Original Research Article

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

ABSTRACT

Total 12-cases having long bone fractures were successfully managed using totally intravenous anaesthesia (TIVA) in different breed of dogs. Intramedullary pinning, bone-plating, external skeletal fixation system or combination of two different fracture fixation techniques were performed for surgical management of presented fracture case. All cases were evaluated by radiographs as well as clinical performance of operated limb.

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

INTRODUCTION

Occurrence and incidence of fractures in small animals increased from past years and it may be supposed because of 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 (sometimes 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 accordingly (Fossum, 2019). Appendicular fractures are more frequent in domesticated pets (Jain *et al.,* 2018; Vidane *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 the 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 are depends on type and configuration of presented fracture case.

Materials and Methods

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

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, surgical instruments and whole set was prepared and sterilized according to the presented case. Anesthesia was induced by intramuscular injection of a combination of xylazine hydrochloride (1 mg/kg) and ketamine hydroclorure (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 intamedullary pins for single IM-pin insertion except in stack pinning cases. 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 done using normograde technique (Fig.2) (for detail see Table.1).

b) For Bone plating: Dynamic compression plate (DCP) and Reconsrtuction 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 pining or circlage wiring was also done as ancillary fixation to make implant more rigid. Bone plates were affixed with self-tapping screws using different size drill bit and screw-drivers (for detail see Table. 1).

c) For external skeletal fixation: In present study ESF has 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, normal saline solution was used for flushing during pin drilling process. Cranio-lateral and craniomedial approach has been used for radial fracture (single case using Type-II, Uniplanner Bilateral) while due to presence of heavy muscles, no safe corridors was found for humeral and femoral fractures and that’s why unilateral uniplanner and free-form ESF techniques using epoxy putty has been used. Exceptionally one humeral condylar fracture was stabilised using Type-II uniplanner bilatreral along with cross pining 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).

Postoperative follow-up: Implant placement and reduction of fracture fragments were evaluated by taking 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% polyvidon-iode solution twice in a week. Robert Jones bandaging 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 improvement of the dogs and their clinical status and were advised to limit the movements of their dogs for the following 10-15 days.

Results and Discussion

Total 12-cases, age ranging from 7-month to 96-months with mean body weight of 18.25 ± 2.79 Kg, were operated. 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	73rd 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	184th day	154th day	Massive Callus, Bone trabeculae crossing 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	177th day	Single pin(4.5mm) was	Homogeneous bone structure, fracture union

							removed on 22nd day	achieved
4.	Labrador/ M/48	Humerus/Right/Simple,oblique,Distal 1/3rd	4.5mm, 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	28th day of surgery	94th day	Only ESF was removed on 24th day	Massive Callus, Bone trabeculae crossing fracture line, union achieved
5.	Doberman /F/12	Humerus/Left/Simple, condylar fracture	2.5mm and 3 mm, 3 K-wires for cross-pinning and ESF respectively	Cross-pinning along with Type-II, Bilateral-Uniplanner ESF	17th day of surgery	87th day	Complete implant was removed on 31st day	Apparent callus, Bridging of fracture line
6.	Persian cat/M/12	Femur/Left/compound, transverse, distal1/3rd	2mm end-threaded, Negative profile, Steinman-pin for IM-pinning while 2.5mm(2) and 2mm (2) K-wires along with four Jess-clamps (3mm) for ESF construct	Retrograde IM-pinning with Unilateral,uniplanner ESF	Next day of surgery	83rd day of surgery	36th day	Apparent callus, Bridging of fracture line, union achieved
7.	Great Dane/F/9	Femur/Left/Simple, long-oblique, Spiral	4mm,7-holes,Reconstruction plate affixed with four(4mm) self tapping cortical screws and stack pinning using three pins of 3mm and whole implant was finally stabilised by ancillary wiring (1.5mm orthopaedic wire)	Combination of Bone plating, stack pinning and circlage wiring	Next day of surgery	Only partial weight bearing observed till 3 month of follow-up	Complete implant removed on 36th day excluding one pin.	Trace callus. No bridging of fracture line, moderate periosteal reaction, union not-achieved
8.	German shepherd/ F/96	Femur/Right/Simple, short-oblique, mid-shaft	3.5mm,6-holes, Dynamic compression plate (DCP) 2affixed with five 3.5mm self	Combination of DCP and IM-pinning	25th day of surgery	61st day of surgery	31st day	Apparent callus, Bridging of fracture line,

