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Bone splinting techniques for long bone fractures in small ruminants: A review of six cases

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Abstract

Long bone fractures are a prevalent orthopedic concern in small ruminants, particularly goats, often resulting from trauma such as road accidents, falls, or dog attacks. This clinical study evaluated six cases of long bone fractures presented to the Large Animal Surgery Unit at VCRI, Namakkal, employing three fixation techniques which include external skeletal fixation (ESF), intramedullary pinning (IMP), and minimally invasive plate osteosynthesis (MIPO). Each case underwent thorough clinical and radiographic assessment to guide implant selection and surgical planning. ESF was used for metacarpal and metatarsal fractures with open wounds, facilitating drainage and early weight bearing. IMP was applied to humeral and tibial fractures, promoting secondary bone healing through callus formation. MIPO was reserved for comminuted tibial fracture, enabling early mobilization and primary bone healing. Across all techniques, postoperative care and implant sizing were critical to functional recovery. The study highlights the therapeutic versatility and clinical efficacy of fixation strategies in managing long bone fractures in field conditions.

Keywords: External skeletal fixation (ESF), intramedullary pinning (IMP) and minimally invasive plate osteosynthesis (MIPO)

1. Introduction

Orthopaedic conditions in small ruminants are common, with long bone fractures being the most frequently encountered. In goats, such fractures typically result from falls, road accidents, blunt trauma, or dog attacks (Gupta, 2015) [3]. Among young small ruminants aged 1-3 years, the metacarpal and metatarsal bones are most affected (50%), followed by the tibia (12%), radius and ulna (7%), and humerus (5%) (Awatif *et al.*, 2006) [2].

The configuration and anatomical location of the fracture dictate the choice of fixation technique necessary for effective stabilization and healing (Fossum, 2019) [6]. Fracture management involves a spectrum of approaches tailored to the bone affected, fracture type, and species, including external coaptation (e.g., splints and casts), external skeletal fixation (ESF), and internal fixation using plates, screws, intramedullary pins, or interlocking nails. Treatment decisions are influenced by biomechanical demands, anatomical considerations, and the biological potential for fracture repair (Aithal *et al.*, 2023; Kapler and Dycus, 2015) [1, 4].

The present study underscores the clinical relevance and therapeutic diversity in managing long bone fractures in small ruminants, particularly goats, within a field-oriented veterinary surgical setting.

2. Materials and Methods

A total of six cases (table 1) presented to the Large Animal Surgery Unit, Veterinary Clinical Complex, Veterinary College and Research Institute, Namakkal, with a history of trauma and clinical signs suggestive of long bone fractures were included in the study. Animals were selected irrespective of age, breed, or sex. Each case underwent thorough clinical and radiographic evaluation.

2.1 Preoperative Planning

Each fracture case was thoroughly evaluated to rule out any underlying neurological abnormalities. Following clinical examination, two orthogonal radiographic views of the affected limb were obtained for all animals. These radiographs were used to identify the exact fracture location, number of fragments, and the orientation and position of longitudinal fissures. They also facilitated measurements of the medullary cavity diameter at the isthmus for selecting appropriate intramedullary pins, cortex-to-cortex width for determining ESF pin diameter and suitable dimensions for bone plates and screws. Based on these assessments, all implants, surgical instruments, and necessary accessories were selected and sterilized according to the specific requirements of each case. Preoperatively, all animals received 0.5 mL of tetanus toxoid administered deep intramuscular injection.

2.2 Anaesthesia

Animals were premedicated intramuscularly with xylazine hydrochloride at a dose of 0.05 mg/kg body weight and butorphanol at 0.1 mg/kg. General anesthesia was employed for the surgical procedure, with induction achieved via intravenous administration of ketamine (2.5 mg/kg) in combination with diazepam (0.5 mg/kg). Anesthesia was maintained through an intravenous administration of ketamine and diazepam in a 1:1 volume ratio, adjusted as needed throughout the operation.

