67

Fracture Repair in Exotics Using Internal Fixation

Mitchell Bush, DVM
James L. Hughes Jr, MD
Philip K. Ensley, DVM
A. Everette James Jr, ScM, MD

Introduction

The aim of internal fixation of fractures is to rigidly immobilize the involved osseous structures in order that primary osseous union can occur in association with an approximation of normal physiological function of the affected limb. If this objective is accomplished in an ideal manner, complications such as muscle atrophy and limitation of joint motion are minimized. Theoretically, the use of internal fixation for fractures in exotic specimens is desirable and a number of methods of internal fixation for these problems have been attempted. Due to the wide variety of species involved and the variation in patient size in association with the technical problems of anesthesia and aftercare, operative intervention in order to effect internal fixation has created many challenges. This report, while discussing certain general principles, specifically deals with the use of ASIF bone plates in the African lion (*Panthera leo*), timber wolf (*Canis lupus*), rhea (*Rhea americana*), and greater kudu (*Tragelaphus strepsiceros*). These principles will be illustrated by clinical examples.

Undiagnosed trauma occurred to three yearling lions that were in an open exhibit at a drive-through park. The animals were referred to the National Zoological Park for diagnostic evaluation. Surgery was performed on all the lions within 18 hours of injury. Anesthesia for surgery was induced with 300 mg tiletamine hydrochloride and zolazepam[a] IM, and the lions were intubated and placed on a semi-closed anesthesia machine using halothane[b] and nitrous oxide.

Doctors Bush and Ensley are from the Office of Animal Health, National Zoological Park, Smithsonian Institution, Washington, DC 20009, where Dr. Bush is Head of the Office of Animal Health. Dr. Hughes was from the Department of Orthopedic Surgery and Dr. James was Director of Laboratory Radiological Research, Johns Hopkins Medical Institutions, Baltimore, Maryland 21205. Dr. Hughes is presently Chief, Amputee-Problem Fracture Service, Orthopedic Surgery, Mississippi Methodist Rehabilitation Center, Jackson, Mississippi 39216. Dr. James is presently professor and chairman, Department of Radiology, Vanderbilt University Medical School, Nashville, Tennessee and a consulting radiologist for the National Zoological Park, Smithsonian Institution.

Case Histories

Cases 1 and 2: Two eight-month-old female lions were observed to develop almost simultaneous acute lameness in the left rear leg. Both were sedated with 175 mg of tiletamine hydrochloride and zolazepam. Palpation of the fibular tarsal bone suggested a fracture. Radiographs confirmed this finding (Fig. 1a).

Fixation of both fracture sites was accomplished by using a cancellous bone screw with a washer placed in by lag screw fashion. A four-hole bone plate was placed on the plantar surface of the fibular tarsal bone as a neutralization plate (Fig. 1b).

[a] CI-744, Parke, Davis & Company, Detroit, MI 48232.
[b] Fluothane, Ayerst Laboratories, Inc., New York, NY 10017.

