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Brian S. Beale and Antonio Pozzi

Biomechanical Concepts in Small Animal Fracture Fixation 853  
Peini Chao, Daniel D. Lewis, Michael P. Kowaleski, and Antonio Pozzi

Understanding the basic biomechanical principles of surgical stabilization of fractures is essential for developing an appropriate preoperative plan as well as making prudent intraoperative decisions. This article aims to provide basic biomechanical knowledge essential to the understanding of the complex interaction between the mechanics and biology of fracture healing. The type of healing and the outcome can be influenced by several mechanical factors, which depend on the interaction between bone and implant. The surgeon should understand the mechanical principles of fracture fixation and be able to choose the best type of fixation for each specific fracture.

Minimally Invasive Plate Osteosynthesis Fracture Reduction Techniques in Small Animals 873  
Bruno Peirone, Gian Luca Rovesti, Alessandro Boero Baroncelli, and Lisa Piras

Indirect fracture reduction is used to align diaphyseal fractures in small animals when using minimally-invasive fracture repair. Indirect reduction achieves functional fracture reduction without opening the fracture site. The limb is restored to length and spatial alignment is achieved to ensure proper angular and rotational alignment. Fracture reduction can be accomplished using a variety of techniques and devices, including hanging the limb, manual traction, distraction table, external fixators, and a fracture distractor.

Perioperative Imaging in Minimally Invasive Osteosynthesis in Small Animals 897  
Laurent P. Guiot and Loïc M. Déjardin

Perioperative imaging using various appropriate modalities is critical to the successful planning and performance of any orthopedic surgery. Although not an absolute prerequisite, the use of intraoperative imaging considerably facilitates the smooth and effective execution of minimally invasive osteosynthesis (MIO). However, the risk of overexposure to radiation is real, particularly when considering its insidious effect over time. Therefore, the primary concern of the surgeon must be safety of the surgical team. This article outlines basic, simple steps that will be effective in reducing radiation exposure, which in turn will make MIO a safe alternative to open reduction and internal fixation.

External Fixators and Minimally Invasive Osteosynthesis in Small Animal Veterinary Medicine 913  
Ross H. Palmer

Modern external skeletal fixation (ESF) is a very versatile system that is well suited to the ideals of minimally invasive osteosynthesis (MIO). It offers
variable-angle, locked fixation that can be applied with minimal to no disruption of the fracture zone. Technological advances in ESF have fostered the ability to use more simple frame applications than in previous generations. Even when rigid bilateral or multiplanar frames are required, timely staged-disassembly is easy to perform and allows for a gradual shift of loading from the frame to the healing bony column. Hybrid ESF is ideally suited for the MIO treatment of many juxta-articular fractures and osteotomies. Adherence to the principles of ESF and postoperative care is essential to overcome the various disadvantages that are inherent to ESF.

Interlocking Nails and Minimally Invasive Osteosynthesis
Loïc M. Déjardin, Laurent P. Guiot, and Dirsko J.F. von Pfeil

Interlocking nailing of long bone fractures has long been considered the gold standard osteosynthesis technique in people. Thanks to improvements in the locking mechanism design and nail profile, a recently developed veterinary angle stable nail has become the first true intramedullary fixator providing accurate and consistent repair stability while allowing semirigid fixation. As a result, indications for interlocking nailing have expanded to include treatment of periarticular fractures, corrections of angular deformities and revisions of failed plate osteosyntheses. Perfectly suited for minimally invasive osteosynthesis, interlocking nailing is an attractive and effective alternative to bone plating and plate-rod fixation technique.

Percutaneous Pinning for Fracture Repair in Dogs and Cats
Stanley E. Kim, Caleb C. Hudson, and Antonio Pozzi

This article describes the technique of percutaneous pinning in dogs and cats. Only acute fractures evaluated within the first 48 hours after trauma are selected for percutaneous pinning. Reduction is performed with careful manipulation of the fracture to minimize the trauma to the growth plate. After ensuring the fracture is reduced anatomically, smooth pins of appropriate size are inserted through stab incisions. Depending on the anatomic location, the pins are cut flush with bone or bent. The main advantages of this technique are the minimal surgical trauma and lower perioperative morbidity.

