EXOTIC DVM

VOLUME 7
ISSUE 6

CAL RESOURCE FOR CLINICIANS

Care of
Red-eared Sliders

Fracture Repair
in Small Mammals

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EXOTIC DVM
VOLUME 7
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A PRACTICAL RESOURCE FOR CLINICIANS

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External Fixation for Fracture Repair in Small Exotic Mammals

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Orthopedic lesions are common in small exotic mammals such as rabbits, rodents and mustelids (ferrets and skunks). Most lesions are the result of improper handling and restraint, falls from a height, attacks from other animals or injuries secondary to entrapment in cages. Fractures are seen most frequently, usually affecting long bones.

Evaluation of the Orthopedic Patient

One of the most important pieces of historical information is the alleged time elapsed since the injury occurred. If the injury is recent, the animal is considered a trauma patient; therefore, accompanying abnormalities such as shock, the presence of other thoracic and/or abdominal trauma and potential hemorrhage often must be addressed and treated immediately before the definitive orthopedic repair. Conversely, small mammals, especially those with limited owner interaction, may be presented hours, and in some cases days or weeks, after the initial injury has occurred.

With the exception of orthopedic injuries directly impacting the central nervous system (e.g., skull or spinal fractures) or respiratory tract (e.g., severe fractures of the ribs) and/or open fractures, bone and articular lesions do not constitute true emergencies, and the owner must be advised that primary repair may be delayed until the patient is stabilized and possibly until resolution of soft tissue swelling and/or accompanying hematoma.

Fractures of distal limbs are often open due to the lack of significant overlying soft tissue, especially in rabbits and rodents. Open fractures are often hidden by thick fur, which necessitates careful examination, especially in the case of grade I and grade II open fractures (classifications of open fractures are reported in the literature).

Fig 1. Grade III open fracture of the distal tibia in a pet rabbit. The skin wound was not shaved properly, and the open fracture was treated with a green-colored antimicrobial spray. Grade III open fractures are prone to osteomyelitis, and the risk for nonunion or other complications post fixation is high.

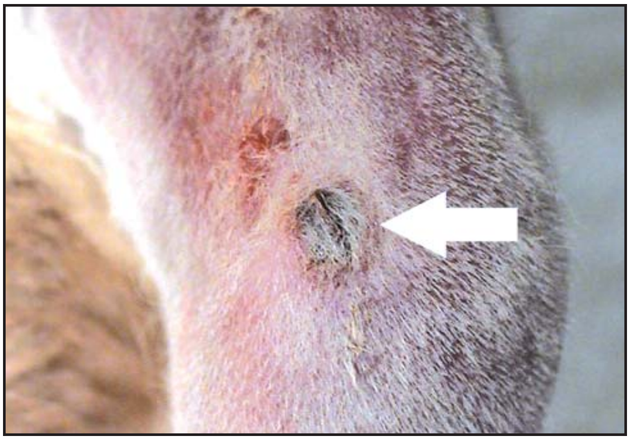


Fig 2. Small skin wounds caused by grade I open fractures are often hidden under fur and are frequently missed, especially in thick-furred rabbits and rodents. Careful shaving of the fur will reveal these lesions.

Open fractures must be managed with strict aseptic technique, even in cases of highly contaminated wounds. Shaving the fur before evaluation of the wound is mandatory.

In unstable trauma patients, survey radiographs of the unanesthetized animal can be performed to rule out other lesions and confirm the presence of fractures. When the patient is stable, complete evaluation of the fracture is performed with a minimum of 2 basic projections (lateral and anterior-posterior [AP]). Due to the difficulty of restraining some small exotic mammals, radiographs may need to be taken with the patient under general anesthesia. Oblique projections may also be helpful in fracture evaluation.

Open fractures must be aseptically bandaged and the limb appropriately splinted until primary repair can be performed. This is not always feasible and depends on the species, body type and fracture location. Strict cage confinement may be the only reasonable option in some cases. Patients are best confined in wireless cages, such as plastic containers, to prevent climbing, further entrapment and damage to the fractured limb. All patients with traumatic wounds should receive appropriate analgesics.

Definitive fracture repair may be achieved through external coaptation, intramedullary (IM) pinning, wiring, plating and external fixation. Only a select few fractures will heal well with external coaptation, which may not be well tolerated by some small exotics. In many cases, IM pinning may not offer enough stability, and bone plating is often not feasible due to the patient size and relatively thin bone cortices. External fixation is reasonably priced, provides excellent stability and is usually well accepted by most small exotic species. This paper focuses on that treatment modality and ways in which external fixation techniques used for small mammals differ from those used in dogs and cats.

The veterinarian who performs orthopedic surgery on exotic mammals needs to know the basic principles of orthopedics in other mammal species; the surgeon must be well versed in the principles of surgical fixation and the use of proper equipment. The clinician must also be familiar with the surgical anatomy and physiology of movement of the exotic species presented for treatment and the differences that need to be considered due to the small size and behavior of these species. If this is not the case, referral to a board-certified specialist in a particular species and/or surgery should be encouraged.

Basic Principles of External Fixation

The main indications for external fixation are open fractures or comminuted or highly comminuted fractures where IM pinning is not feasible, because this method of fixation allows stability without involving the fracture site. In general, external fixation allows proper stabilization against all forces acting on bone fragments in 3 dimensions: latero-lateral and craniocaudal bending forces as well as rotational forces. These advantages are particularly important in small mammals, where postoperative control of excessive movement is much more difficult than in dogs and cats.

Shaving of fur and surgical scrubbing must be performed carefully in rabbits and rodents in order to avoid damage to the thin delicate skin in these species. Excessive scrubbing can lead to severe dermatitis, which can result in postoperative complications. The author prefers the use of 1% chlorhexidine and saline for presurgical preparation.

The surgeon must have an excellent knowledge of surgical anatomy and understand the anatomic differences among species. Pins must be inserted into bones in such a way as to minimize negative impact on soft tissues (e.g., blood vessels and nerves) and prevent interference with the body wall (Table 1).

For example, due to the normal physiologic hyperflexed position of the hindlimb in rabbits and chinchillas, a unilateral external fixator is better placed on the lateral aspect of the tibia rather than the medial surface where it can interfere with the lateral abdominal wall and the genitalia of male animals.

Depending on the bones affected and the features of the fracture, closed or open reduction can be performed.