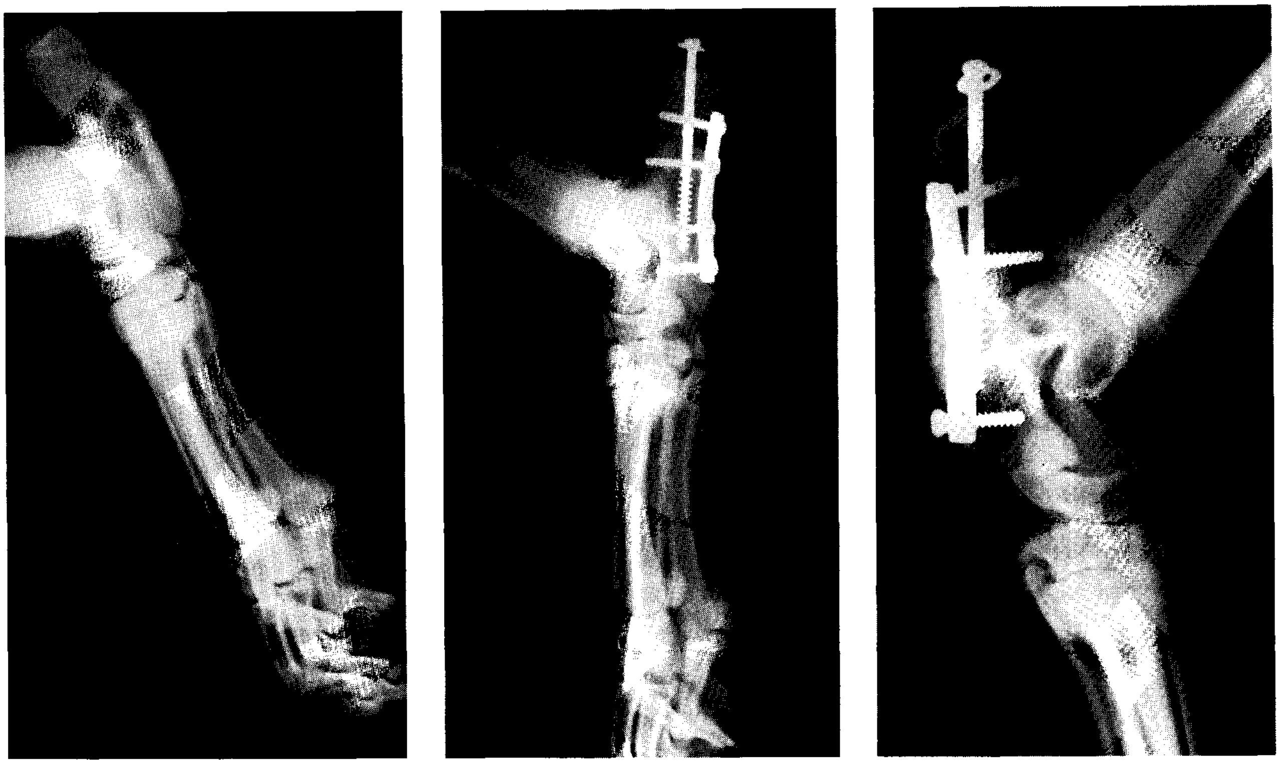

Fig. 1a— Lateral view of the hock of an African lion (*Panthera leo*) with a fractured fibular tarsal bone.

Fig. 1b— Surgical repair of the fractured fibular tarsal bone of the lion.

Fig. 1c— Three-month postoperative radiograph. There is some loosening of the screws and periosteal reaction present, but the fixation was clinically solid and the leg functional.

Following surgery, the postoperative course of both lions was similar. They received postoperative oral chloramphenicol[c] (1.5 gm twice a day for two weeks). Both had good weight-bearing capability on the affected leg in two and one half to three weeks. The function of these limbs returned to normal in eight weeks. Reevaluation at eight months following surgery showed no lameness present.

Postoperative radiographs at three months in one case showed demineralization around the prosthesis as evidence of some screw loosening and periosteal reaction (Fig. 1c). The lag screw on one lion was broken but the plate remained in place. Closer observation of the postoperative radiographs in both lions showed the original fracture sites. This resulted from slight misplacement of bone screws through the fracture site. In spite of this, the fracture sites were clinically solid and both lions have functional legs with no noticeable limitation in locomotion.

Case 3: One of the above female lions, 11 weeks after the initial fracture, sustained an additional fracture to the right tibia. The origin of this fracture also was uncertain. The lioness was anesthetized with 225 mg tiletamine hydrochloride and zolazepam. A temporary splint was placed on the leg and the animal was transported for radiographs and surgery. The radiographic findings were an oblique comminuted distal tibial fracture and a fibular fracture (Fig. 2a).

The fracture site was immobilized with two neutralization plates, one on the anterior surface and one on the lateral surface of the tibia (Fig. 2b). The lion was placed on oral tetracycline, 1 gm twice a day for three weeks. She was bearing weight on the leg in three days. A small opening occurred at the surgery site but healed well as an open wound. The animal had no locomotion problem after eight weeks.

[c] Chloromycetin, Parke-Davis & Company, Detroit, MI 48232.

Fig. 2a— Anteroposterior radiograph of an African lion (*Panthera leo*) with a comminuted fracture of the distal right tibia 11 weeks following the fractured tarsal bone.

Fig. 2b— Anteroposterior postoperative radiograph of the fractured tibia repaired with two neutralization bone plates.

Case 4: An eight-month-old male lion was found down in the hind quarters after being chased by an older male in the pride. The animal appeared to be in pain and was very reluctant to initiate motion. Following immobilization with 200 mg of tiletamine hydrochloride and zolazepam, palpation suggested bilateral tibial fractures. Temporary splints were placed on the legs and the lion was transported to obtain radiographs and surgery. The radiographic findings were bilateral proximal tibial and fibular fractures (Fig. 3a).

