning prior to surgery. Advanced imaging techniques such as fluoroscopy and arthroscopy allow guiding the reduction of the fracture and the application of the implants.

SPECIFIC FRACTURES

Tibial and radial fractures are the easiest fractures to treat using minimally invasive technique due to less soft tissues covering the bone. This allows a simple surgical approach, and it is easier for the surgeon to assess limb alignment and length. Surgical placement of implants is also easier. Use of pre-bent plates is particularly useful to assist reduction and stabilization of the fracture for these types of fractures. Placement of a percutaneous intramedullary (IM) pin is very helpful when treating comminuted fractures of the humerus and femur using minimally invasive technique. It is usually easy to place an IM pin in these bones. The pin can be placed in normograde fashion or through a small incision over the facture site in retrograde fashion. The IM pin provides axial alignment, appropriate limb length and partially stabilizes the fracture making placement of other implants (bone plate) simple. The pin can either be left in place (plate-rod repair) or used as an alignment pin only and removed once the primary implant is applied.



Healing of this comminuted tibial fracture occurred in 8 weeks following MIPO repair with a plate-rod using 3 small incisions

IM pins are also useful in treating radius and ulna fracture using MIPO technique with a plate-rod concept. The ulna is approached first through a small incision over the fracture site. The ulnar fracture is reduced and stabilized with IM pin is placed in retrograde fashion. The repair of the ulna helps to restore limb length, partially align the radius and provides limb stability to facilitate placement of a locking plate on the radius through a separate minimally invasive approach.

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