International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2025): 5.29
IJABR 2025; 9(10): 459-469
www.biochemjournal.com
Received: 02-08-2025
Accepted: 05-09-2025

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Surgical management of supracondylar femoral fractures in dogs using supracondylar plates and plate-rod constructs

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DOI: https://www.doi.org/10.33545/26174693.2025.v9.i10g.6062

Abstract
A clinical study at the Department of Veterinary Surgery and Radiology, PVNRTVU, Hyderabad evaluated management of metaphyseal and supracondylar femoral fractures in 12 dogs, divided into two groups: supracondylar plating (J-plate) and plate-rod construct with Steinmann pin. Most cases involved young, non-descript breeds with acute, non-weight bearing lameness but stable physiological parameters at admission.

Supracondylar plating (J-plate) preserved periosteal blood flow and offered excellent outcomes for distal femoral fractures, especially those with caudal bowing. Plate-rod constructs provided superior biomechanical stability, reducing implant fatigue and promoting healing, but required removal in growing dogs. Both the methods led to satisfactory recovery, though quadriceps contracture occurred in one case. Radiographs confirmed healing at intervals post-surgery.

In conclusion, plate-rod constructs yielded the best mechanical stability and recovery rate but necessitated timely removal in immature dogs; plating provided good stability. Individualized treatment considering mechanical, biological and patient factors is recommended to optimize outcomes.

Keywords: Supracondylar femur plate, plate-rod, dogs and fractures

Introduction

The complex field of veterinary orthopaedics focuses on enhancing treatment protocols for common musculoskeletal injuries in companion animals. Supracondylar femoral fractures in dogs present a notable clinical challenge due to the anatomical intricacies and vital function of the distal femur. These fractures often the result of high energy trauma such as falls or vehicular accidents are particularly common in young, active dogs because of the vulnerability of their developing bones (Voss *et al.*, 2009; Scott *et al.*, 2007 and Harasen, 2003) [26, 24, 11].

Long bone fractures, especially femoral injuries, are frequently encountered in small animal practice, with distinct patterns arising from different loading forces (Johnson, 2007) [13]. Accurate diagnosis relies on comprehensive orthopaedic assessment and radiographic imaging, including contralateral limb comparisons to aid surgical planning (Zurita and Craig, 2022) [28]. Supracondylar fractures in young dogs often require strategies such as osteosynthesis or anatomical reduction (Rathnadiwakara *et al.*, 2020; Chandler and Beale, 2002; Beale, 2004 and Fossum, 2013) [22, 7, 3, 9].

Treatment options for distal femoral fractures include pins, wires, plate-rod constructs, and dynamic cross-pinning, with the latter being a reliable and cost-effective option in select cases (Scotti *et al.*, 2007; Cebecci and Karsli, 2021; Miraldo *et al.*, 2020) [24, 6, 19]. The need for effective and stable fixation is crucial in preventing long-term complications and promoting optimal healing and limb function.

This study assesses the incidence and treatment outcomes of supracondylar femoral fractures in twelve canine patients at the Department of Veterinary Surgery and Radiology, P.V. Narsimha Rao Telangana Veterinary University, Rajendranagar, Hyderabad. The objectives include examining fracture patterns, evaluating clinical and radiological outcomes of two surgical methods i.e. supracondylar plating and plate-rod constructs, monitoring biochemical and hematological changes, and reviewing intra- and post-operative complications.

Materials and Methods
Pre-Operative Clinical Examination
At presentation, twelve canine patients with supracondylar femur fractures commonly showed pain on palpation, swelling, inability to bear weight, stifle joint instability, and visible deformity with functional impairment. Palpable crepitus was consistently noted and all fractures were closed. Despite these local signs, baseline physiological parameters such as pulse, respiration and body temperature were stable, and cardiovascular and respiratory assessments including mucous membrane color and capillary refill time were within normal limits.

Pre-Operative Radiographic Evaluation
Medio-lateral and cranio-caudal radiographic views provided critical information for managing supracondylar femur fractures. These orthogonal images confirmed the fracture, detailed its configuration, aided classification and facilitated selection of appropriately sized surgical implants (Fig. 1-12).

Planning of Surgery
Preoperative radiographic measurements of the affected femur, including bone length and transcortical diameter at various sites, were crucial for accurately determining the appropriate length of supracondylar plates and screws for fracture fixation.

Fig 1: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, supracondylar - 33-A1 (Group I - Case 1).

Fig 2: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, oblique, metaphyseal - 33-A1(Group I - Case 2).