Surgical fixation for both fractures included one compression plate and one neutralization plate for each fracture site, one plate on the lateral surface and one on the medial surface of the tibia (Fig. 3b). Cancellous screws were used to secure the proximal end of the bone plate to the tibia. The lion had a wound dehiscence on the 14th postoperative day on the left leg that was resutured. He received oral chloramphenicol for eight weeks postoperatively and injectable gentamicin[d] 250 mg daily for two weeks following surgery. This lion was very reluctant to move for two weeks, but progressively improved and at five months postoperatively had no noticeable limp.

The postoperative radiographs at four months in both tibias showed moderate callus formation around

[d] Gentocin, Schering Corp, Bloomfield, NJ 07003.

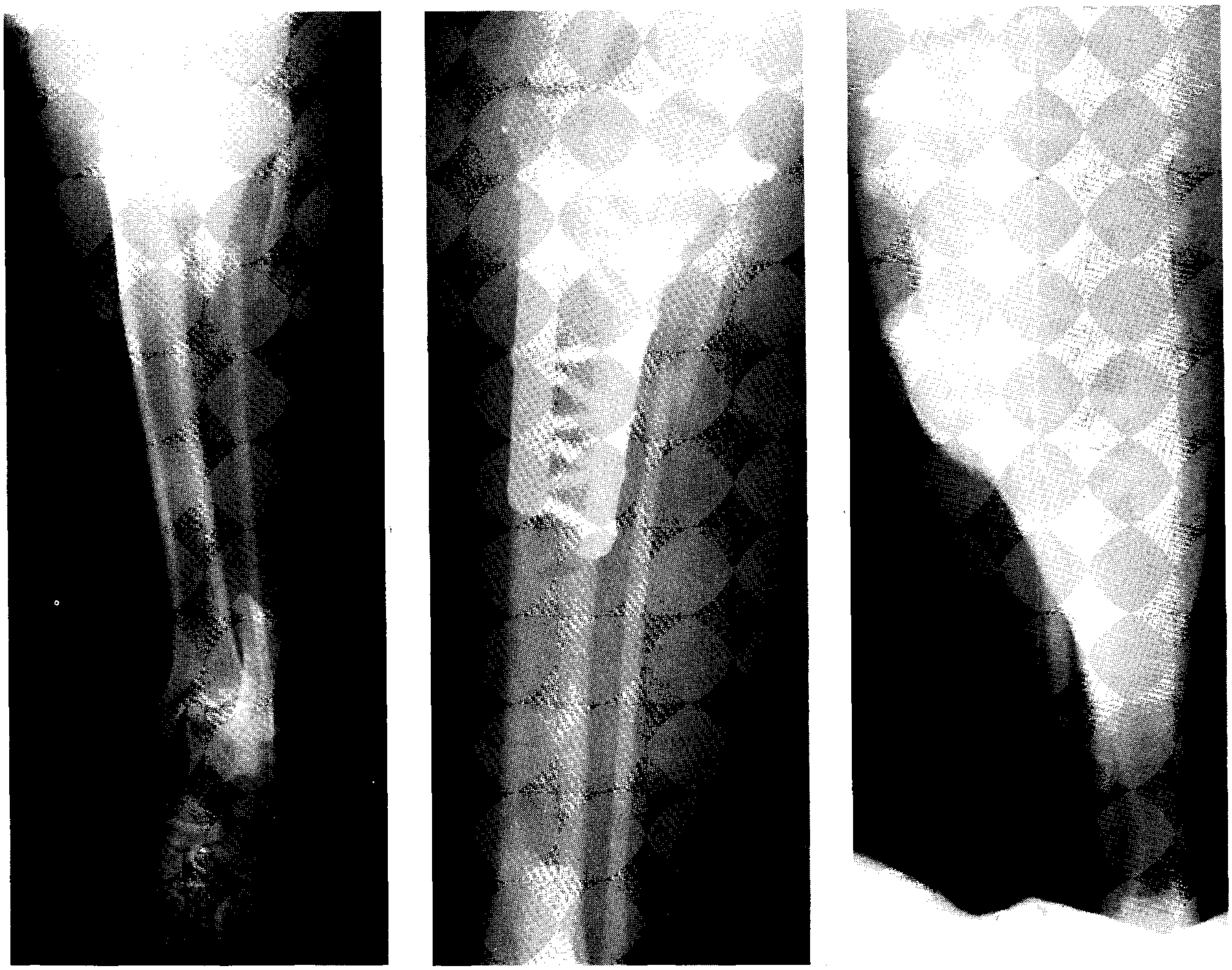

Fig. 3a— Anteroposterior radiograph of right fractured proximal tibia and fibula in an eight-month-old male African lion (*Panthera leo*). The fractured left tibia was similar.