2.3 Surgical procedures

The surgical site was prepared aseptically with povidone iodine. For overriding fractures, traction via the hanging limb method was applied for 30 minutes preoperatively. Sterile bandages covered the limb ends, tincture of iodine was applied, and the site was draped.

a) For External Skeletal Fixation (ESF): Fracture reduction and stabilization were achieved via a closed approach using traction. Alignment was maintained intraoperatively with manual traction and counter-traction, using either a hoof-secured bandage roll or the hanging limb method. Pins (20-30% of bone width) were inserted craniomedially to caudolaterally with a low-speed drill, two per segment, perpendicular and parallel to the bone axis. Saline irrigation minimized heat during drilling. Pins were bent 1 cm from the skin with help of pin bender toward the fracture, taped temporarily, and stabilized permanently with M-seal.

b) For intramedullary pinning: Intramedullary pinning was performed for tibial and humeral fractures using bone-specific approaches and techniques. For tibial fractures, a normograde method was employed, with closed pinning preferred in fresh, simple cases and open reduction indicated for delayed or comminuted fractures. The pin was inserted at the craniomedial tibial margin, between the patellar and medial collateral ligaments, and advanced distally into the medullary canal under fluoroscopic or manual guidance. Humeral fractures were managed via a retrograde approach following a craniolateral incision from the greater tubercle to the lateral epicondyle. Layered dissection exposed the fracture site while preserving neurovascular structures, with dissection proceeding between the brachialis and brachiocephalicus muscles and careful retraction of the triceps and radial nerve. The pin was introduced into the proximal fragment and advanced distally.

c) For minimally invasive plate osteosynthesis (MIPO): MIPO was performed via a medial approach with two small (2-4 cm) incisions at the distal and proximal ends of the tibial fracture. A subcutaneous and epiperiosteal tunnel was created using Metzenbaum scissors. A 3.5 mm LC-LCP was inserted through the distal incision and guided along the medial tibial surface. Holes were drilled with a 2.5 mm bit, and screws were placed distally and proximally to stabilize each major fragment. Surgical site closure was done according to standard protocol in all the cases.

2.4 Postoperative care

Postoperatively, pin entry sites in ESF cases were dressed with povidone-iodine-soaked sterile gauze and the fixation construct was securely bandaged. For intramedullary pinning and plating, a modified Robert Jones bandage was applied. Postoperative care involved administering ceftriaxone-tazobactam intravenously at 10 mg/kg body weight for five days, and meloxicam intramuscularly at 0.2 mg/kg body weight for three days. Wound dressing was performed on alternate days. Animals were kept on stall rest with restricted movement for two weeks, followed by gradual, supervised walking.

3. Results and Discussion

The six cases evaluated demonstrated a spectrum of fracture types and anatomical locations commonly encountered in clinical practice. These findings align with previous epidemiological reports indicating that metacarpal and metatarsal fractures are most prevalent in young goats, followed by tibial, radioulnar, and humeral fractures (Awatif *et al.*, 2006; Lozier *et al.*, 2018; Rani *et al.*, 2025) [2, 7, 8]. Automobile accidents accounted for the majority of fractures (4 cases, 66.67%), while blunt trauma and dog attacks contributed to one case each (16.67%), consistent with the observations of Kumaresan (2013) and Rani *et al.* (2025) [8]. Effective fracture management relied on accurate diagnosis, biomechanical planning, and appropriate implant selection. Orthogonal radiographs (mediolateral and craniocaudal views) of the injured limb and adjacent joints were essential for evaluating fracture configuration and guiding fixation choices, in line with the principles described by Piermattei *et al.* (2006) [5] and Fossum (2019) [6]. Measurements of the medullary canal and cortical width facilitated precise implant sizing, while contralateral limb radiographs ensured optimal fit and alignment. Additionally, the anaesthetic protocol employed provided smooth induction, maintained a stable surgical plane, and resulted in uneventful recovery in all animals.

External skeletal fixation (ESF) was employed in three cases, two involving metacarpal fractures and one metatarsal fracture (Fig 5) each presenting with open wounds. Hanging limb technique has aided in reduction of fracture fragments (Fig-2). ESF allowed adequate drainage and facilitated regular wound dressing. Pins measuring 20-30% of the cortex-to-cortex width provided rigid and stable fixation. Partial weight bearing was observed by the 15th postoperative day in all cases (Fig 1), with complete weight bearing achieved by day 30 in two animals. One metacarpal fracture case exhibited weight-bearing lameness until day 45 and moderate mal alignment was noticed (Fig-4).

