

Original Research Article

Management of long bone fractures using diverse fracture fixation techniques in small animals

ABSTRACT

Total 11-cases of dogs and one case of cat having long bone fractures were successfully managed using totally intravenous anaesthesia (TIVA) in different breeds of dogs. For TIVA, combination of xylazine and ketamine were used for induction whereas sole ketamine was used for maintenance and atropine sulphate was used as preanaesthetic anticholinergic agent. TIVA found suitable for orthopaedic surgeries in this study. Intramedullary pinning, bone-plating (Dynamic compression plating and Reconstruction plating), external skeletal fixation system (using jess clamps and epoxy) or combination of two different fracture fixation techniques were performed for surgical management of presented fracture cases. For combination of two orthopaedic techniques, either bone plating with supplementary IM-pinning or ESF with IM-pinning were used in this study. All cases were evaluated by radiographs as well as clinical performance of operated limbs. Radiographs were taken at regular interval for assessment of radiographic bone healing and in those cases where radiographs were not possible owner contacted telephonically.

Key Words: Long bones, IM-pinning, Bone-plating, ESF, radiographs, clinical evaluation

INTRODUCTION

Occurrence and incidence of fractures in small animals increased from past few years and it may be attributed to increased number of automobile accidents, rapidly growing pet animal population and higher number of stray dogs at particular geographical area (Sharma, 2021 and Mohan Lal, 2020). Complete or incomplete break in the continuity of bone or cartilage results in an emergency condition called fracture, which is accompanied by various degrees of injury to the surrounding soft tissues (including, muscles, tendons, ligaments, nerves, blood supply) which ultimately leads to compromised locomotor system (Piermattei *et al.*, 2006) and different fracture configurations demands different fixation techniques (Fossum, 2019). Appendicular fractures are more frequent in pets (Jain *et al.*, 2018; Vidaneet *et al.*, 2014). Internal fixation with open

reduction (Brinker *et al.*, 1974; Hulse and Johnson, 1997), external skeletal fixation (ESF) with open or closed reduction (Aron and Toombs, 1984) and external coaptation (De Camp, 1993) are various options for fracture treatment. Advantages as well as drawbacks are associated with each fracture fixation technique. Use of fracture fixation techniques with significant clinical results depends on type and the configuration of a presented fracture case.

Materials and Methods

Total 12 cases (11 dogs and a cat) referred to Veterinary Clinical Complex, College of veterinary and animal science, Navania, Vallabh Nagar, (RAJUVAS-SOUTH CAMPUS), Udaipur, Rajasthan, were used in this study between March 2021 and November 2021. The 11 dogs presented were of different age, breed and sex.

Preoperative planning, Anaesthesia, Surgical procedures and Postoperative follow-up

Presented fracture cases were completely examined to rule out any neurological condition. After clinical examination, two orthogonal radiographs of fractured limb were taken in all cases. The exact location of the fracture, the number of fragments in one fracture, the directions and locations of longitudinal fissures, medullary cavity diameters at isthmus, cortex to cortex diameter, appropriate intramedullary pin diameters and bone plate and screw size, the number of Ellis-pins for ESF and IM-pins for Stack-pinning to be used, pin types (threaded and smooth), pin lengths were determined from these radiographs. The implants and the whole set of surgical instruments including all the accessories were prepared and sterilized according to the presented case. Anaesthesia was induced by intramuscular injection of a combination of xylazine hydrochloride (1mg/kg) and ketamine hydrochloride (5 mg/kg), Atropine sulphate (0.04mg/kg) and maintained with repeated intravenous injections (IV) of Ketamine hydrochloride. In case of cat, for induction, intramuscular injections of xylazine (0.5 mg/kg) and ketamine (15mg/kg) was used and maintained by repeated IV ketamine hydrochloride.