Fig. 3b— Anteroposterior postoperative radiograph of the right tibia following repair by one compression bone plate and one neutralization bone plate.

Fig. 3c— Anteroposterior radiograph of the right tibia four months following surgery. There is periosteal callus. All plates and screws are in place and the fixation is solid.

both fracture sites, but all metal plates appeared intact and in good position (Fig. 3c).

Case 5: A two and one-half-month-old rhea was presented with a developmental leg deformity, which resulted in lateral rotation of the right leg. As the bird grew, this deformity became accentuated and the bird had difficulty with motion (Fig. 4a). Radiographic examination of the stifle and hock joints revealed no osseous abnormality. The gastrocnemius tendon was still in its correct anatomical location (Fig. 4b).

Anesthesia was induced and maintained with halothane and nitrous oxide using a semi-closed system. After induction, the bird was intubated. A mid-tibial osteotomy was performed and the tibia rotated to the proper position. For stability a four-hole semi-tubular plate was placed on the lateral surface of the tibia (Fig. 4c). The bird received injectable gentamicin for 10 days following surgery. It was ambulatory in three days and was walking in an almost normal fashion in 10 days. Within six weeks, as the bird continued to grow, the leg again appeared deviated laterally. A second surgical procedure was performed 10 weeks later. At surgery, callus had covered the plate which was delineated on radiographs (Fig. 4d). This was removed over the distal two holes and the two screws were removed. The plate was left in place by the proximal two screws. The tibia was again transected and rotated medially, but this time the leg rotated 45 degrees past normal position. This was done with the belief that as the bird continues to grow, the tibia will rotate to a normal

Fig. 4a— A two and one-half-month-old rhea (*Rhea americana*) with a rotated right leg. The bird had great difficulty with locomotion.

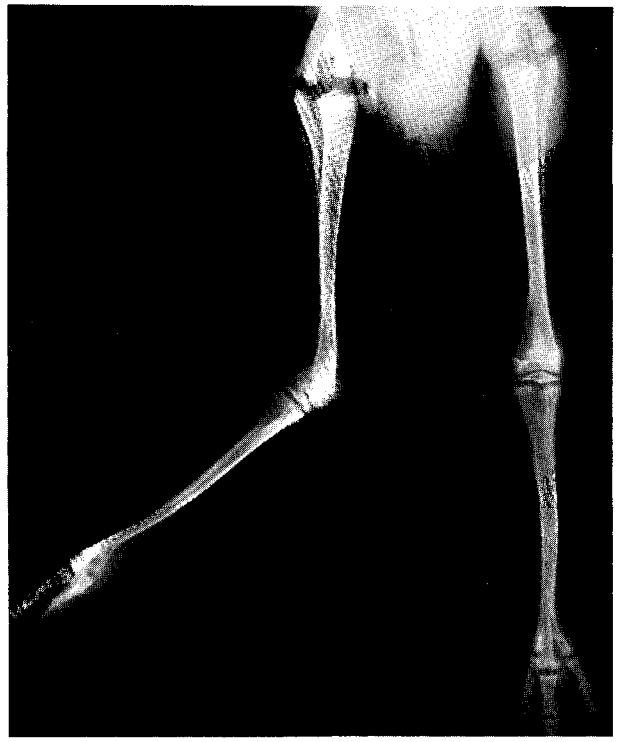

Fig. 4b— A ventrodorsal radiograph of the rhea showing the marked tibial rotation of the right leg.

position. The distal two screws were reseated in the distal fragment and the skin closed. The bird was very excitable after the surgery and was able to generate an excessive amount of force by virtue of the strong leg muscles. The fixation failed to hold and the osteotomy site did not remain intact. Because of this, the bird was euthanatized as it was believed the quality of bone and callus was not adequate to hold the plate in place.