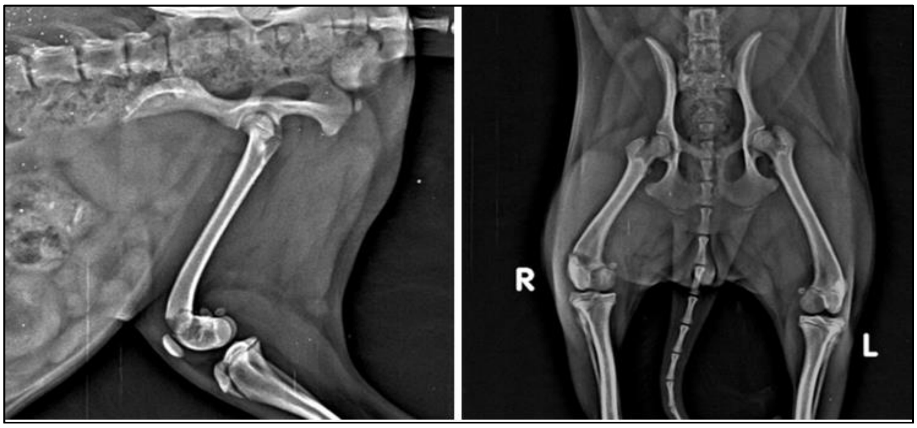


Fig 3: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, supracondylar - 33-A1 (Group I - Case 3).

Fig 4: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, supracondylar - 33-A1 (Group I - Case 4).

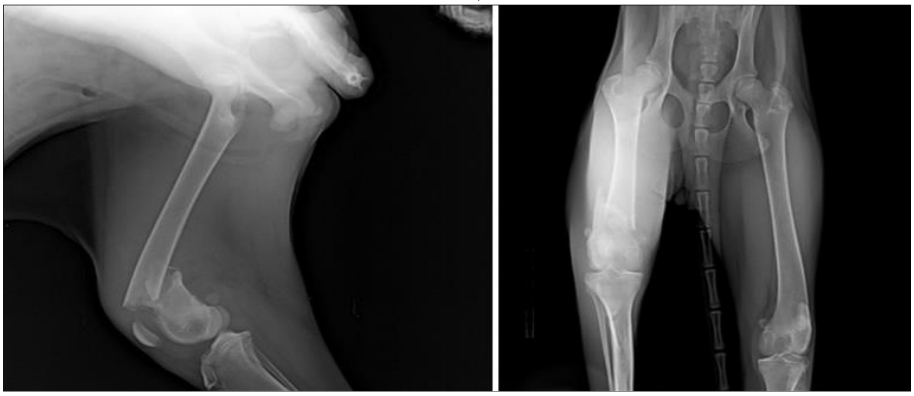


Fig 5: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, short oblique, metaphyseal - 33-A1(Group I - Case 5).

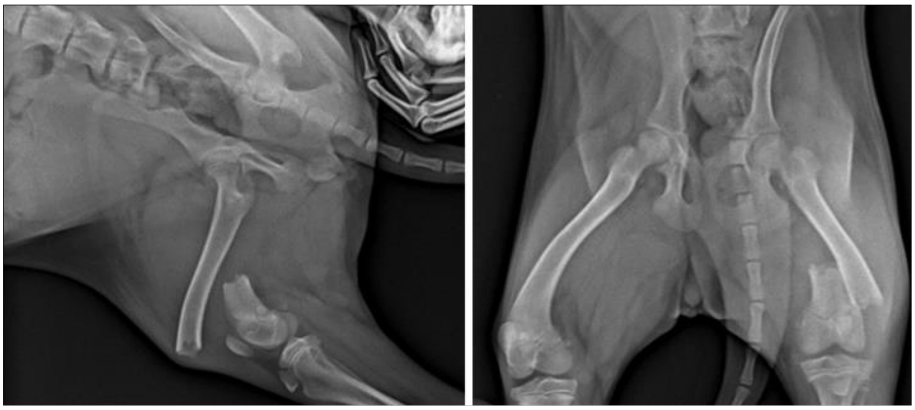


Fig 6: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, metaphyseal - 33-A1 (Group I - Case 6).

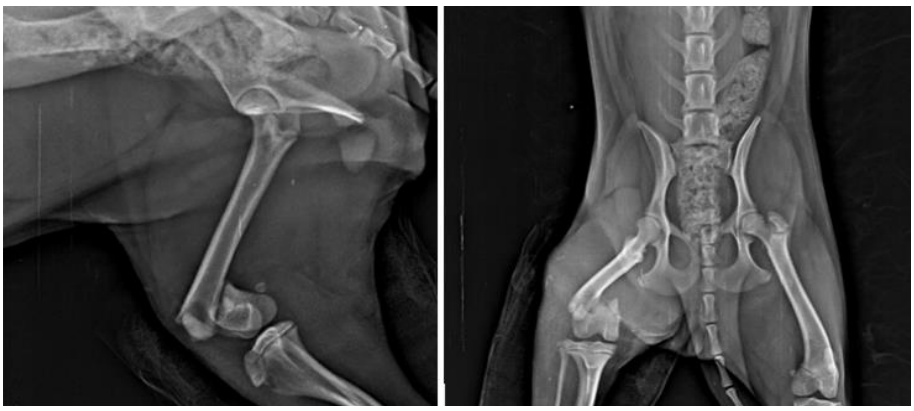


Fig 7: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, supracondylar - 33-A1 (Group II - Case 1).