Surgical procedures

- a) For intramedullary pinning : A craniolateral approach has been used for both humerus and femur fractures and 50-60% of medullary cavity diameter at isthmus of bone was chosen as size of intramedullary pins for single IM-pin insertion. In all cases (excluding one tibia fracture), where intramedullary pins were used, open fracture reduction was done and pins were inserted through retrograde manner (Fig.1), using Jacobs chuck. In one tibia intramedullary pin insertion has been done using antegrade technique (Fig.2) (for detail see Table.1).
- b) For Bone plating: Dynamic compression plate (DCP) and Reconstruction plates were used in few cases of femur fracture (Fig.3&4). Bone plates were applied in cranio-lateral surface of the femur. In all the cases where bone plates were applied, simultaneously intramedullary pinning or circlage wiring was also done as ancillary fixation to make implant more rigid. Bone plates were affixed with self-tapping screws using appropriate size drill bits and screw-drivers (for detail see Table. 1).
- c) For external skeletal fixation: In present study, ESF has been done in radial, femur and humeral fractures (Fig.5, 6&7). Transcortical pins/Ellis pins of required diameter (20% of cortex to cortex diameter) were drilled through safe-corridors using low rpm (150 rpm) drill machine. To minimize thermal necrosis, sterilized solution was used for flushing during pin drilling process. Cranio-lateral and craniomedial approach has been used for radial fractures due to presence of heavy muscles, no safe corridors were found for humeral and femoral fractures and therefore unilateral uniplanner and free-form ESF techniques using epoxy putty has been used. Exceptionally one humeral condylar fracture was stabilised using Type-II uniplanner bilateral along with cross pinning technique (Fig.7). In most of the cases except radial fracture, where ESF has been done, simultaneously intramedullary pins or cross pinning were also used to make implant more rigid (for detail see Table. 1).
- d)

Postoperative follow-up: Implant placement and reduction of fracture fragments were evaluated by 15-days regular intervals of radiographs postoperatively. Antibiotic; cefopodoxime (15 mg/kg, peros) and NSAID; carprofen (4 mg/kg, peros) were administered for 15 days and 3 days, respectively, to all operated cases. Owners were advised to dress the incision line and pin penetration surfaces (in case of ESF) with 10% povidone-iodine solution twice a week. Robert Jones bandage (Fossum, 2019) was applied to minimize postoperative oedema formation (in case of internal fixation) and to avoid external contamination to ESF assembly. We contacted owners to obtain information about the condition of their pets and were advised to limit the movements of their pets for the following 10-15 days.

Results and Discussion

Total 11-cases of dogs, age ranging from 7-month to 96-months with mean body weight of 18.25 ± 2.79 Kg, were operated. One cat having 12 month age and 6 kg body weight were also reported. Aetiology noted in study was: dog-fight (n=5, 41.67%); owner abuse (n=2, 16.67%); automobile accidents (n=2, 16.67%); fall from height (n=2, 16.67%) and unknown (n=1, 8.33%). Complete clinical findings along with outcomes is summarised in Table .1

Table 1: Details of clinical findings and Results (also see figures)

Case No	Breed/Sex /Age (in months)	Bone/Limb/type of fracture	Details of implant used	Surgical technique	First day of partial weight bearing	Day of complete weight bearing	Day of Implant Removal	Radiographic healing status on the day of implant removal
1.	Labrador/ M/8	Femur/Right/Simple, Short-oblique, mid-shaft	3 mm Smooth trocar pointed Steinman-pin	Retrograde IM- pinning along with ancillary circlage wiring	Next day of surgery	Not observed till implant removal	73 rd day	Apparent callus, Bridging of fracture line

2.	Non-descript /F/14	Femur/Left/Simple, Transverse, mid-shaft	3.5 mm,end-threaded, negative profile, Steinman-pin	Retrograde IM-pinning	Next day of surgery	184 th day	154 th day	Massive Callus, Bone trabeculaecrossing fracture line
3.	German-shepherd/ M/18	Femur/Left/Simple, transverse, mid-shaft	4.5 mm and 2.5 mm Smooth trocar end Steinman-pin	Stack pinning	Next day of surgery	177 th day	Single pin(4.5mm) was removed on 22 nd day	Homogeneous bone structure, fracture union achieved
4.	Labrador/ M/48	Humerus/Right/Simple,oblique,Distal 1/3 rd	4.5 mm, end-threaded, Positive profile, Steinman-pin for IM-pinning while 2.5 mm 4 K-wires for ESF construct	IM-pinning with Free – form ESF using epoxy putty	28 th day of surgery	94 th day	Only ESF was removed on 24 th day	Massive Callus, Bone trabeculaecrossing fracture line, union achieved
5.	Doberman /F/12	Humerus/Left/Simple, condylar fracture	2.5 mm and 3 mm, 3 K-wires for cross-pinning and ESF respectively	Cross-pinning along with Type-II, Bilateral-Uniplanner ESF	17 th day of surgery	87 th day	Complete implant was removed on 31 st day	Apparent callus, Bridging of fracture line
6.	Persian cat/M/12	Femur/Left/compound, transverse, distal1/3 rd	2 mm end-threaded, Negative profile, Steinman-pin for IM-pinning while 2.5 mm(2) and 2 mm (2) K-wires along with four Jess-clamps (3 mm) for ESF construct	Retrograde IM-pinning with Unilateral,uni planner ESF	Next day of surgery	83 rd day of surgery	36 th day	Apparent callus, Bridging of fracture line, union achieved
7.	Great Dane/F/9	Femur/Left/Simple, long-oblique, Spiral	4 mm,7-holes,Reconstruction plate affixed with four(4mm) self tapping cortical screws and stack pinning using three pins of 3 mm and whole implant was	Combination of Bone plating, stack pinning and circlage	Next day of surgery	Only partial weight bearing observed	Complete implant removed on 36 th day	Trace callus. No bridging of fracture line, moderate periosteal