MIPO Techniques for the Humerus in Small Animals
Don Hulse

Knowledge of regional and topographic anatomy is paramount for success when using minimally invasive plate osteosynthesis (MIPO) for fracture management. Preoperative planning is essential for an optimal outcome and reducing stress among the surgical team; factors to consider include biologic assessment, mechanical assessment, clinical assessment, portal placement, and implant selection. MIPO is a useful technique for the direct or indirect reduction of humeral diaphyseal fractures. Implants should span the length of the bone for ease of implant application and to optimize the mechanical advantage of the implant. After surgery, incision care and controlled activity are 2 primary considerations.
Minimally Invasive Plate Osteosynthesis in Small Animals: Radius and Ulna Fractures 983
Caleb C. Hudson, Daniel D. Lewis, and Antonio Pozzi

Minimally invasive plate osteosynthesis (MIPO) is a biologically friendly approach to fracture reduction and stabilization that is applicable to many radius and ulna fractures in small animals. An appropriate knowledge of the anatomy of the antebrachium and careful preoperative planning is essential. This article describes the MIPO technique, which entails stabilization of the fractured radius with a bone plate and screws that are applied without performing an extensive open surgical approach. This technique results in good outcomes, including a rapid time to union and return of function.

Minimally Invasive Osteosynthesis Techniques of the Femur 997
Michael P. Kowaleski

Indirect reduction techniques and carefully planned and executed direct reduction techniques result in maximal preservation of the biology of the fracture site and bone fragments. These techniques, coupled with the use of small soft tissue windows for the insertion of instruments and implants, result in minimal additional trauma to the soft tissues and fracture fragments. Without direct visualization, minimally invasive osteosynthesis (MIO) techniques are more demanding than open reduction and internal fixation; however, the biologic advantages are vast. As such, MIO techniques represent a fascinating new armamentarium in fracture fixation.

Minimally Invasive Plate Osteosynthesis: Tibia and Fibula 1023
Brian S. Beale and Ryan McCally

Fractures of the tibia and fibula are common in dogs and cats and occur most commonly as a result of substantial trauma. Tibial fractures are often amenable to repair using the minimally invasive plate osteosynthesis (MIPO) technique because of the minimal soft tissue covering of the tibia and relative ease of indirect reduction and application of the implant system on the tibia. Treatment of tibial fractures by MIPO has been found to reduce surgical time, reduce the time for fracture healing, and decrease patient morbidity, while at the same time reducing complications compared with traditional open reduction and internal fixation.

Minimally Invasive Repair of Meta-bones 1045
Alessandro Piras and Tomás G. Guerrero

Metacarpal and metatarsal fractures are common injuries in small animals and, in most of the cases, can be treated by minimally invasive techniques. Bone plates applied through epi-periosteal tunnels can stabilize meta-bones. Meta-bones III and IV are stabilized by dorsally applied plates. Meta-bones II and V are stabilized using plates applied medially and laterally. The scarcity of soft tissue coverage and the simple anatomy of meta-bones make these fractures amenable to fixation by using minimally invasive techniques. This practice should reduce morbidity and enhance healing time.
Minimally Invasive Osteosynthesis Technique for Articular Fractures
Brian S. Beale and Grayson Cole

Articular fractures require accurate reduction and rigid stabilization to decrease the chance of osteoarthritis and joint dysfunction. Articular fractures have been traditionally repaired by arthrotomy and internal fixation. Recently, minimally invasive techniques have been introduced to treat articular fractures, reducing patient morbidity and improving the accuracy of reduction. A variety of techniques, including distraction, radiographic imaging, and arthroscopy, are used with the minimally invasive osteosynthesis technique of articular fractures to achieve a successful repair and outcome.

Minimally Invasive Repair of Sacroiliac Luxation in Small Animals
James Tomlinson

Sacroiliac fracture-luxation is a common injury that is associated with ilial and acetabular fractures of the opposite hemipelvis. Sacroiliac fracture-luxation results in an unstable pelvis and potentially collapse of the pelvic canal. A minimally invasive technique for repair of sacroiliac-fracture luxation is a viable option for repair of this injury and has considerable benefits. Reduction and fixation using a minimally invasive technique provides results comparable to an open technique without the associated morbidity of an open technique. Exact screw placement is facilitated by fluoroscopy to make sure that the disk space or vertebral canal is not penetrated yet allows an adequate length of screw purchase in the sacrum.

Percutaneous Plate Arthrodesis in Small Animals
Antonio Pozzi, Daniel D. Lewis, Caleb C. Hudson, and Stanley E. Kim

Arthrodesis is an elective surgical procedure designed to eliminate articular pain and dysfunction by deliberate osseous fusion. A percutaneous approach can be used to perform tarsal and carpal arthrodeses in dogs and cats. Intraoperative imaging facilitates cartilage debridement performed with a burr inserted through stab incisions. The plate is introduced through an epiperiosteal tunnel and secured with screws inserted through the skin insertion incisions. Additional screws can be placed through separate stab incisions. The primary advantage of this technique is a decreased risk of soft tissue complications such as plantar necrosis or wound dehiscence. Preliminary clinical results are promising.