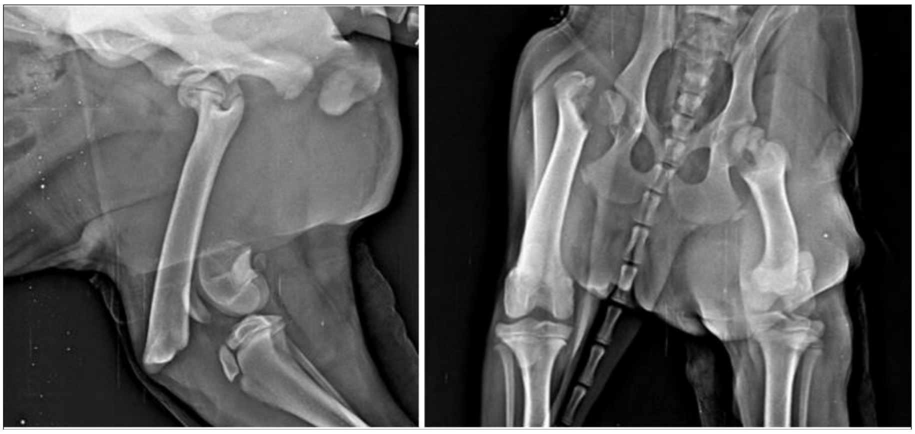


Fig 8: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, supracondylar - 33-A1 (Group II - Case 2).

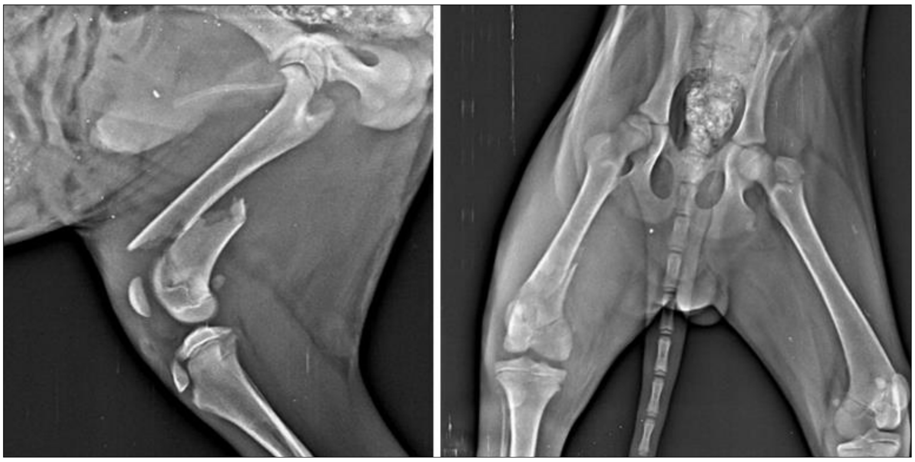


Fig 9: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, oblique, metaphyseal - 33-A1- 33-A1 (Group II - Case 3).

Fig 10: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, transverse, distal third diaphyseal- 33-A1 (Group II - Case 4).

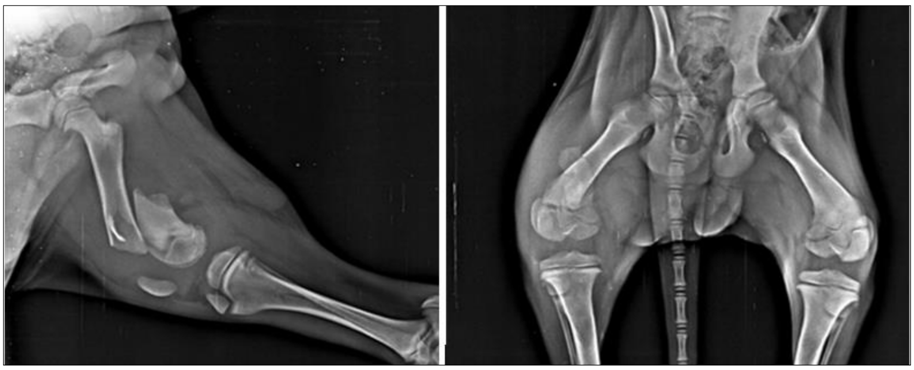


Fig 11: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, short oblique, distal third diaphyseal with wedge- 33-A2 (Group II - Case 5).

Fig 12: Pre-operative radiographs (medio-lateral and cranio-caudal view) illustrating a closed, oblique, supracondylar- 33-A1 (Group II - Case 6).

Patient Preparation

To ensure patient safety before surgery, owners were advised to withhold food for 12 hours and water for 6 hours. The affected limb was aseptically prepared by shaving and scrubbing with 7.5% povidone-iodine, followed by surgical spirit, covering from the dorsal midline to the tarsal joint. The cephalic vein on the same side was prepared for intravenous access. During surgery, continuous intravenous infusion of normal saline at 5 ml/kg/hour was maintained to support hydration and circulation.