Table 1. Proper Sites of Pin Insertion

Femur	Lateral aspect
Tibia	Medial aspect
Humerus	Craniolateral aspect
Distal radius and ulna	Craniolateral aspect
Proximal radius and ulna	Craniolateral aspect
Mandible	Lateral aspect

BASIC PRINCIPLES OF PROPER PIN INSERTION

- Pins should be inserted through at least 2 bone cortices and, ideally, at an angle of 70° relative to the longitudinal axis of the bone (Fig 3a). This increases pin resistance compared to pin insertion perpendicular to the bone axis.
- Proper pin size in small exotic mammals should not exceed 30% of the bone diameter, which necessitates the use of pins with a diameter often as small as 0.8-1.5 mm. Kirschner wires, or pins, can be smooth or threaded. Threaded pins are much more secure and unlikely to loosen during the postoperative period.
- Pin insertion should be accomplished using a low-speed power drill (about 350 rpm) rather than a hand chuck. Hand-driven pins tend to produce an oval-shaped insertion site, which increases the risk of pin loosening. The risk of thermal injury to cortical bones with a drill is less than the risk of excessive forces applied with a hand chuck. However, in very small exotic mammals where the weight of the power drill alone can produce excessive movement of the entire limb (or the entire patient!), a hand chuck may be useful.
- Pins should be inserted along a single plane to allow connection with a single external rod. A unilateral connecting bar configuration is most frequently used in small exotic animals, but bilateral configuration may occasionally be preferable. With the latter configuration, 2 pins (the distal of the proximal fragment and the proximal of the distal fragment) may not be connected to the contralateral bar. Pins used as connecting bars are usually 2.0 mm in diameter. Polymethylmethacrylate (PMMA) can be used to connect pins to bars or used alone to fashion versatile and lightweight connecting bars. Alternatively, a system using miniature lightweight pins and clamps may be used (see Figs 6-13).
- Ideally a minimum of 3 pins should be inserted in each bone fragment. However, insertion of more than 2 pins per fragment is often impossible in small exotic mammals.
- Maximum stability is accomplished by inserting pins proximally and distally in each fragment while avoiding the fracture site. Pins placed too close to the epiphysis (and too far from the fracture site) often result in insufficient stabilization of bone fragments.
- External fixation can be used in conjunction with other methods of fixation (e.g., IM pins, screws or cerclage wires) (Fig 3b). The most common combined technique is external fixation with IM pinning using a previously described tie-in technique.[1] Since in this configuration the goal of the external fixator is to provide antirotational stability, a single pin per fragment is considered by the author to be adequate.

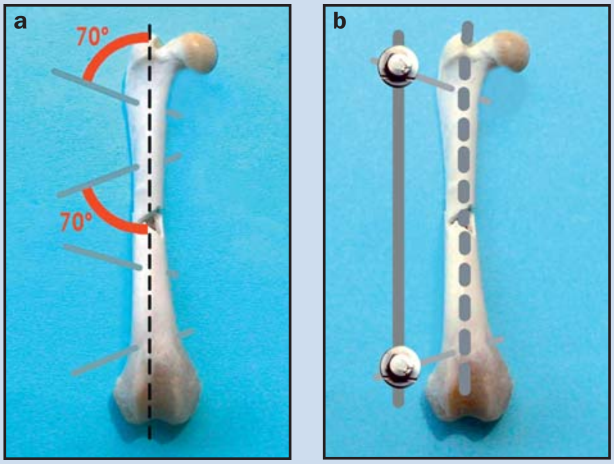
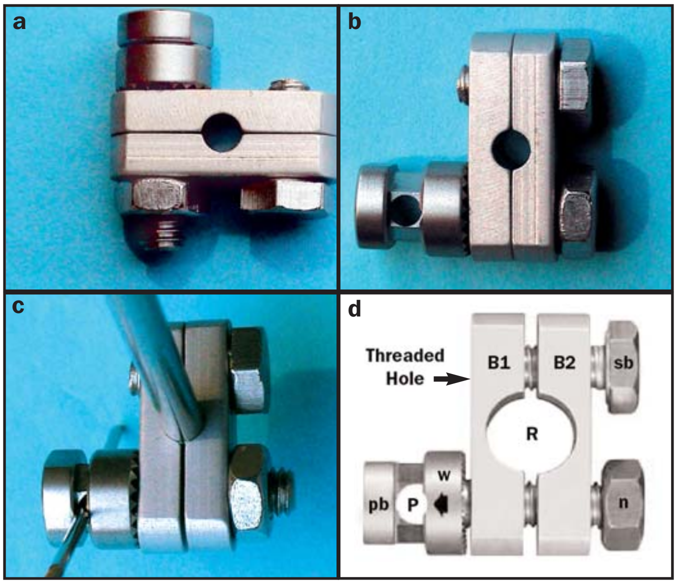


Fig 3 a) Pins should be inserted through at least 2 bone cortices and, ideally, at an angle of 70° relative to the longitudinal axis of the bone. **b)** With the external fixator providing rotational stability, a single pin per fragment is considered adequate.

The IMEX SK™ External Skeletal Fixation System

Fig 4. The Miniature IMEX Interface Fixation Half-Pins are threaded Kirschner wires with trocar points on both the smooth and threaded ends. The central area of the pin shank is roughened to improve the interface with methymethacrylate, which is often used in conjunction with this system.



Figs 5a-d. The aluminum clamp body is comprised of two different parts (B-1 and B-2). Each has a pair of holes, the lower one to receive the primary pin-gripping bolt (pb) and the upper one to receive the secondary bolt (sb). None of these holes has threads except for the secondary bolt hole in B-1 body part. The large rod-gripping channel (R) is in the center of the clamp. The primary pin-gripping bolt (pb) has a washer with a slot or meniscus (arrow), which enables a wide range of pin diameters to be securely gripped by the clamp. The clamp is tightened by the secondary bolt and by a nut (n) on the primary pin-gripping bolt.

Insertion of Pins and Positioning of Clamps

IMEX threaded pins (1.2-mm) and mini clamps were used to construct a lateral, unilateral 2+2 pin configuration to repair a complete fracture of the femoral shaft of a 1.0-kg ferret.

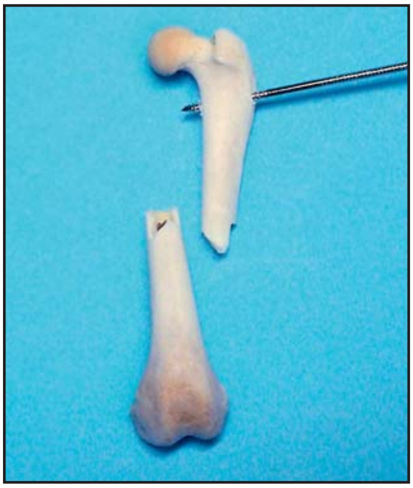


Fig 6. The first pin is inserted through the lateral and medial bone cortices in the proximal end of the proximal bone fragment.