			tapping cortical screws along with 3mm negative profile, end-threaded, single Steinman pin					union achieved
9.	French Bulldog/M/7	Femur/Left/Simple, transverse, distal 1/3rd	3.5mm,5-hole, reconstruction plate affixed with five,3.5 mm self tapping cortical screws along with Single 3mm Steinman pin as IM-pinning	Plate-Rod combination	Next day of surgery	62nd 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	4mm, Negative-profile,end-threaded, single Steinman pin	Normograde IM-pinning	Next day of surgery	69th day of surgery	Pin migration occurred 11th day of surgery	Trace callus. No bridging of fracture line
11.	German shepherd/M/12	Radius-ulna/Simple, transverse, distal 1/3rd	Three transcortical pins of 3mm diameter were used for ESF construct using epoxy	Epoxy ESF (Type-II, Uniplanner, bilateral) by closed reduction	Next day of surgery	66th day of surgery	28th 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	90th day	ESF assembly get loosened and removed on 66th day of surgery	Radiograph not achieved

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 that's why not learned up to cope up with hazards unlike their older counterparts and similarly higher number of young ones reported in present study. Automobile accidents are most common cause of fracture (Sharma, 2021; Mohan lal, 2020; Hemant Kumar, 2019 and Mathai, 2012) but in present study majority of fractures happened due to dog fight and it may be supposed that breed dogs are domesticated and like stray animals such breed dogs are restricted or not habitual for free wandering. 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 research. Techniques used to reduce fractures must overcome the physiologic processes of muscle contraction and fracture fragment overriding (Fossum, 2019) and cortical bone is the most demanding of stability and is represented by fractures of shaft of long bones (Piermattei et al., 2006) similarly in present study majority of cases reported 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 in present study. However few cases were stabilised by sole fracture fixation technique (like sole IM-pinning, or ESF) but such cases were not showed good results in this study. Purely 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 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, they 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 and similarly in 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 only and found economical along with pin migration in almost 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. The choice can be difficult. Of all procedures plate osteosynthesis showed highest mechanical stability, but the worst course of fracture healing and similarly in present study one case which were operated with plate-rod combination showed worst radiographic follow-up (Fig. 18). They also mentioned that overall best results were obtained with the bridging osteosyntheis 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 recorded in the presence of infection and these results in migration of the pin (Uddin *et al.* 2017) similarly in this study 55% cases showed migration even after application combination of techniques and it may be supposed due to post-operative infection and over activity 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;Ozak *et al.,* 2009; Marti and Miller, 1994 and Whitehair and Vasseur, 1992) which were matched with present study (See Table. 2).

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Figures

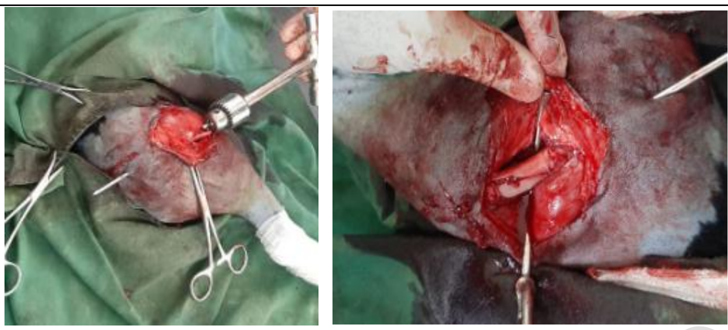
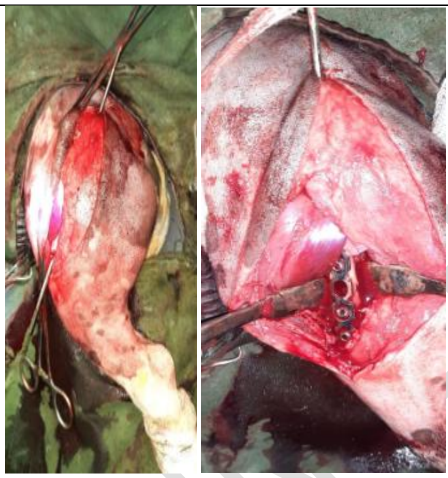
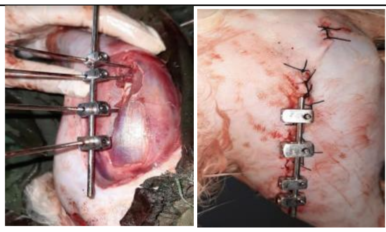
<table>
<tr><th colspan="3">A. Intra-operative photographs</th></tr>
<tr><td colspan="2">
Fig.1 Retrograde IM-pinning placement and complete reduction of oblique femur fracture (case 1)</td><td>