Anaesthesia

Preoperative drugs included intravenous ceftriaxone (20 mg/kg) and subcutaneous meloxicam (0.2 mg/kg). Premedication with atropine sulfate (0.02 mg/kg, SC) was given 30 minutes before anesthesia induction. Sedation was achieved using intramuscular xylazine (1 mg/kg) and butorphanol (0.2 mg/kg), followed by intravenous induction with diazepam (0.2 mg/kg) and ketamine hydrochloride (5 mg/kg). Anesthesia was maintained with propofol administered IV at 0.5 mg/kg. Endotracheal intubation was performed post-induction.

Positioning

The surgical approach targeted the cranio-lateral femur by positioning dogs in lateral recumbency with the fractured limb uppermost. The distal limb was wrapped in sterile gauze to maintain sterility during manipulation. Sterile draping was applied to expose the surgical site while isolating non-sterile areas.

Orthopaedic Instruments

The surgical management of supracondylar femur fractures utilized a standard orthopedic instrument set for fracture reduction and fixation. This included Gelpi and Hohmann retractors for soft tissue retraction, periosteal elevators, bone hooks for fragment handling, bone files, rongeurs, cutters for bone trimming, reduction and bone holding forceps, pin and K-wire cutters, and both hand and electric drills with drill bits. Plate benders were used for implant shaping. All instruments, including implants, were sterilized using a horizontal autoclave, while the electric bone drill underwent chemical sterilization before surgery, ensuring aseptic conditions throughout the procedure.

Implants

Implant (Fig.13) details are summarized in Table 1. Plate length for Group I was selected using medio-lateral radiographs matched to bone size, with 2.7 mm plates for dogs ≤10 kg and 3.5 mm plates for those >10 kg. Screw length was calculated by measuring transcortical bone diameter at multiple sites using digital calipers, adding plate thickness to ensure secure bicortical fixation.

In Group II, combined fixation with a supracondylar plate and intramedullary pin was used. Plate and screw sizes followed the same weight-based criteria. The intramedullary pin occupied about 40% of the medullary canal diameter at the isthmus. Radiographic views guided accurate implant sizing and placement. Implant specifications are listed in Table 2.

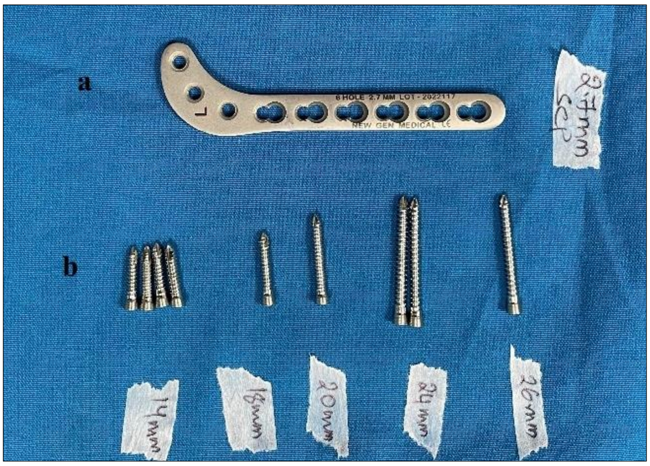


Fig 13: Implant - Supracondylar plate 2.7mm 6 holes supracondylar plate; b. Self-tapping locking screws

Table 1: Implant specifications for group I

Case no	Breed	Age (Months)	B.Wt (Kg)	Implant specification		
				Plate	Proximal	Distal
1	Lhasa Apso	08	10	2.7mm	5	2
2	ND	08	17	3.5mm	5	4
3	Pomeranian	06	3.5	2.7mm	5	1
4	ND	07	16	3.5mm	7	2
5	ND	06	10	2.7mm	7	3
6	Beagle	10	15	3.5mm	5	3

Table 2: Implant specifications for group II

Case no	Breed	Age (Months)	B.Wt (Kg)	Implant specification			
				Plate	No. of screws		IM pin
					Proximal	Distal	
1	Maltipoo	07	4.5	2.0mm	3	1	1.5mm
2	Labrador	05	10.5	2.7mm	5	2	2.0mm
3	ND	04	6.5	2.7mm	3	2	2.0mm
4	ND	12	18	3.5mm	5	3	2.5mm
5	Siberian Husky	03	08	2.7mm	3	3	2.0mm
6	ND	96	14	3.5mm	3	3	3.0mm

Surgical Approach to the Distal Femur

Surgical access to distal femur fractures was achieved through a craniolateral parapatellar approach extending to the stifle joint. The procedure involved incising the tensor fascia lata, separating the biceps femoris and vastus lateralis muscles and performing stifle arthrotomy in most cases, except for fractures proximal to the joint capsule (Fig.14-21). The incision was extended proximally to expose part of the femoral diaphysis for plate placement. This combined approach aligns with techniques described by Piermattei *et al.* (2006) [20] and Madhu *et al.* (2014) [16].

Fig 14: Craniolateral approach extending to the stifle joint.