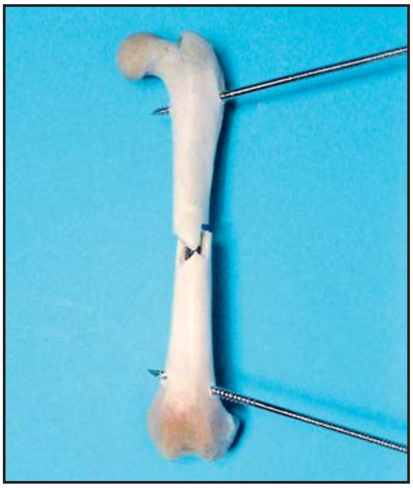


Fig 7. The fracture is reduced, and the second pin is inserted at the distal end of the distal bone fragment. These 2 pins must be inserted on the same plane of the femoral shaft.

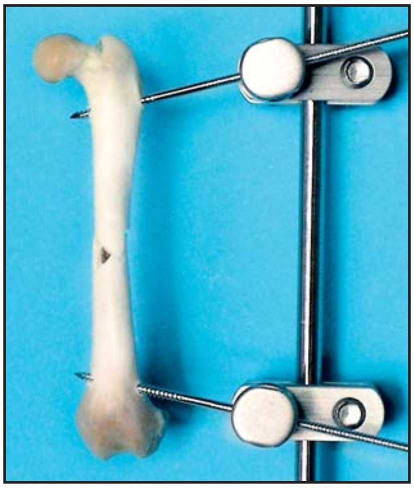


Fig 8. Each of the 2 pins is connected to the rod with a clamp. Primary stabilization of the fracture is thus accomplished, allowing insertion of the other 2 pins.

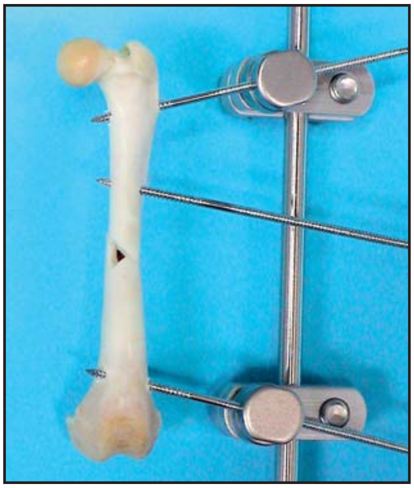


Fig 9. The third pin is inserted at the distal end of the proximal fragment but not too close to the fracture site. The rod helps to insert the pin on the same plane as the other 2 pins.

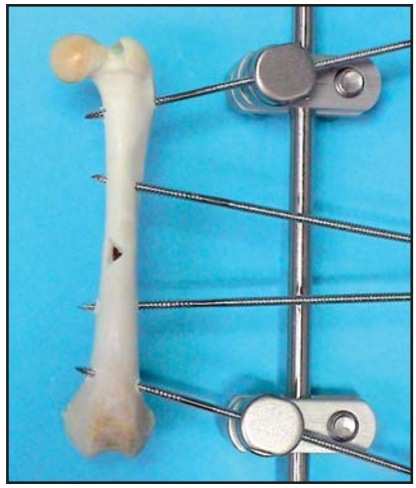


Fig 10. The fourth pin is inserted at the proximal end of the distal fragment, again leaving distance between the pin and the fracture site.

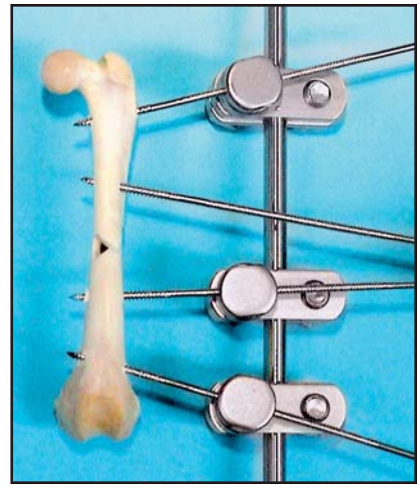


Fig 11. Another option is to pre-place the center 2 clamps, which will then facilitate placement of the outer pin in the same plane.

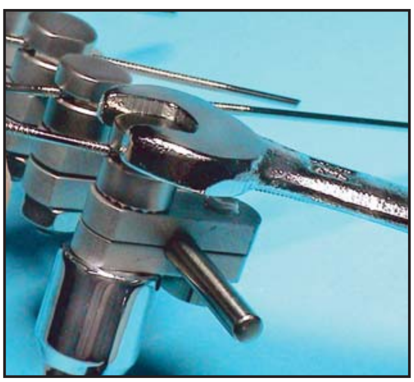


Fig 12. The pin-gripping bolts and accompanying nuts, which attach the KE wires to the connecting bar(s), are tightened using a 7-mm wrench.

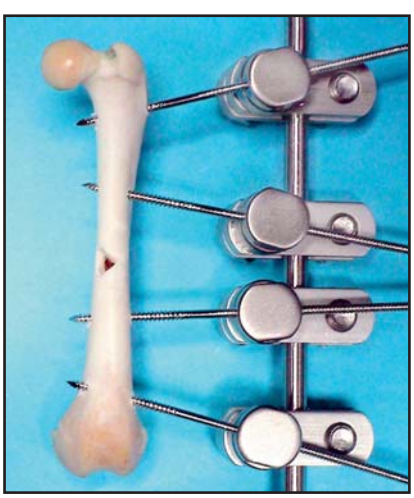


Fig 13. The configuration is complete and the fracture properly stabilized.

Common Fractures in Pet Rabbits

Fractures of the Tibia and Fibula

The most common fractures of pet rabbits are fractures of the hind limb, particularly fractures of the tibia and fibula. These fractures usually occur when the foot becomes trapped in the cage or while the animal is running on smooth surfaces such as indoor flooring. Diagnosis of complete fracture of the tibia is straightforward due to the resultant lameness and foot deviation.

Fig 14. Comminuted, distal metaphyseal fracture of the tibia and fibula. Lateral (a) and AP (b) projections. Comminuted fractures of the tibia are common, especially those involving the distal leg. Highly comminuted fractures usually occur when the rabbit has been stepped on rather than dropped or trapped. The short distal fragment makes fixation of these fractures challenging.

Fractures of the Femur

Fig 15. Femoral fractures in pet rabbits usually occur after a fall or when the rabbit is inadvertently stepped on. Shown is a short oblique, interdigitating fracture of the shaft of the femur, lateral projection.

Fig 16. Highly comminuted, intercondylar femur fracture. Lateral (a) and AP (b) projections. Both radiographic views are necessary to diagnose intercondylar fractures. These articular fractures require early and exact fixation to heal properly.

Fig 17. This 5-month-old rabbit had a spiral oblique fracture of the proximal metaphysis of the femur, which occurred secondary to metabolic bone disease. Note the very thin cortices of the distal femur and the proximal tibia (arrows). Fracture repair is particularly difficult in the presence of underlying metabolic bone disease, as the bone cortices are often too fragile to allow pin insertion. In most cases, fixation by splinting or simple cage rest are the only options, although bone cement has been used to augment repair in some cases.