			finally stabilised by ancillary wiring (1.5 mm orthopaedic wire)	wiring		till 3 month of follow-up	excluding one pin.	reaction, union not-achieved
8.	German shepherd/ F/96	Femur/Right/Simple, short-oblique, mid-shaft	3.5 mm,6-holes, Dynamic compression plate (DCP) 2affixed with five 3.5 mm self tapping cortical screws along with 3mm negative profile, end-threaded, single Steinman pin	Combination of DCP and IM-pinning	25 th day of surgery	61 st day of surgery	31 st day	Apparent callus, Bridging of fracture line, union achieved
9.	French Bulldog/M /7	Femur/Left/Simple, transverse, distal 1/3 rd	3.5 mm,5-hole, reconstruction plate affixed with five,3.5 mm self tapping cortical screws along with Single 3 mm Steinman pin as IM-pinning	Plate-Rod combination	Next day of surgery	62 nd day of surgery	Implant left as it is and not removed	Homogeneous bone structure, union achieved
10.	Non-descript/M /12	Tibia/Left/Simple, Short-oblique,mid-shaft	4 mm, Negative-profile,end-threaded, single Steinman pin	Normograde IM-pinning	Next day of surgery	69 th day of surgery	Pin migration occurred 11 th day of surgery	Trace callus. No bridging of fracture line
11.	German shepherd/ M/12	Radius-ulna/Simple, transverse, distal 1/3 rd	Three transcortical pins of 3 mm diameter were used for ESF construct using epoxy	Epoxy ESF (Type-II, Uniplanner, bilateral) by closed reduction	Next day of surgery	66 th day of surgery	28 th day of surgery	Apparent callus, Bridging of fracture line, union uncertain
12.	Labrador/ M/14	Femur/Right/Simple, spiral, mid-shaft	Four 3.5 mm, end threaded negative profile, transcortical pins and 4mm Jess clamps to make an ESF-construct	Unilateral-uniplanner Linear ESF system	Next day of surgery	90 th day	ESF assembly get loosened	Radiograph not taken

							and removed on 66 th day of surgery	
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M: Male, F: Female, ESF: External skeletal fixation

Table.2 Post-operative complications

Post-operative complications		Percentage	
Pin-migration	Proximal pin migration	44.44% (4/9)	55% (5/9)
	Distal pin-migration	11.11% (1/9)	
Suture line sepsis		9.09% (1/11)	
Bone-plate displacement		33.33% (1/3)	
Severe periosteal reaction		8.33% (1/12)	
Complete ESF-assembly dislodgement		20% (1/5)	
Pin-skin interface sepsis (In ESF)	Early (up to 7 days)	20% (1/5)	100% (5/5)
	Late (after 7 days)	80% (4/5)	
Joint-stiffness		25% (3/12)	
Periarticular fibrosis		16.67% (2/12)	