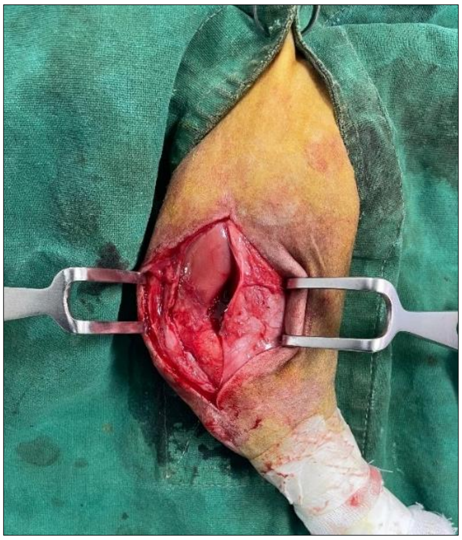


Fig 15: Surgical incision of tensor fascia lata.

Fig 16: Muscle separation: biceps femoris and vastus lateralis

Fig 17: Arthrotomy of the stifle joint.

Fig 18: Reduction of fracture fragment using serrated forceps.

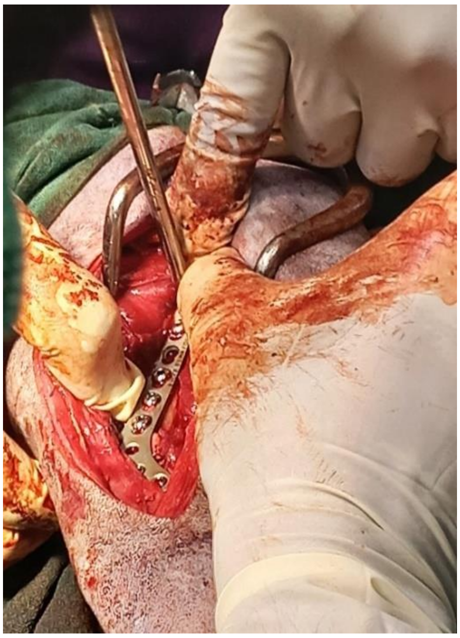


Fig 19: Hexagonal orthopedic screwdriver securing the plate with screws, bicortically.

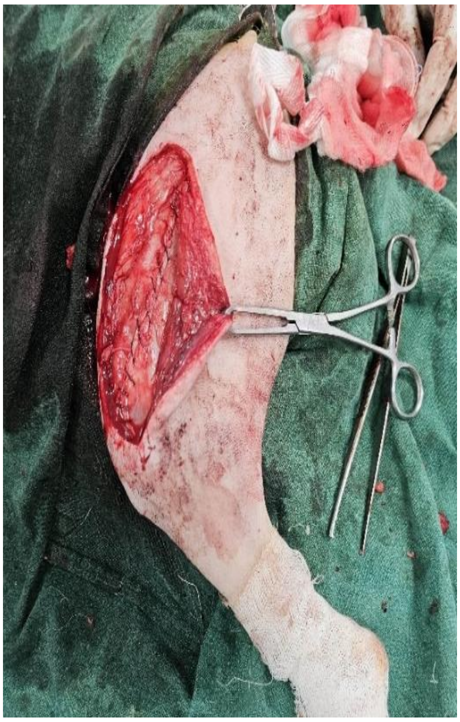


Fig 20: Soft tissue closure: arthrotomy, and fascia lata apposition with continuous 2-0 polyglactin 910.

Fig 21: Skin closure with No. 2-0 polyamide.

Closure of the incision

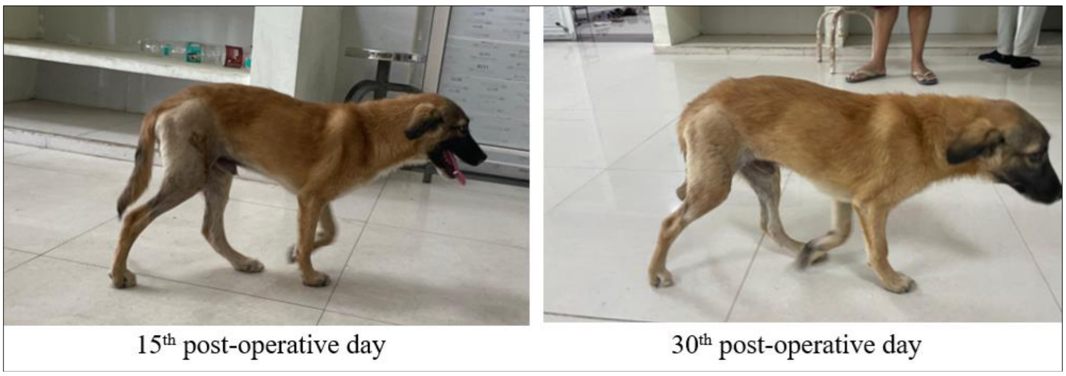
In case of femoral approach, the fascia lata was sutured with 2-0 polyglactin 910 in a simple continuous suture pattern. Subcuticular sutures were applied with 2-0 polyglactin 910(Fig.20). Skin incision was closed with a row of cruciate mattress sutures of 2-0 polyamide (Fig.21)

Post-Operative Care and Management

Postoperative radiographs were taken immediately after surgery for all groups. Surgical sites were managed with 5% povidone-iodine dressings, resulting in clean wounds. Limb immobilization was effectively achieved using a modified Robert-Jones bandage. Pain control was maintained with oral carprofen (2 mg/kg) and infection was prevented with prophylactic amoxicillin (15 mg/kg) in all cases.