Fractures of the Radius and Ulna

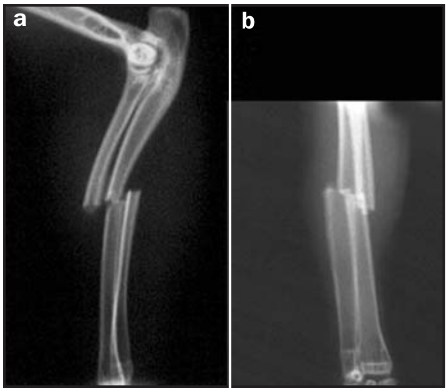


Fig 18. Fractures of the radius and ulna in pet rabbits usually occur as a result of improper handling (e.g., when the rabbit is lifted by the forelimbs) or when the animal jumps down or falls from a height. Shown is a transverse fracture of the diaphyses of the radius and ulna. Lateral (a) and AP (b) projections.

Fractures of the Humerus

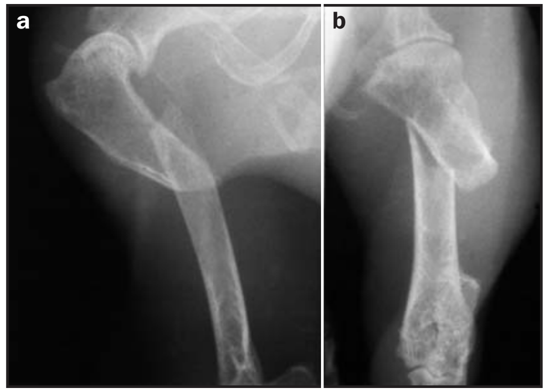
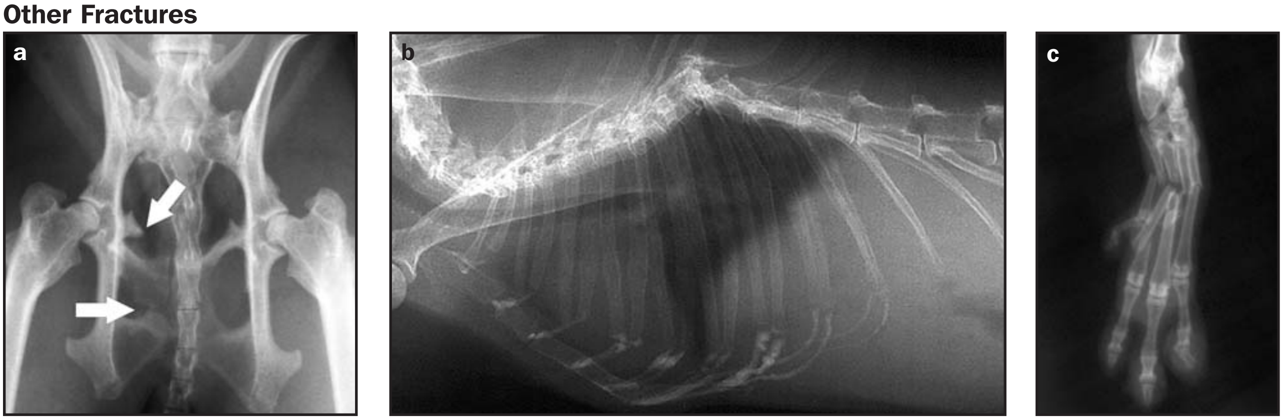


Fig 19. Humeral fractures in pet rabbits usually occur after a fall from a height or other blunt trauma. Patients should always be checked for the presence of thoracic trauma. Shown is a proximal metaphyseal, short oblique spiral fracture of the humerus. Lateral (a) and AP (b) projections.

Other Fractures



Figs 20 a,b,c. Many other types of fractures commonly occur in pet rabbits. Some are difficult, if not impossible, to repair surgically; fortunately, many will heal well without surgical intervention. Shown are fractures of the pubis and ischium (arrows) (a); a comminuted, overriding T8 vertebral body fracture (b) and fractures of the 4 metatarsal bones (c).

Case Report

Fig 21. A 2-year-old, 1.3-kg male rabbit was presented with pronounced lameness of the right hindlimb and abnormal movement of the foot. Lateral (a) and AP (b) radiographic projections revealed a highly comminuted, short oblique, diaphyseal fracture of the tibia and segmental fracture of the fibula.

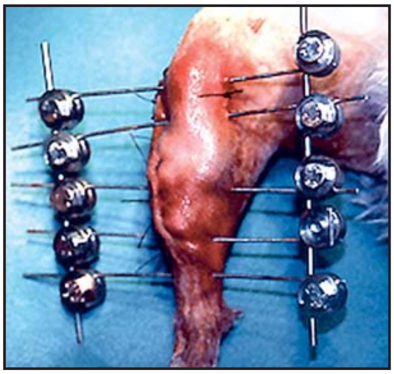


Fig 22. A Type 2 full, monoplanar bilateral, 5-pin, external fixator was placed with three 1-mm smooth pins in the proximal fragment and two in the distal fragment. The pins were inserted parallel to each other. The external fixator was constructed using 10 clamps. In this image, the skin appears red and inflamed due to overzealous scrubbing with concentrated povidone iodine and alcohol. The delicate skin of rabbit and rodents must be scrubbed very gently; the preferred scrub is 2% chlorexidine without alcohol.

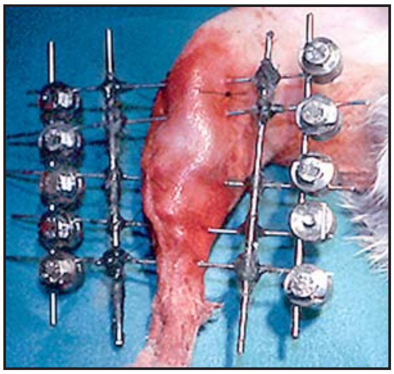


Fig 23. The bar clamps were then removed in favor of bars connected with lighter polymethylmethacrylate (PMMA). The initial clamps were placed far from the leg to allow room for the final connecting bars. The reason for this 2-step process is that in very small mammals (e.g., chinchillas), reduction and stabilization of the fracture can be difficult to maintain as the PMMA hardens. Once the metal connecting bars have been used for stabilization and the PMMA has been placed, the heavier metal bars are removed.

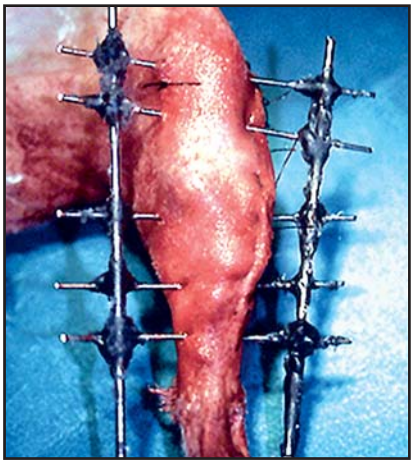


Fig 24. The definitive external fixator after the removal of the temporary external bars.