According to Aithal *et al.*, (1999) and Sharma, (2021) young ones are more active and playful and so more prone hazards unlike their older counterparts and similar to these findings, in the present study, more number of cases reported are younger ones. Automobile accidents are the common cause of fractures (Sharma, 2021; Mohan Lal, 2020; Hemant Kumar, 2019 and Mathai, 2012) however, the present study, with a small group of eleven dogs, showed dog fight as the major cause of fractures. Open fractures usually occur in about 5% to 10% of the total fracture cases seen (Piermattei *et al.*, 2006) and similarly, 8.33% (n=1, single Tom-cat) open fracture cases were reported in this study. Techniques used to reduce fractures must overcome the physiologic processes of muscle contraction and fracture fragment overriding (Fossum, 2019). As cortical bone is the most demanding structure of stability, more fractures were reported at shaft of long bone. (Piermattei *et al.*, 2006). Similarly, the present study, majority of cases were with mid-shaft fractures and for better stability, combination of two different internal fixation techniques or combination of internal and external skeletal fixation techniques were used. However few cases were stabilised by sole fracture fixation technique (like sole IM-pinning, or ESF) but such cases did not show better outcome comparatively, in this study. Solely internal fixation (or combination of two internal fixation technique) was done in 58.33% (n=7) cases, whereas, 41.67% (n=5) cases were stabilised either with ESF or a combination of internal and external skeletal fixation. Phillips, (1979) mentioned in their survey results that intramedullary pins are supreme for shaft fractures of the femur in small dogs and cats. Uddin *et al.*, (2017) in their study, stated that femur fractures were most commonly reported in young dogs than adult and internal fixation with IM-pinning was found satisfactory as well as economical with minimum complications. Similarly, in the present study, 66.67% (n=8) fractures reported in femur but only four cases (n=3, 37.50%) were managed by sole IM-pinning technique and found economical along with pin migration in almost all cases. Ganesh, (2019) reviewed that several options such as plate osteosynthesis, intramedullary implants, or external skeletal fixation (ESF) are available for the treatment of fractures of long bones and that choice can be difficult. Of all procedures, plate osteosynthesis showed highest mechanical stability, but the poorest course of fracture healing and similarly, in the present study, one case which was operated with plate-rod combination showed poorest radiographic follow-up (Fig. 18). Ganesh (2019) also mentioned that overall best results were obtained with the bridging osteosynthesis and external skeletal fixation with an intact endosteal and periosteal perfusion. In this study, 57.15% (n=4 out of 7) cases operated with internal fixation, showed overall good results whereas 80% (n=4 out of 5) good results were reported in cases where ESF was applied and overall best results were obtained with

external skeletal fixation as stated by Ganesh, (2019). In case of intramedullary implant placement, most complications were recorded with occurrence of infection and which results in migration (Uddin *et al.* 2017). Similarly, in this study, 55% cases showed migration even after application of combination of different techniques and it may be attributed to post-operative infection and hyperactivity of animal. Pin tract sepsis, joint stiffness, periarticular fibrosis and muscle atrophy are the common complications associated with ESF (Sharma, 2021; Mohan Lal, 2020; Yardimci *et al.*, 2011; Ozaket *et al.*, 2009; Marti and Miller, 1994 and Whitehair and Vasseur, 1992) which were in accordance with the present study (See Table. 2).

Conclusions: Simple intramedullary pinning technique using open method of reduction was found suitable technique for management of femoral fractures in light body weight pets. Proximal pin migration was the most common complication of simple IM-pinning technique. Normograde IM-pinning technique is suitable method for internal fixation of fractures of tibia. IM-pin migration can be reduced if other fracture fixation technique is used simultaneously. Bone plating provided more rigid fixation but require further invasive process for removal of implant. Plate-rod combination can be more rigid combination. Compound fracture can be managed successfully using external skeletal fixation system. distal radial fracture can be successfully managed using ESF alone, instead of bone plating. ESF removal doesnot requires any further invasive process like other internal fixation techniques. ESF and IM pinning combination found suitable for management of femur fracture in cat without any complication. All invasive fracture fixation techniques associated with postoperative hurdles both for surgeon as well as owner. ESF has more postoperative complications as compare to other fracture fixation techniques and it hampered dressing in postoperative period. Minor pin tract discharge is most common postoperative complication associated with ESF-technique in pets. An orthopaedic surgeon should always inform to owner about outcome and postoperative problems associated with fracture fixation technique.