Results

Clinical evaluation was carried out every alternate day to check for the presence of swelling, exudation and weight bearing in all the dogs. The appearance of suture line was also examined every alternate day until the sutures were removed. The post- operative day on which the day started bearing weight was recorded and graded for lameness (Fig. 22). After suture removal, the dogs were examined once in a week for the limb stability until fracture healing was considered satisfactory.



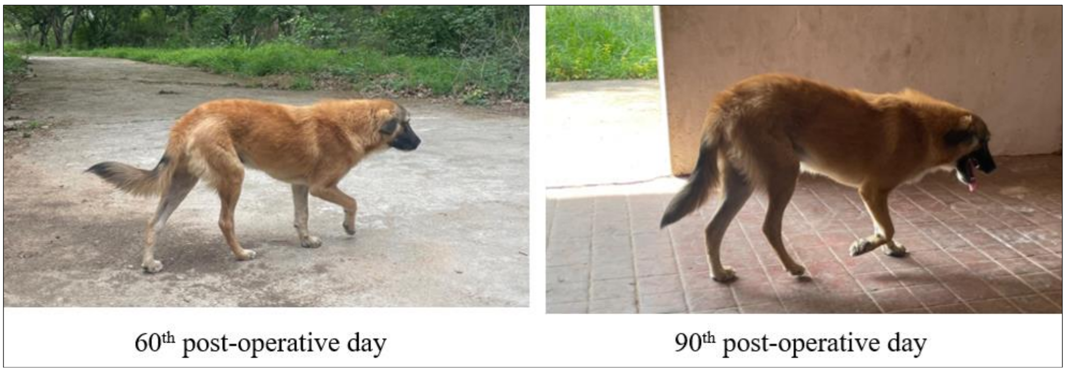


Fig 22: Progressive weight-bearing of the right hind limb (Group II, Case 3) over different post-operative days.

Postoperative Clinical Evaluation

Throughout the study, surgical wounds healed primarily by first intention, with no discharge observed in any group. Skin sutures were removed between 10 to 14 days postoperatively, allowing clean wounds to close with minimal complications. Systemic administration of broad-spectrum antibiotics effectively supported infection prevention during the recovery period.

Lameness grading

A detailed summary of lameness assessments for all dogs across the three groups is shown in Table 3. Initially, all dogs in Group I exhibited grade V lameness, which improved to grade IV immediately after surgery. By 15 days post-operation, five dogs reached grade III with normal weight bearing, while one case achieved this by day 45. At 90 days, all but one dog showed no lameness and good joint mobility; one case remained at grade II.

Similarly, Group II dogs started with grade V lameness, improving to grade IV post-surgery. By day 15, all but one dog reached grade III lameness, with the remaining case reaching it by day 50. Most dogs in this group had no lameness and good joint function by 90 days, except one that had persistent grade II lameness and limited stifle motion at day 60.

Table 3: Lameness grading in all three groups of dogs

Group	Case no	Pre-operative	Lameness Grade				
			0th day	15th day	30th day	60th day	90th day
I	1	V	IV	III	I	I	I
	2	V	IV	III	I	I	I
	3	V	IV	IV	III	II	II
	4	V	IV	III	I	I	I
	5	V	IV	III	I	I	I
	6	V	IV	III	I	I	I
II	1	V	IV	III	I	I	I
	2	V	IV	III	I	I	I
	3	V	IV	III	II	II	II
	4	V	IV	III	I	I	I
	5	V	IV	III	I	I	I
	6	V	IV	IV	III	II	I

Post-Operative Radiographic Observations

Immediate postoperative radiographs confirmed correct placement of the supracondylar femur plate with self-tapping cortical screws and good alignment of fracture fragments in all dogs (Figs. 23-24). Immobilization was satisfactory in every case. Radiographs taken on the 30th postoperative day showed proper fragment alignment, reduced fracture gaps, and progressive callus formation with increasing radiodensity. By day 60, the fracture line had disappeared, callus was fully radiodense, and the cortico-medullary canal was clearly defined in all dogs. Both groups demonstrated excellent radiographic healing without complications (Figs. 25-26).

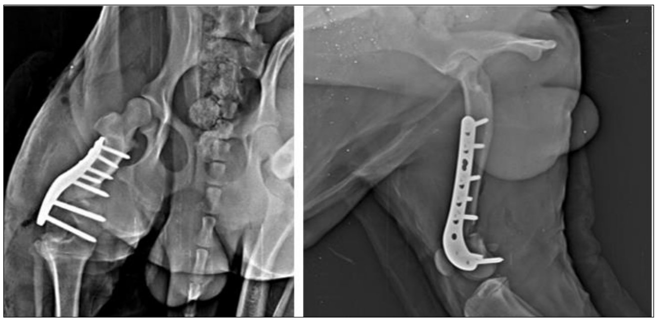
Post-operative complication

In Groups I and II, all implants remained until plate removal, with full functional recovery by day 60 post-surgery. Muscle atrophy in two cases due to poor postoperative care was successfully treated with implant removal and physiotherapy. Post-removal radiographs confirmed complete fracture healing with no displacement, highlighting the pin-plate construct's effectiveness in providing stable fixation and promoting bone healing.