Fig.2 Normograde IM-pin placement in Tibia (case 10)</td></tr>
<tr><td>
Fig.3 Combination of IM-pinning and Reconstruction plate (Case 9)</td><td>
Fig.4 Dynamic compression plate application (Case 8)</td><td>
Fig.5 Type-II ESF application in radius-ulna fracture using epoxy putty (Case 11)</td></tr>
<tr><td colspan="3">
Fig.6 Type-I ESF application in cat (case6)</td></tr>
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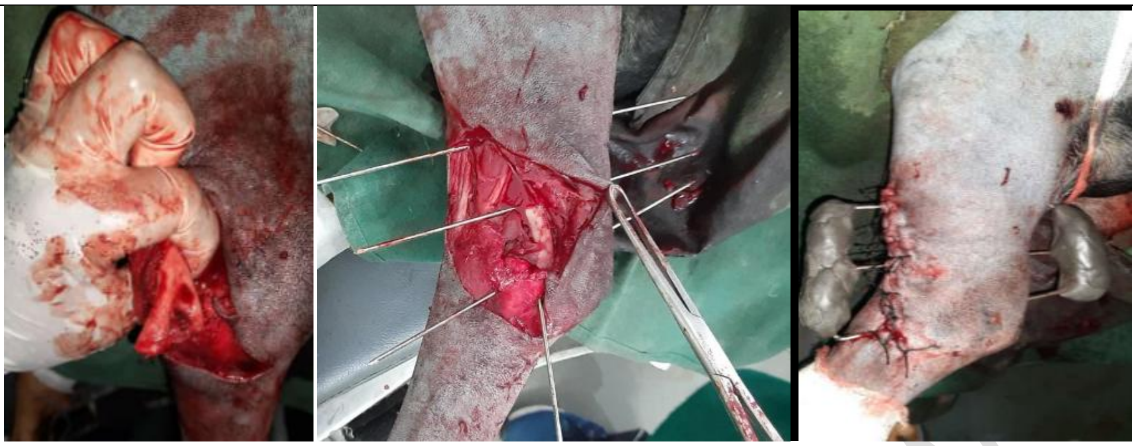

Fig.7 Sequence of photographs showing condylar fracture, placement of ESF assembly with cross pinning and final appearance after complete placement of fixator (Case 5)

B. Radiographs

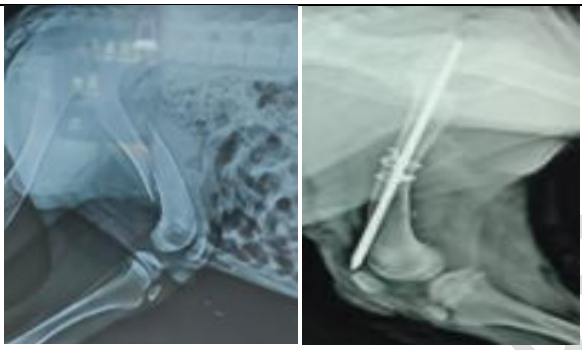

Fig.8 Preopertaive and Immediate postoperative radiographs (case1)

