Recent Trends in Fracture Management in Canines: A Brief Study

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OPEN ACCESS

Keywords

Canines, Fracture, Management

How to cite this article:

Karir, S. R., Anita., Bharia, A. and Pandey, N. 2025. Recent Trends in Fracture Management in Canines: A Brief Study. *Vigyan Varta* 6 (5): 84-87.

ABSTRACT

Fracture management in canines has significantly evolved with the advent of advanced technologies, refined surgical techniques and a deeper understanding of bone healing biology. Techniques such as minimally invasive osteosynthesis (MIO), locking plate systems, robotic-assisted surgeries, AI-driven decision-making, 3D printing of customized implants and regenerative therapies have revolutionized canine orthopaedics. This article comprehensively reviews recent trends, discusses clinical applications, evaluates advantages and limitations and explores future perspectives in the domain of veterinary orthopaedic surgery.

INTRODUCTION

Orthopaedic injuries, particularly fractures, are common in veterinary practice, especially among active and young canines. Traditional fracture treatments focused primarily on bone alignment and stabilization; however, modern trends emphasize biological healing, minimal tissue trauma, rapid functional recovery and patient-specific interventions. Emerging technologies like robotic surgery, 3D modelling, AI assistance, biodegradable implants and smart biosensors are reshaping the management of fractures (Meeson and Bowlt, 2023; Singh and Brown, 2024).

1. Minimally Invasive Osteosynthesis (MIO)

Minimally Invasive Osteosynthesis (MIO) minimizes surgical trauma by achieving fracture stabilization with minimal exposure. Techniques like closed reduction and percutaneous plating preserve the fracture hematoma and periosteal blood supply, both critical for osteogenesis (Petrie *et al.*, 2018).

Advantages:

- Reduced infection risk.
- Faster bone healing.
- Less postoperative morbidity.

Limitations:

- Requires specialized training and intraoperative imaging support.

Clinical Applications:

- Long bone fractures (femur, tibia, humerus).
- Pelvic fractures.

2. Locking Plates and Locking Compression Plates (LCP)

Locking plates function as internal fixators where screws lock into the plate, providing angular stability without relying on bone-plate friction (Rist *et al.*, 2020).

Advantages:

- Suitable for osteoporotic or comminuted fractures.
- Decreased soft tissue disruption.
- Enhanced mechanical stability.

Limitations:

- Higher cost and technical complexity.

Clinical Applications:

- Comminuted, metaphyseal and periarticular fractures.

3. Robotic Surgery and Artificial Intelligence (AI)

Robotic systems provide precision in fracture fixation, while AI aids in surgical planning, predicting healing outcomes and personalizing rehabilitation protocols (Rech *et al.*, 2021; Allen and Pluhar, 2023).

Advantages:

- Greater surgical accuracy.
- Reduced surgical time and trauma.

Limitations:

- Expensive equipment and high initial investment.

Applications:

- Complex fracture reconstructions.
- Personalized treatment planning.

4. 3D Printing and Custom Implants

Three-dimensional (3D) printing enables the fabrication of customized implants tailored to the patient's unique anatomy, ensuring perfect fit and optimal function (Meeson and Bowlt, 2023).

Advantages:

- Personalized implants.
- Reduced intraoperative adjustment time.

Limitations:

- Time-consuming production.
- Regulatory approvals needed for clinical use.

Applications:

- Mandibular, pelvic and skull fractures.

5. Rehabilitation and Postoperative Care

Postoperative rehabilitation is essential to restore muscle strength, joint mobility and overall function, leading to faster and better recovery (Petrie *et al.*, 2018).

Rehabilitation Techniques:

- Hydrotherapy.
- Laser therapy.
- Passive range of motion (PROM) exercises.
- Neuromuscular electrical stimulation.

Outcomes:

- Faster return to activity.
- Prevention of complications like joint stiffness and disuse atrophy.

6. Biodegradable Implants

Biodegradable materials such as polyglycolic acid (PGA) and magnesium alloys are used to create implants that naturally degrade after bone healing (Singh and Brown, 2024).

Advantages:

- Eliminates need for implant removal surgery.
- Reduced stress for animals and owners.

Challenges:

- Balancing mechanical strength and degradation rate.

7. Advanced Bone Grafting and Regenerative Therapies

Regenerative approaches, including stem cells, platelet-rich plasma (PRP) and bone morphogenetic proteins (BMPs), enhance fracture healing (Meeson and Bowlt, 2023).

Clinical Benefits:

- Accelerated bone regeneration.
- Improved outcomes in non-unions and critical-sized defects.

8. Computer-Assisted Fracture Reduction and Navigation

CT-based 3D modelling and computer navigation aid in precise fracture reduction and optimal implant placement (Allen and Pluhar, 2023).

Advantages:

- Improved alignment.
- Reduced intraoperative trial-and-error.

Applications:

- Complex fractures of the pelvis and long bones.

9. Smart Implants and Biosensors

Next-generation implants are embedded with sensors that monitor mechanical loads, temperature and biochemical markers during healing (Li *et al.*, 2024).

Future Applications:

- Real-time fracture healing monitoring.
- Early infection detection.
- Remote rehabilitation adjustments.

10. Nanotechnology and Surface Engineering

Surface modifications using nanoparticles (e.g., silver) promote osteointegration and provide antimicrobial properties (Singh and Brown, 2024).

Impact:

- Reduced implant-associated infections.
- Improved implant longevity and success rates.

Future Perspectives and Challenges

- Broader clinical adoption of smart implants and AI-driven predictive modelling (Li *et al.*, 2024).
- Development of cost-effective 3D printing technologies.
- Ethical and regulatory considerations for regenerative therapies.
- Expansion of tele-rehabilitation techniques for remote patient care.

CONCLUSION

The landscape of canine fracture management has transformed remarkably due to minimally invasive techniques, advanced fixation devices, regenerative therapies and personalized approaches. These innovations are contributing to faster recoveries, lower complication rates and improved quality of life for canine patients. Continuous research, technological integration and cost-effective solutions will further revolutionize veterinary orthopaedic care.

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