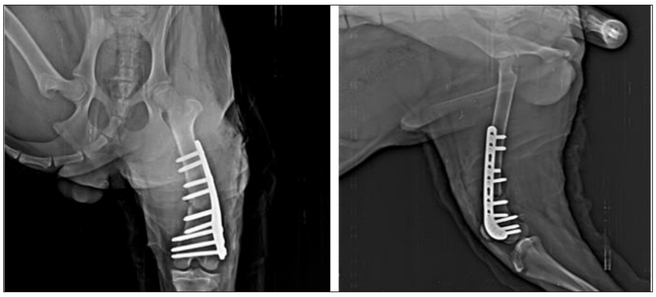
Discussion

Post-operative management in the present study demonstrated the efficacy of a multi-modal approach for orthopedic surgical wound healing. The consistent application of 5% povidone-iodine pads effectively maintained a clean surgical site in all canine subjects. This was complemented by immediate post-operative limb bandaging, specifically using a Modified Robert Jones bandage for ten days, a practice supported by established veterinary orthopedic recommendations (Tobias, 1995; De Camp, 2003; Johnson, 2013; Reddy, 2020; Pravalika, *et al.* 2023) [25, 8, 12, 23, 21]. Furthermore, a week-long course of amoxicillin proved satisfactory in preventing post-operative infections, aligning with the positive outcomes reported by Bose (2017) [4] and Kumar (2017) [14]. While this comprehensive approach consistently yielded well-healed surgical wounds without complications in all dogs, it was important to acknowledge contemporary perspectives. For instance, Yayla *et al.* (2022) [27] suggest that for certain procedures like plating, avoiding bandaging might facilitate earlier ambulation. Similarly, Mercillin and Freeman (2005) [18] advocate against post-joint surgery bandaging to promote early rehabilitation and mitigate negative effects of immobilization. Despite these contrasting viewpoints, the protocols employed in this study consistently led to satisfactory outcomes, indicating their suitability for the specific surgical contexts investigated.

Case 1



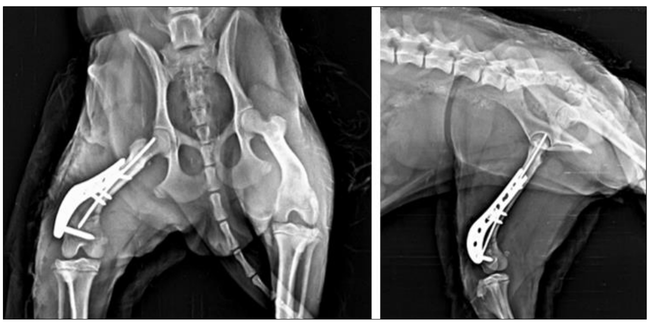
Case 2



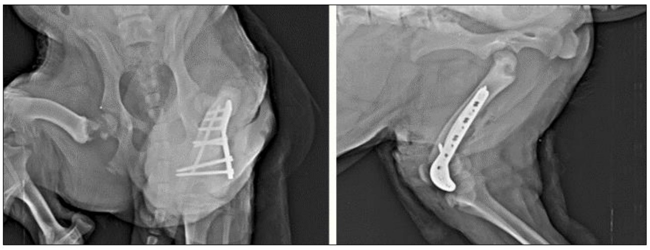
Case 3

Fig 23: Immediate post-operative radiographs (cranio-caudal and medio-lateral views) in Group I cases 1 to 3.

Case 1



Case 2



Case 3

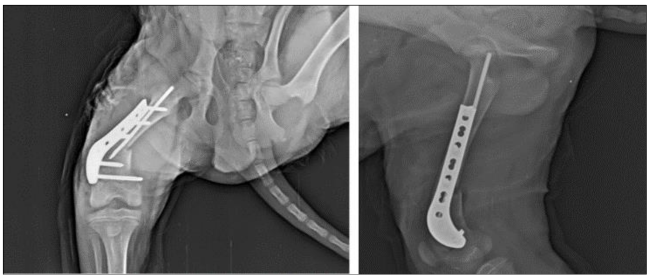
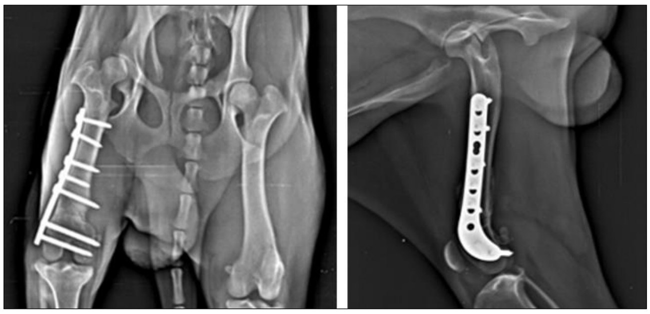
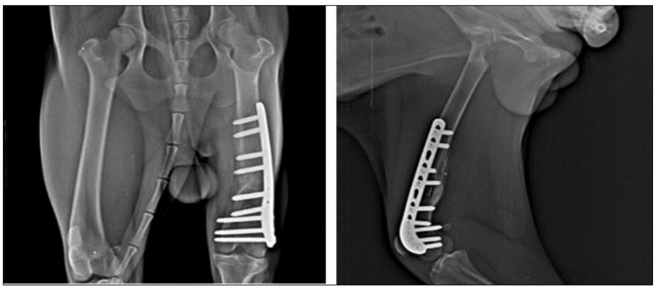