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A. Intra-operative photographs

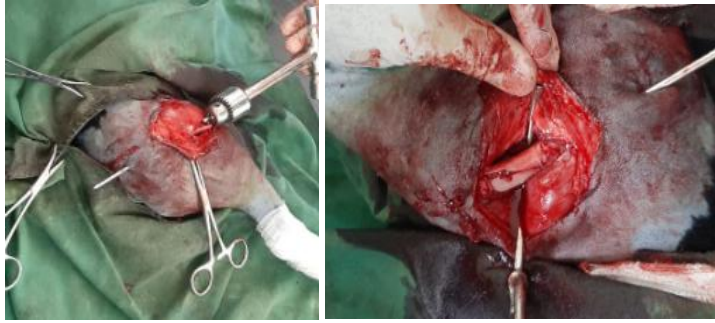


Fig.1 Retrograde IM-pinning placement and complete reduction of oblique femur fracture (case 1)



Fig.2 Normograde IM-pin placement in Tibia (case 10)



Fig.3 Combination of IM-pinning and Reconstruction plate (Case 9)



Fig.4 Dynamic compression plate application (Case 8)



Fig.5 Type-II ESF application in radius-ulna fracture using epoxy putty (Case 11)

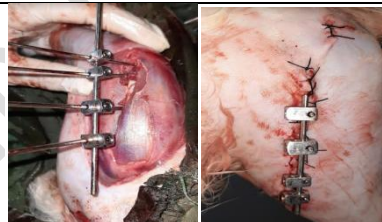


Fig.6 Type-I ESF application in cat (case6)

Figures



Fig.7 Sequence of photographs showing condylar fracture, placement of ESF assembly with cross pinning and final appearance after complete placement of fixator (Case 5)

B. Radiographs

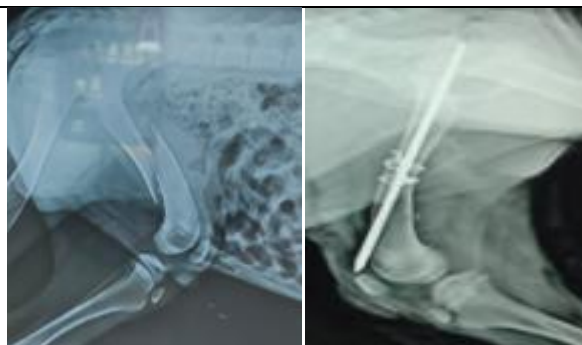


Fig.8 Preoperative and Immediate postoperative radiographs (case1)



Fig.9 Preoperative, immediate postoperative and 15-days postoperative photographs (case2)

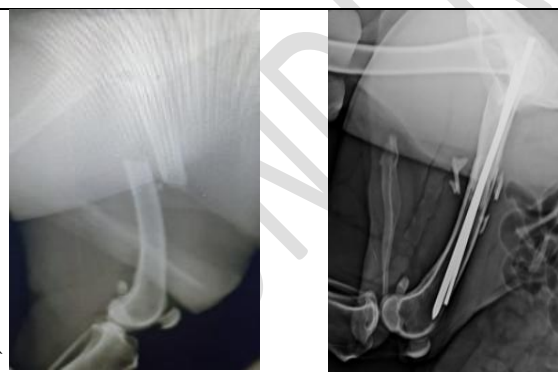


Fig.10 Preoperative and 22-days postoperative (Case3)

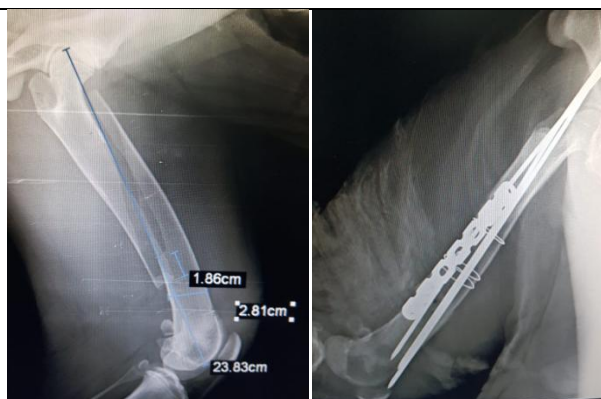


Fig.11 Preoperative and 15-days postoperative radiograph (Case7)