Case 6: An adult male timber wolf at a drive-through park sustained a fractured tibia while being recaptured from an adjacent enclosure. A coaptation splint was placed on the leg for 21 days, but he would not tolerate the splint and removed it on two occasions. It was then decided to repair the fracture surgically. A radiograph showed a spiral fracture of the distal one-third of tibia (Fig. 5a). The fracture was repaired with a six-hole plate placed on as neutralization plate. Two middle screws were placed in by lag fashion.

The wolf had some weight-bearing capability in two days and was walking normally in six weeks. Postoperative radiographs at four weeks showed a good bony union starting (Fig. 5b).

Case 7: A two-month-old male kudu was noted limping on his right foreleg. In order to examine the animal, it was immobilized with 0.75 mg etorphine[e] and 40 mg xylazine.[f] This dose was not adequate for complete immobilization and a second dart with 200 mg of tiletamine hydrochloride and zolazepam was used to immobilize the animal. The impact of the second dart fractured the left femur.

The radiographs showed a distal radius and ulna fracture with minimal displacement (Fig. 6a) and a long oblique midshaft femur fracture.

Surgery was performed on the femur with the animal under halothane anesthesia. Preoperative preparation included an antibiotic, corticosteroids and intravenous fluids. Surgical repair required two lag screws and two neutralization plates to stabilize the fracture (Fig. 6b). The foreleg was placed in a fiberglass cast[g] and the animal was moved to a padded recovery stall. When examined in the morning, the animal had struggled and refractured the femur proximal to the plates, and both plates were loose. With a hopeless outlook, the animal was euthanatized.

These examples have been utilized to illustrate part of the decision process associated with the use of internal fixation in exotic animals.

[e] M99, D-M Pharmaceuticals, Inc., Rockville, MD 20850.
[f] Rompun, Chemagro, Kansas City, MO 64120.
[g] Lightcast II, Merck, Sharpe & Dohme, West Point, PA 19486.

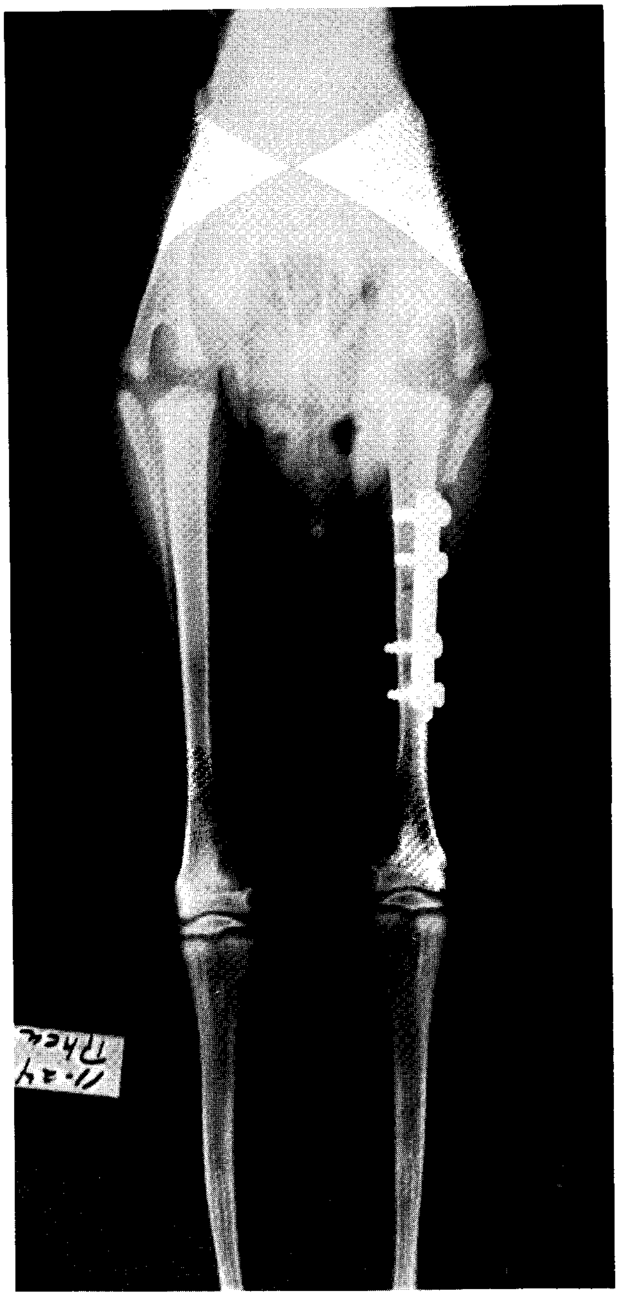

Fig. 4c— A postoperative anteroposterior radiograph following osteotomy and rotation of tibia. A four-hole semi-tubular bone plate is holding the leg in good anatomical position.

