

EXTERNAL SKELETAL FIXATION IN RUMINANTS

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External skeletal fixation (ESF) refers to the stabilization of a debilitating musculoskeletal injury (typically fractures but also joint luxation or tendon rupture) using transfixation pins (or transcortical pins) and any external frame connecting the pins and spanning the region of instability. The goal of ESF is to provide a sustainable, comfortable means to return the patient to weight-bearing (or function) as soon as possible after surgery, to maintain normal joint mobility, if possible, and to provide an optimal environment for osteosynthesis and wound healing.

Although techniques have been available for many years, the use of ESF in human and veterinary surgery has increased dramatically in the last 10 to 15 years. Mechanical limitations of external skeletal fixators include failure of the implants (bending or breaking of the pins), side bars, or clamps because of acute failure or cyclical fatigue. These potential problems have contributed to the slow and cautious adaptation of ESF in large animals. Use of ESF in ruminants has also been impeded by economic constraints. External skeletal fixation is being increasingly used in cattle, sheep, goats, llamas, and alpacas.

SURGICAL TECHNIQUE

Surgical techniques for implantation of orthopedic pins are designed to minimize thermal injury to the surrounding bone, minimize the potential of inducing microcortical fractures during implantation, and maximize bone-implant contact. The effects of thermal injury to bone, independent of orthopedic trauma, have been investigated in rabbits and in human cadaveric bone.^{46, 77} Bone resorption was noted during a 30-day period after exposure to high temperatures.⁴ⁱⁱ At 30 days, 10% bone resorption was induced by exposure to 47°C for 1 minute, and 30% bone resorption was induced by exposure to 50°C for 1 minute or to 47°C for 5 minutes. Drill speed and pin point design contribute to thermal injury to the cortical bone surrounding orthopedic implants.⁷⁷

Hand drilling, medium-speed drilling (300 rpm), and high speed drilling (700 rpm) all induced thermal changes in cortical bone of more than 50°C up to 2-mm distance from the pin. In vivo experiments on the temperature of the tip of the pin on exiting the far cortex of the tibia have been examined in the dog.⁴⁴ In this study, the temperature of the tip of the pin after hand chuck insertion was similar to that with hand drilling (300 rpm) and low-speed power insertion (150 rpm), but was lower significantly than that with high-speed power insertion (1200 rpm). Predrilling beforehand reduced the exit temperature of the pin. Radial preloading of an implant refers to the predrilling of a hole in the bone smaller than the size of the implant in an attempt to reduce the likelihood of thermal or mechanical injury to the bone, but maintaining optimal pin-bone contact. The effect of the disparity between the diameter of the predrilled hole and the diameter of the pin used has been studied.²² A size misfit of less than 0.1 mm did not produce detectable macroscopic fractures in human tibiae. Size misfits of 0.2 mm to 1 mm resulted in creation of macrofractures in 16.7% to 52.6%, respectively, of the specimens examined. Optimal surgical technique may not completely prevent the development of osteolysis at the pin-bone interface. Insertion of the pin, especially threaded implants, disrupts haversian

systems and local nutrient mechanisms within the bone. Therefore, the bone undergoes remodeling adjacent to the implant, Osteoclasts within the affected bone is a natural predecessor to osteogenesis. Mediators of osseous changes include prostaglandins, tissue growth factors, interleukins, and colony stimulating factors. Optimal surgical technique will, however, limit the extent to which the surrounding bone is remodeled and increase the likelihood of osseous tissue replacement of the damaged bone. Based on this research and clinical experience, we recommend predrilling with low-speed power drilling and radial preloading of transfixation pins.

GUIDELINES FOR ESF IN FOOD ANIMALS

The author usually repair fractures of the metacarpus/metatarsus III/IV, radius, ulna, and tibia with the patient in dorsal recumbency and the limb suspended from an overhead frame. Fractures of the humerus and femur are approached with the animal in lateral recumbency. Excessive soft-tissue swelling and inflammation is typical of fractures in large animals. After the animal is clipped and aseptically prepared for surgery, the authors place marker needles (18 gauge, 3.8 cm [1.5 in] for most fractures; 18 gauge, 8.9 cm [3.5 in] for the tibia in adults) at the proposed site for placement of the transcortical pins. Radiograph images are obtained and the pins sites are chosen based on the relationship of the marker needles with the fracture, fissure lines, adjacent joints, and intact cortical bone. A 1-cm incision is made through the skin at the chosen pin site. A hole is then drilled through the bone and another incision is made for the exit site of the pin (for bilateral transcortical pins). We use a pneumatic orthopedic drill with variable speeds up to 700 rpm (Small Air Drill, Synthes, Paoli, PA). Pins are implanted with the drill at low speed. However, standard electric or battery-powered drills may be used after appropriate sterilization. During drilling, the drill bit should be continuously flushed with a sterile isotonic solution to help decrease thermal injury to the bone. Finally, the pin is implanted. A tissue protector, or pin guide, is beneficial to prevent excessive soft-tissue trauma during drilling and implantation.

TRANSFIXATION PINNING AND CASTING: TPC has been used successfully in cattle for fractures of various bones. This adaptation of ESP techniques has the distinct advantage of multiplanar fixation with the placement of transfixation pins limited only by anatomic structures and fracture configuration. Also, TPC allows minimal postoperative case management with a high degree of success. This advantage is particularly suited to food animals. We exclusively use fiberglass casting tape for TPC. We have found that inclusion of metal braces or walking bars is not necessary when using fiberglass casts. Pin position and fixator configuration cannot be adjusted after the cast has been applied when using TPC. Also, open wounds or open fractures are difficult to manage with TPC. Complications during TPC, such as creation of an open fracture or development of cast sores, are difficult to assess and some delay may result before these problems are addressed.

COMPLICATIONS

The most common clinical complications with use of external skeletal fixators are instability at the fracture site, pin loosening, pin tract osteolysis, pin tract infections, implant failure, osteomyelitis, and delayed union or nonunion of the fracture. ESF in ruminants has, most commonly, been performed using cast material as the external supporting frame for the pins (transfixation pinning and casting). Complications of ESF that are not caused by fixator instability are the result of weakening at the level of the bone-pm interface. Transcortical implant

failure seems to result from disruption of the pin-bone interface. Excessive loading of the bone-Implant interface or instability of the initial fixation method results in loosening of the pin. Micromotion results in adverse tissue reaction around the pin, bone resorption, sepsis of the pin tract, discomfort for the patient, and. May cause failure of the fixation attempt. Despite improvements in pm design, surgical techniques, and external frame configuration, pin tract complications are the most serious complication of ESF in orthopedic surgery.