Fig 25. The external fixator was padded with cotton and a conforming bandage. The abdominal wall must be protected from the medial aspect of the metal bar and pins.

Fig 26. Radiographic appearance of the fracture after surgery. The most distal pin in the proximal fragment (arrow) has been placed too close to the fracture site.

Fig 27. At 18 days post surgery, skin inflammation is minimal, and the hair is beginning to regrow.

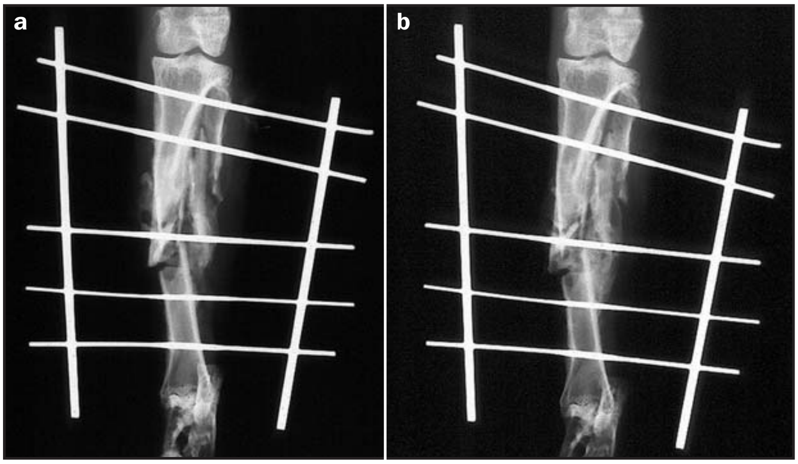


Fig 28. Two AP views show the radiographic appearance 17 days (a) and 40 days (b) post surgery. Obtaining a true lateral projection can sometimes be difficult due to the position of the external fixator). Bone healing at the fracture site is poor in Fig 28a; improper position of the third pin may have contributed to this. Exuberant calcification of the comminuted fragments and periosteal reaction of the caudolateral tibia is occurring in (a), which is beginning to bridge the fracture site and will result in clinical union in (b).

Common Fractures in Pet Rodents

The most common fractures in pet rodents are fractures of the tibia and fibula. Distal epiphyseal fractures are also common in hamsters. Similar to rabbits, these usually occur when the foot is trapped in cage wiring. Clinical signs of lameness may not be easily detected by the owner, especially in hamsters. It is not uncommon to diagnose an old fracture long after the bone has healed.

Figs 29 a,b. This chinchilla sustained a segmental metaphyseal fracture of the tibia and fibula. The proximal fracture is transverse and nondisplaced; the distal fracture is a comminuted transverse fracture with minimal displacement. Lateral (a) and AP (b) projections.

Case Report

Fig 30. A 1-year-old male chinchilla was presented for right hind limb lameness. Physical examination revealed a probable midshaft fracture of the tibia and fibula. Careful shaving of the fur (inset) ruled out an open fracture, which is common in fractures of this segment of the hind limb.

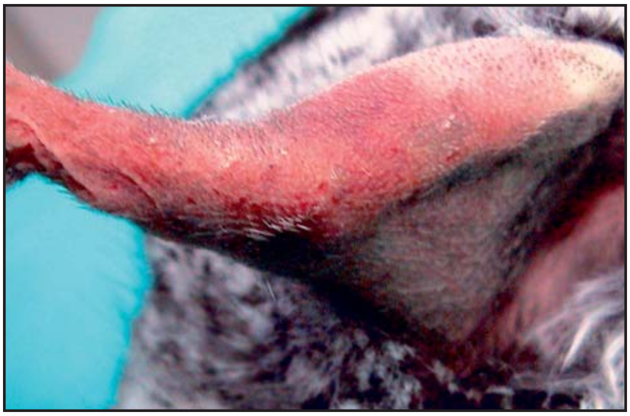


Fig 31. The tibial fracture produces abnormal lateral deviation of the distal limb, which is more obvious when the entire limb is shaved prior to surgery.

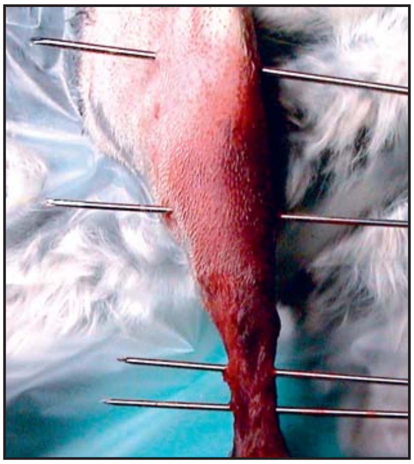


Fig 32. Two smooth 1-mm pins are inserted in the proximal and distal fracture fragments in preparation for placement of a full, Type 2 uniplanar external fixator. Although 3 pins may have fit in each bone segment, the author believed that a 2+2 pin configuration would be sufficient for this small species, because 1) pins used in small mammals are proportionately larger; 2) there may not have been enough room for the drill if pins were placed too closely together; and 3) a relatively rigid external fixator (such as a 3+3 or an oblique 3+2 or 2+2) could lead to delayed union or nonunion.

Fig 33. While the fracture is maintained in proper reduction, a rubber tube used for intravenous infusion of fluids is inserted along the trocar points of the pins. Another 1-mm pin is inserted into the rubber tube to enhance the strength of the external bar, which will be filled with PMMA. The core pin may not be necessary and may prevent complete filling of the tube with PMMA if the tube is very small.

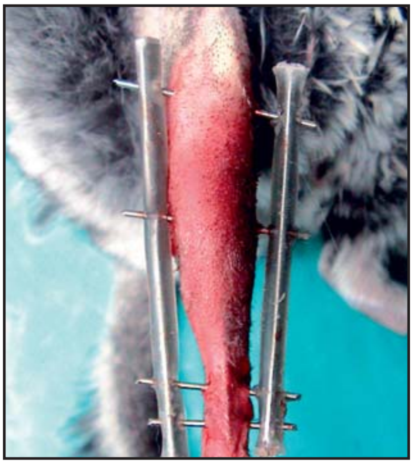


Fig 34. Freshly mixed, fluid PMMA is injected into the rubber tube around the pins. The hardened material provides an effective light external rod. The same procedure is repeated on the medial side to complete the full configuration.

Fig 35. Postoperative radiograph. The tibial fracture is properly aligned in the AP projection.

Fig 36. This photograph, taken 5 days after surgery, shows the chinchilla regularly using the right hind limb, which appears slightly externally rotated due to interference from the medial bar of the external fixator. Usually an E-collar is not necessary, as most chinchillas do not attempt to chew on the external fixator.