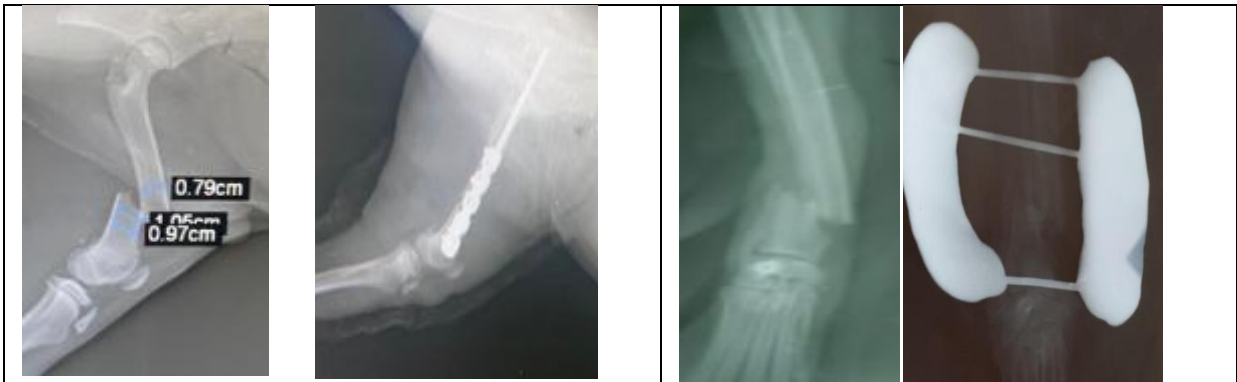


Fig.12 Preoperative and immediate postoperative (case9)

Fig.13 Preoperative and 28-days postoperative (case11)



Fig.14 Preoperative, Immediate postoperative and 36-days postoperative radiograph (case6)



Fig.15 preoperative and 24days postoperative (case5)

C. Postoperative complications and other postoperative pictures



Fig.16 Distal (case1) and proximal pin-migration (case2)



Fig.17 Mild sepsis at pin-skin interface (case4) and suture line sepsis (case7)



Fig.18 36-days postoperative and 46-days postoperative radiographs showing worst healing and periosteal reactions in plate osteosynthesis (case7)



Fig.19 Robert Jones bandaging (RJB) in internal fixation and bandaging of external skeletal fixator in postoperative period

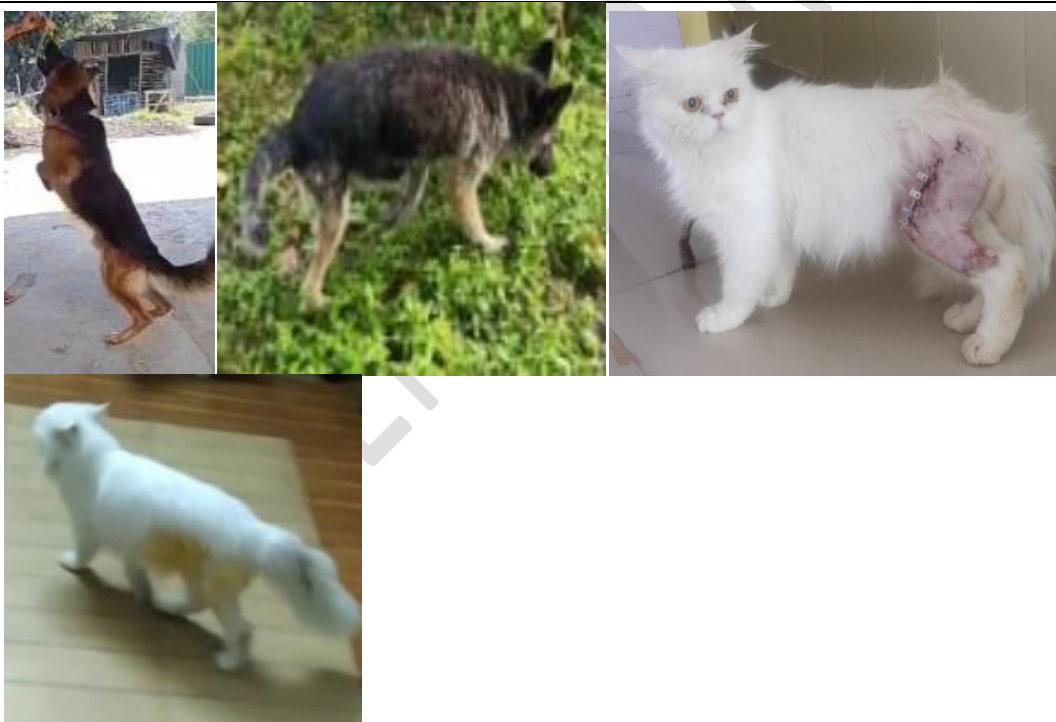


Fig.20 Weight bearing status after internal and external fixation in postoperative period