Fig 24: Immediate post-operative radiographs(cranio-caudal and medio-lateral views) in Group II cases 1 to 3.

Case 1



Case 2



Case 3

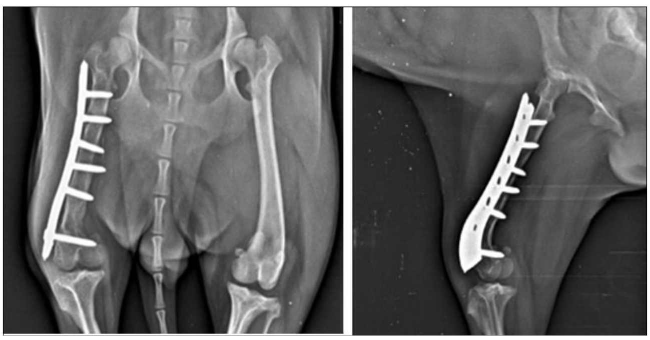


Fig 25: Radiographs showing transition from fracture repair to remodeling with complete bridging of the fracture gap and onset of external callus remodeling at 60 days post-operation in cases 1,2 and 3 of Group I.

Case 1

Case 2

Case 3

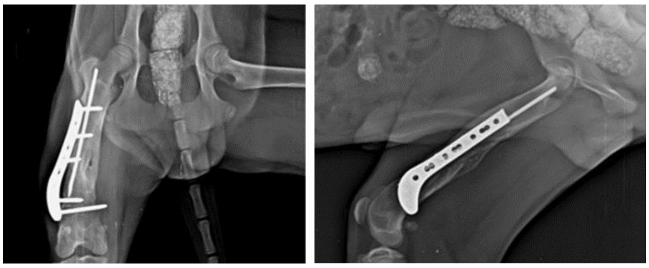


Fig 26: Radiographs showing transition from fracture repair to remodeling with complete bridging of the fracture gap and onset of external callus remodeling at 60 days post-operation in cases 1,2 and 3 of Group II.

In the present study, our findings highlight that orthopedic stabilization of supracondylar fractures can be achieved using several techniques described by Aithal *et al.* (1999) [1], Lidbetter and Glyde (2000) [15], Harasen (2001) [11], and Mahajan *et al.* (2007) [17], including intramedullary pins, crossed K-wires, Rush pins, dynamic compression plates, plate-rod constructs, and hybrid external fixators. Consistent with Braden and Brinker (1973), we observed that plating specifically the use of caudally bowed supracondylar plates (Kumar, 2017; Reddy, 2020; Pravalika *et al.*, 2023) [14, 23, 21] provided stable fixation and facilitated appropriate screw placement in the distal fragment, supporting reliable functional recovery.

For comminuted or multifragmentary fractures, our experience supports a shift towards minimally invasive techniques as promoted by Beale (2004), where use of the plate-rod construct, as advocated by Lidbetter and Glyde (2000) [15], Harasen (2002) and Basha *et al.* (2023) [2], preserved soft tissue attachments and promoted biological osteosynthesis. The plate-rod combination notably increased the implant's fatigue life and resistance to deformation, consistent with their biomechanical findings.

Conclusion

The plate-rod construct offered superior mechanical stability compared to plating alone due to its combination of a rigid fixation plate and an intramedullary rod. This synergistic load-sharing between the plate and rod effectively counters bending, torsional and compressive forces at the fracture site, thereby promoting osteosynthesis. This enhanced stability reduces micromotion, facilitates more direct bone healing and enabled a quicker functional recovery in dogs. In comparison, although plating provided good stability, it lacks the additional intramedullary support and therefore was less effective at counteracting multiple forces simultaneously. Importantly, plates used in both plating and plate-rod techniques generally require removal after clinical union in growing dogs to prevent interference with bone growth. Therefore, the choice between these techniques should consider fracture characteristics, patient size, and the need to preserve physeal function, balancing mechanical demands with biological and clinical factors.

Acknowledgements

The author gratefully acknowledges the College of Veterinary Science, Rajendranagar, PVNRTVU and Hyderabad for providing vital infrastructure and facilities essential to conduct this research. Appreciation is also extended to the dog owners for their cooperation in bringing their dogs for regular postoperative evaluations of supracondylar femur fracture cases.

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