Fig 37. Radiograph taken 6 weeks post surgery. Excellent bone healing is visible at the fracture site.

Fig 38. Radiographic appearance soon after removal of the external fixator. Note the visible pin tracts, which will fill in with new bone relatively quickly after the device is removed.

Common Fractures in Pet Ferrets

Fig 39. Shown is a transverse femoral neck fracture. Similar to the case in most dogs and cats, this orthopedic lesion is best treated with excision of the femoral head and neck rather than fixation.

Fig 40. Fractures of the forelimb are very common in ferrets, especially following falls from a height. Fractures of the radius and ulna are more frequent than humeral fractures. Transverse, midshaft fractures of the radius and ulna, lateral projection.

Fig 41. Transverse fracture of the olecranon process, lateral projection. This intra-articular fracture is highly displaced and requires early, exact fixation for the elbow joint to be functional. Repair is best accomplished by pin and tension band wiring.

Case Report

Fig 42. A 1.6-kg, 11-month-old male ferret was presented for pronounced lameness of the right hind limb that was apparent soon after a fight with a cat. The lateral projection revealed a proximal third, short oblique femur fracture. In male ferrets, the well-developed os penis may interfere with visualization of femoral fractures in the lateral projection. A transverse, nondisplaced (in the lateral view) proximal metaphyseal fracture of the tibia was also present. This fracture was partially stabilized by the intact fibula.

Fig 43. The patient is aseptically scrubbed and draped for surgery. The swelling of the thigh is secondary to hematoma formation, muscle swelling and overriding bone fragments of the fracture.

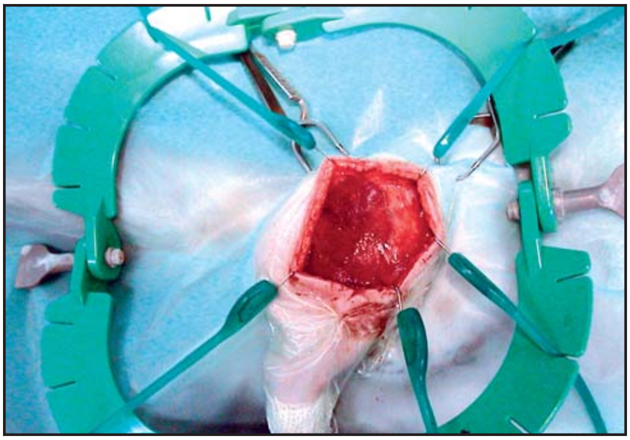


Fig 44. The Lone Star Retractor is extremely useful in small exotic orthopedic procedures.

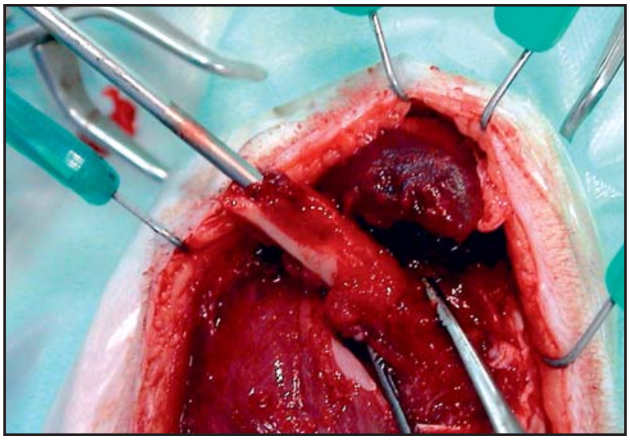


Fig 45. Intramedullary pinning and placement of an external fixator were used in combination; this is referred to as a "tie-in" technique. A 2-mm pin was inserted into the medullary cavity from the proximal end of the distal femoral fragment to confirm suitable pin length prior to definitive placement.

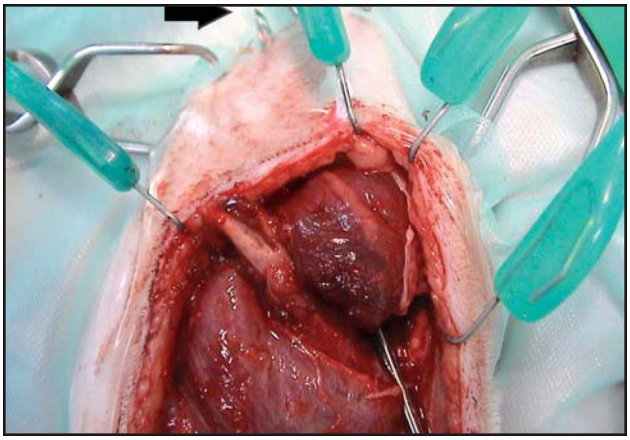


Fig 46. The pin is driven retrograde into the proximal fragment, exiting through the trocanteric fossa (arrow) then removed. The author believes this technique is relatively easier than driving the pin anterograde from the trocantheric fossa. However, the surgeon must take care not to interfere with the sciatic nerve lying medial to the pin's exit site.

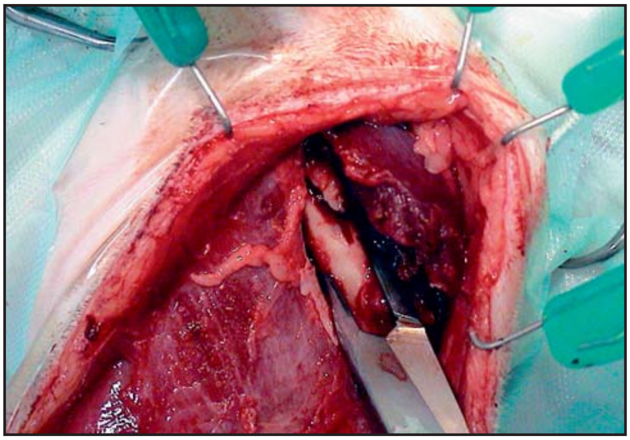


Fig 47. The fracture is reduced and the IM pin is inserted normograde into the trochanteric fossa through the pre-prepared track and into the distal femoral segment. While repeatedly driving and removing an IM pin may create a loose pin tract, a hole (sometimes made with a smaller bit) can be pre-drilled once.