Wound healing was evident by the 15th postoperative day in all animals. ESF was removed on the 60th postoperative day, during which mild discharge and construct loosening were

noted but resolved promptly without complications. Radiographically, initial periosteal proliferation was observed by day 30, followed by exuberant periosteal proliferation by day 45 (Fig 3 & 5).

Intramedullary pinning was employed in two cases involving humeral (Fig-7) and tibial fractures. The surgical approaches provided feasible access and effective fracture realignment. Pins occupying 60-70% of the medullary canal diameter offered adequate stabilization (Fig-10). In the tibial fracture, normograde pinning enabled partial weight bearing by day 15 and complete weight bearing by day 45 (Fig 9). In the humeral fracture, full weight bearing was achieved by day 30 (Fig 6). Surgical wounds healed by the 12th postoperative day in both cases. Radiographic evaluation on day 45 in both the cases revealed exuberant osseous callus formation and a absence of radiolucent line at the fracture gap (Fig 8 & 11), indicative of secondary bone healing.

Minimally invasive plate osteosynthesis (MIPO) was

performed in one case involving a comminuted tibial fracture (Fig-13). Partial weight bearing was observed on the second postoperative day, with complete weight bearing achieved by day 30 (Fig 12). Radiographically, initial periosteal proliferation was evident by day 30, followed by organised periosteal proliferation on day 45 indicating primary bone healing (Fig 14).

The study revealed distinct healing patterns based on fixation type. ESF and MIPO promoted primary bone healing, characterized by minimal callus formation and direct cortical bridging due to rigid stabilization and preserved periosteal integrity, consistent with Kapler and Dycus (2015) ^[4] and Redfern *et al.* (2004) ^[9]. In contrast, secondary healing was observed with intramedullary pinning, evidenced by exuberant callus and a persistent radiolucent gap by day 45, reflecting indirect healing stages as described by Aithal *et al.* (2023) ^[1] and Piermattei *et al.* (2006) ^[5].

Table 1: Details of animals selected for study

Case No.	Animal	Breed	Sex	Age	Body weight (in kg)	Long bone involved	Site and type of fracture	Technique used	Size of implant
1	Sheep	Mecheri	F	3 years	30	Metacarpal	Mid shaft transverse	Type II ESF	2mm K- wire
2	Goat	ND	F	4 years	18	Metacarpal	Distal transverse	Type II ESF	1.5mm K- wire
3	Goat	ND	F	2 years	22	Metatarsal	Mid shaft short oblique	Type II ESF	2mm K- wire
4	Goat	Salem black	M	11 months	12	Humerus	Distal short oblique	IMP	3.5mm Steinmann pin
5	Sheep	Mecheri	F	1 years	25	Tibia	Mid shaft long oblique	IMP	3.0mm Steinmann pin
6	Goat	Salem black	F	3 years	23	Tibia	Distal comminuted	MIPO	3.5 mm LC-LCP



Fig 1: ESF – Animal with metacarpal fracture, Day 15- Partial weight bearing.



Fig 2: Anatomical reduction of fracture fragments.



Fig 3: Case 1 – Day 45 radiograph.



Fig 4: Case 2 – Day 45.



Fig 5: Case 3 – Day 45.



Fig 6: Animal with humerus fracture, Day-30 - Complete weight bearing



Fig 7: Long oblique fracture of right humerus



Fig 8: Case 4- Day 45



Fig 9: Animal with left tibial fracture, Day 45 - Complete weight bearing



Fig 10: Immediate post operative radiograph



Fig 11: Exuberant osseous callus formation



Fig 12: Animal with left tibial fracture, Day 45- complete weight bearing



Fig 13: Comminuted left tibial fracture



Fig 14: Organised periosteal proliferation on day 45

4. Conclusion

In conclusion, the study demonstrates the effectiveness of fracture management in goats using ESF, intramedullary pinning, and MIPO techniques. ESF provided adequate stabilization for metacarpal and metatarsal fractures with open wounds, allowing early weight bearing and progressive healing. Intramedullary pinning offered minimally invasive stabilization for humeral and tibial fractures, with healing consistent with secondary bone repair (Aithal *et al.*, 2023; Gupta, 2015) [1, 3]. MIPO enabled early mobilization and biological healing in a comminuted tibial fracture, as advocated by Redfern *et al.* (2004) [9]. Across all techniques, postoperative care and implant selection were critical to functional recovery.

5. Conflict of Interest

Not available.

6. Financial Support

Not available.

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