Fig. 4d— A lateral radiograph of the right tibia 10 weeks postoperatively. There is extensive callus formation and some loosening of the proximal screws.

Discussion

The origin of the trauma epidemic to the three lions was not established and may have been due to aggressive behavioral factors. Radiographic examination of the skeletons of these lions did not reveal any decalcification or any other predisposing factor to the fractures. These animals were on an adequate diet with a proper Ca to P ratio.

The use of bone plates to repair the lions' fractures provided excellent clinical results. Rigid and strong fixation could be accomplished through the combination of the bone plates anchored in normal bone. If there were problems with demineralization, the chances for clinical success would be less.

The lions tolerated the appliances very well and only minor problems occurred at the surgery site. Their activity was limited in the postoperative period by confinement to small holding cages which lessen

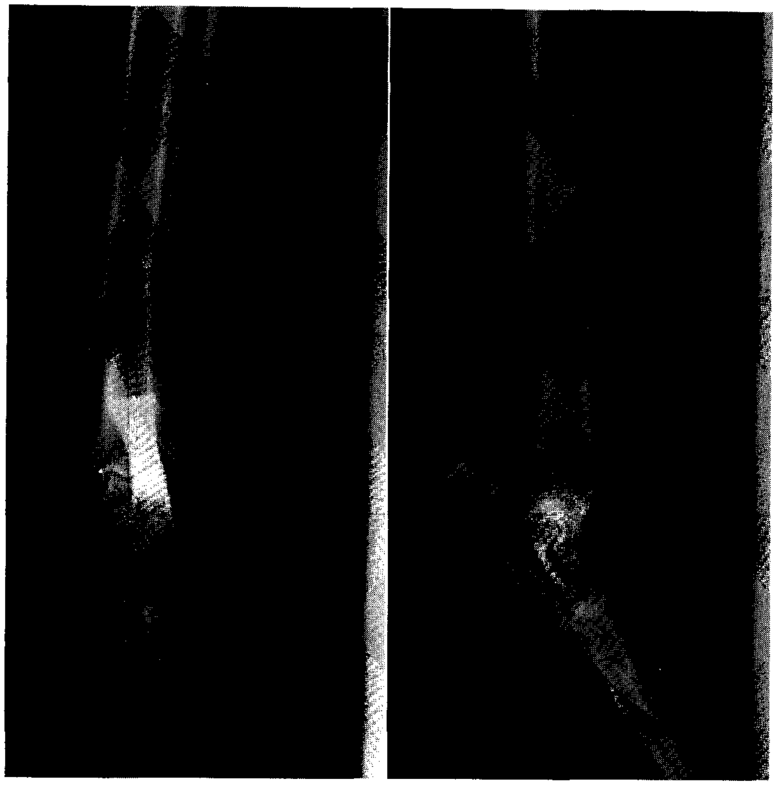

Fig. 5a— Anteroposterior and lateral radiographs of a spiral tibia fracture in a male timber wolf (*Canis lupus*).

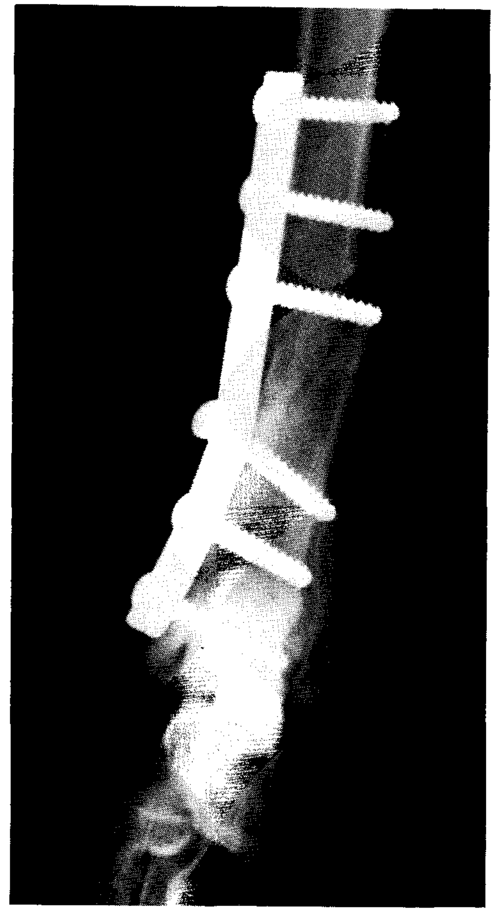

Fig. 5b— Postoperative radiograph at four weeks. The screws and plate are solid and there is good function of the leg.

stress on the fracture sites. All lions returned to full function within four to five months and were returned to the exhibit area.