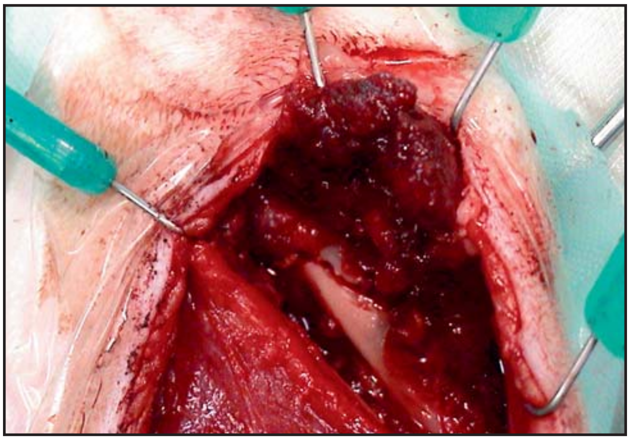


Fig 48. The fracture is properly reduced, but the IM pin is not sufficient to counteract rotational forces that could lead to nonunion. Prevention of these forces must be considered very carefully in mammals where it is more difficult to limit postoperative activity.

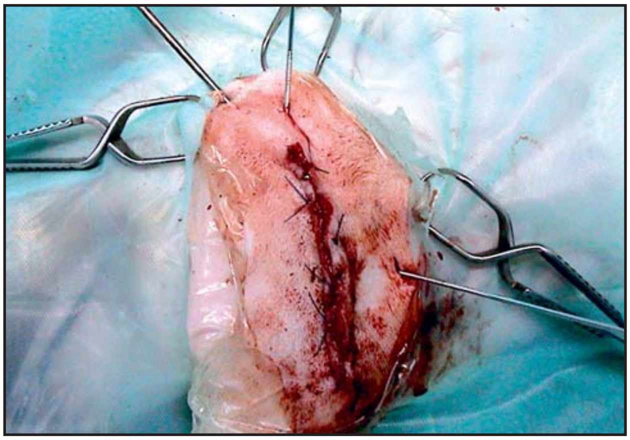


Fig 49. One 1.2-mm threaded external fixation pin is placed in each fracture fragment.

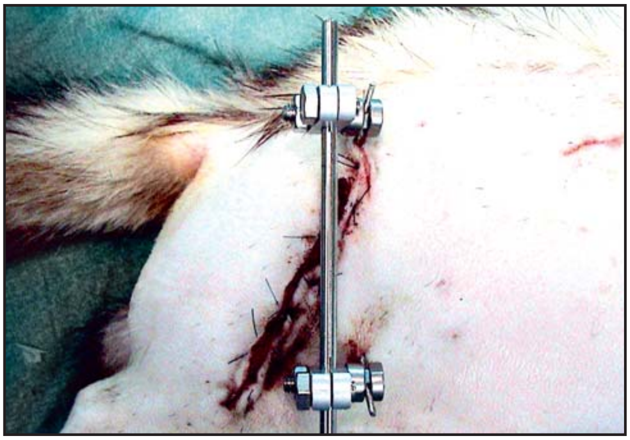


Fig 50. Two mini SK clamps and a 3.2-mm rod are placed to build up a 2-pin, monoplanar (half) configuration. When the goal of the external fixator is simply to counteract rotational forces, it may not be necessary to adhere to the basic principle of 2 pins per bone segment. However, additional pins could increase stability of the fracture.

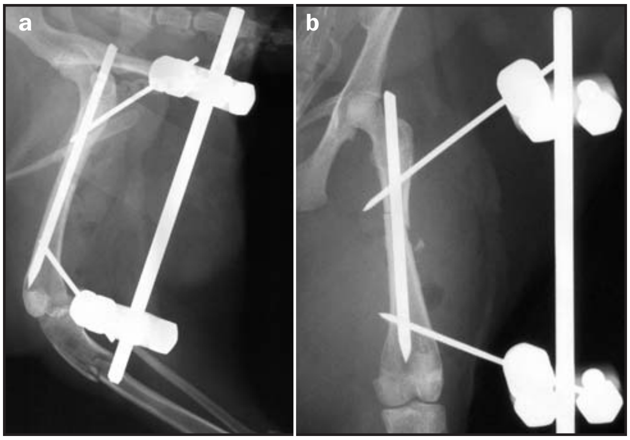


Fig 51. Lateral a) and AP b) radiographic projections post surgery.

Fig 52. The external rod has been covered and protected with cotton and a conforming bandage; however, if sharp pin points are not present, coverage of the external fixator may not be necessary. Application of an Elizabethan collar was not necessary.

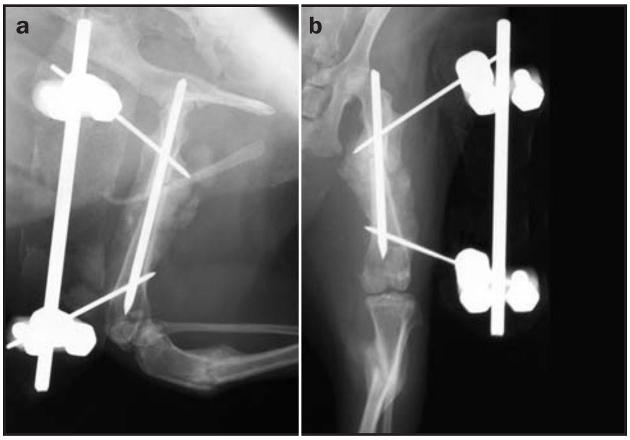


Fig 53. Bone healing is clearly visible in these lateral (a) and AP (b) projections taken 5 weeks post surgery. Marked periosteal calcification is noted, which is not uncommon in young animals. The tibial fracture appears mostly healed with moderate valgus displacement. This did not appear to affect locomotion.

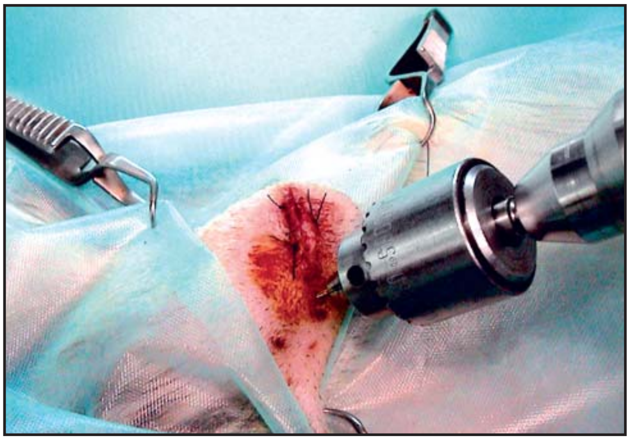


Fig 54. Both the IM pin and the external fixator were removed, but the former is not always necessary. Because the pins are threaded, they must be extracted using a power drill or hand chuck.

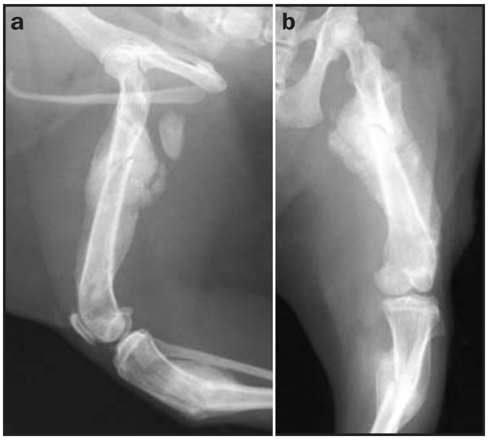


Fig 55. Radiographic appearance after removal of all implants.

Case Report

Fig 56. Radiographs show a proximal third, short spiral oblique metaphyseal femoral fracture in a 1.0-kg, 3.5-year-old ferret.

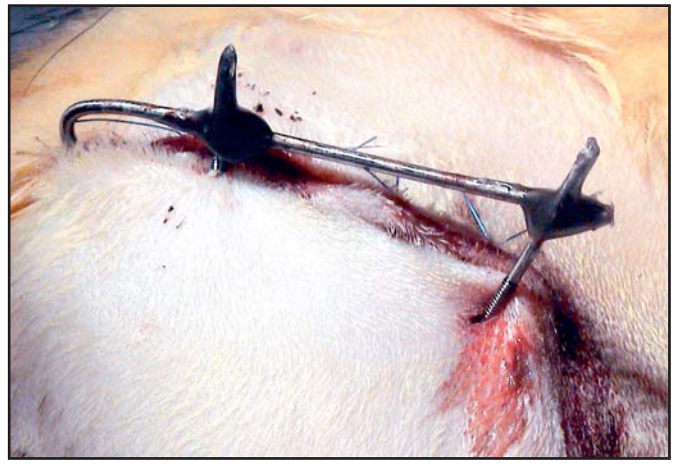


Fig 57. The fracture has been repaired using a 1.5-mm IM pin and 2 smooth antirotational external fixator pins with the "tie in" technique. Ideally, more than 1 pin would be used in each of the bone fragments.

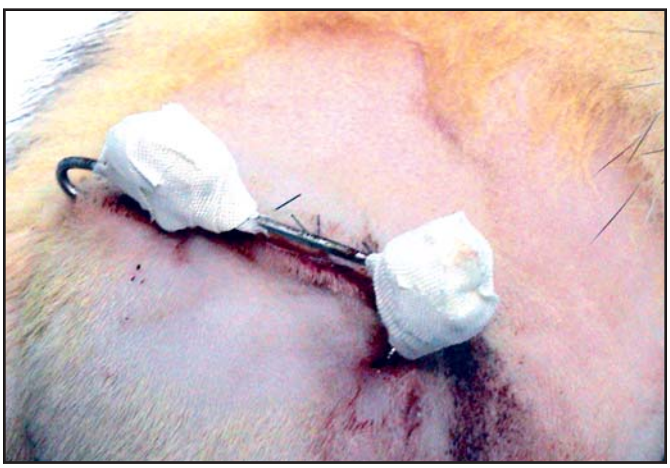


Fig 58. The 2 external pins are connected to the bar using polymethylmethacrylate.

Fig 59. Radiographic appearance post surgery. The external fixator bar is farther from the leg than is ideal.

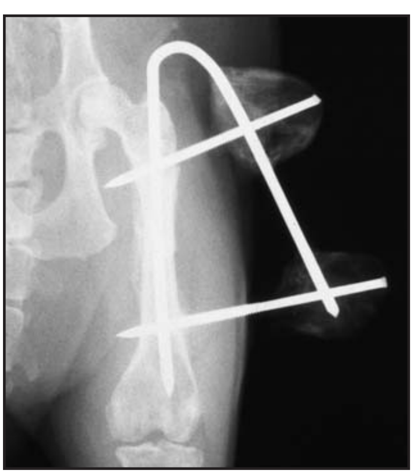
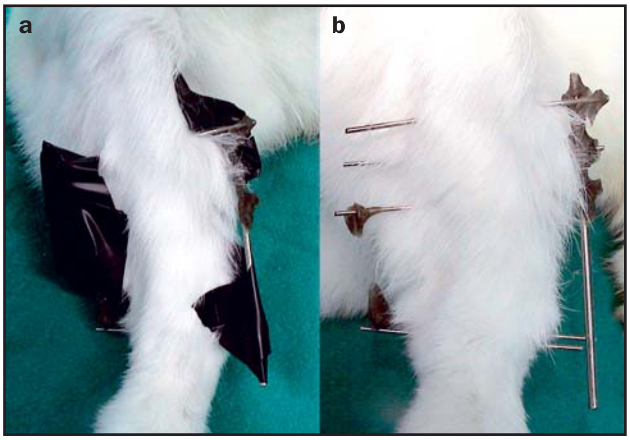


Fig 60. Radiographic appearance 45 days after surgery. Bone healing is visible at the fracture site.

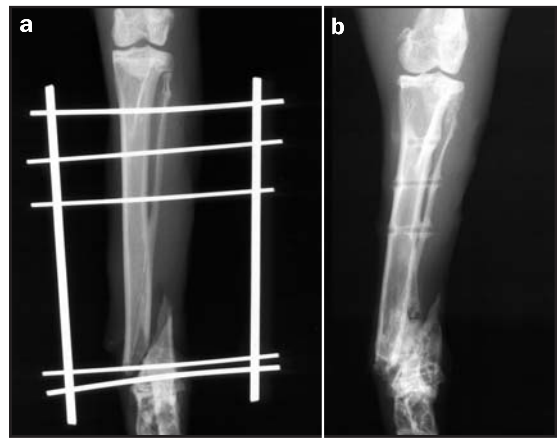
Fig 61. Radiograph after removal of both the IM pin and external fixator device, lateral (a) and AP (b) projections.

Complications

The most common complications of external fixation are similar to those experienced in non-exotic mammals. They include pin tract osteomyelitis, self trauma to the device, soft tissue injuries from the device acting on other body sites (e.g., a medial bar interfering with soft tissue overlying the abdomen), premature removal or loosening of the device, pin tract fractures, fracture of an associated bone due to weight of the device or the device catching on furniture or cage bars, delayed union and nonunion. Proper confinement and covering the device can help reduce the incidence of many of these complications.



Figs 62a,b. Adequate postsurgical recheck examinations are extremely important. In this case involving a 6-year-old, 1.3-kg rabbit with a distal tibial fracture, loosening of the medial rod (a) was hidden when the owner covered the fixator with duct tape. Rod loosening can irritate the abdominal skin and wall, and subsequent disconnection of the distal pins on the lateral aspect can render fixation completely ineffective.



Figs 63a,b. Inadequate stabilization is usually a consequence of loosening of the pins and rod, which can result in delayed union, nonunion or breakdown of the healing fracture site. When a fragment is very short, and/or the fracture plane is oblique, as seen in this short oblique, distal tibial fracture, the initial stabilization can be lost. Because of inadequate stabilization, the bone is attempting to heal as a malunion, which may alter function of the limb. If the fracture does not heal completely, a nonunion is the result.

References and Further Reading

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