The surgical repair in the rhea was initially satisfactory but did not correct the cause of the deformity. As the bird continued to grow, the problem reestablished itself. The callus at the fracture site, in combination with inherent brittleness of avian bones, were factors that compromised the chance of success of the second surgical procedure. These factors in combination with the inability to prevent the bird's excessive movement resulted in the forces of the long and powerful legs breaking down the second fixation. This type of surgery in these birds is feasible, but only as a salvage procedure. It would be contraindicated to permit these birds to reproduce as there is suspected genetic predisposition to these leg problems.

The use of the bone plate in the timber wolf is similar anatomically to the domestic dog. In general, these animals are quite uncooperative and will not tolerate external fixation. This, therefore, dictates the use of rigid internal fixation for which the bone plate is well suited. Once the fracture site was rigidly fixed, the postoperative care was minimal.

There are clinical problems that the bone plating does not solve at the present state of the art or science, or both. The greater kudu's fractured femur was enough of a problem without the associated complication of the fractured radius and ulna. Additionally, we note that the cortical bone of this animal appears very thin radiographically, which predisposed the animal to the fractured femur from the impact of the dart. The thin cortical bone, plus the extremely highly excitable personality of this species,

Fig. 6a— Lateral radiograph of the right radius and ulna of a two-month-old greater kudu (*Tragelaphus strepsiceros*). There is a fracture of the distal radius and a folding fracture of the distal ulna. The osseous cortex is thin and the bone poorly mineralized.

resulted in the fracture following the fixation. The extreme forces generated by the young animal were more than the fixation in the thin cortical bone could tolerate. The growth rate of this animal is very rapid and the size and strength of the muscles progress more rapidly than the mineralization of bone. This creates the type of problem we experienced — how can we rigidly secure a fracture in a large, strong, uncontrollable animal when the cortical bone will not hold bone plates or screws, or both?

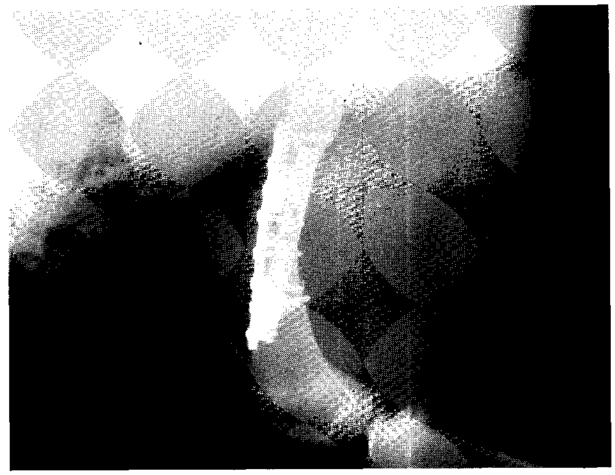

Fig. 6b— Lateral postoperative radiograph of the left femur following fixation with two lag screws and two neutralization plates. Again the thin cortex is noted.

The clinical approach to fracture repair in exotics is not only the establishment of rigid fixation, but a strategy on how to capture, anesthetize and provide care in the postoperative period. These considerations are magnified with exotics when compared to domestic animals and man. At the present time, the use of bone plates as devices for the internal fixation of fractures is just beginning. Our experience with the method reveals that there are situations in the practice of orthopedics in exotic animals where this is the only type of fixation that will properly stabilize the fracture. Other advantages include minimal aftercare, which is almost impossible in many exotics, in association with a rapid return to function.

In analyzing the complications, several factors emerged and can be outlined as follows:

Experience is needed in the proper application of bone plates to fractures in the exotics. Understanding the biomechanics of the fractures and how best to neutralize these forces is mandatory. Prior to the surgical intervention, a review of the anatomy of the region should be undertaken if available. This will allow the surgeon to understand the forces generated by various muscle groups acting upon the fracture site, thus determining the compressive and tensile surfaces of the bone. Radiography is an excellent means of studying the postoperative course and repair.