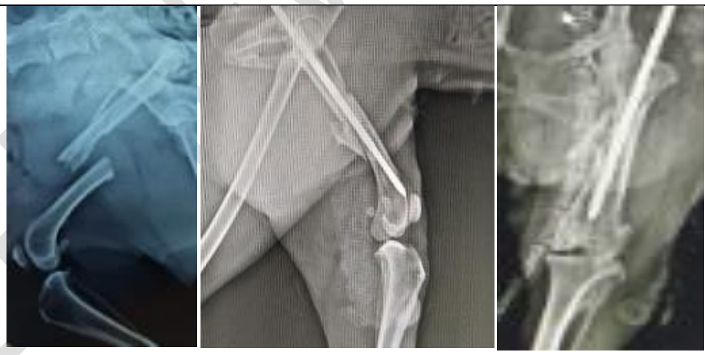

Fig.9 Preoperative, immediate postoperative and 15-days postoperative photographs (case2)

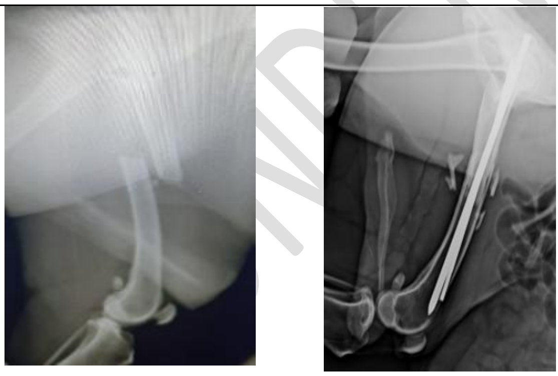

Fig.10 Preoperative and 22-days postoperative (Case3)

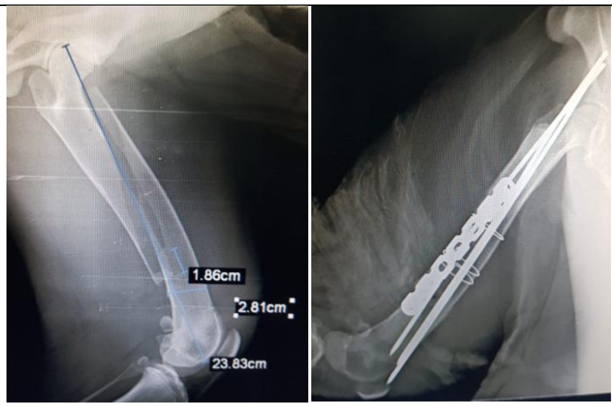

Fig.11 Preoperative and 15-days postoperative radiograph (Case7)

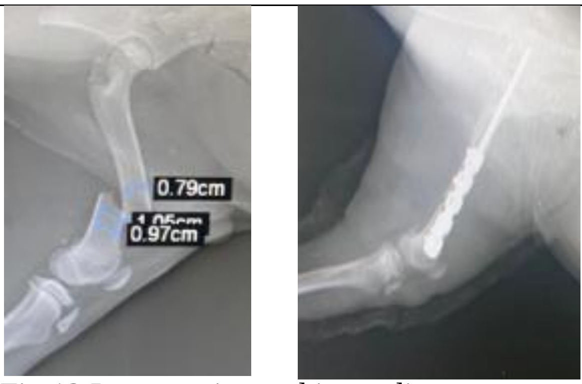

Fig.12 Preoperative and immediate postoperative (case9)

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

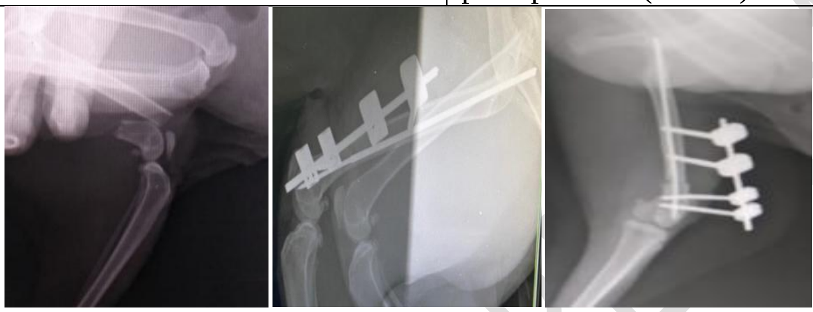

Fig.14 Preoperative, Immediate postoperative and 36-days postoperative radiograph (case6)

Fig.15 preoperative and 24 days 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 osteosyntheis (case7)

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

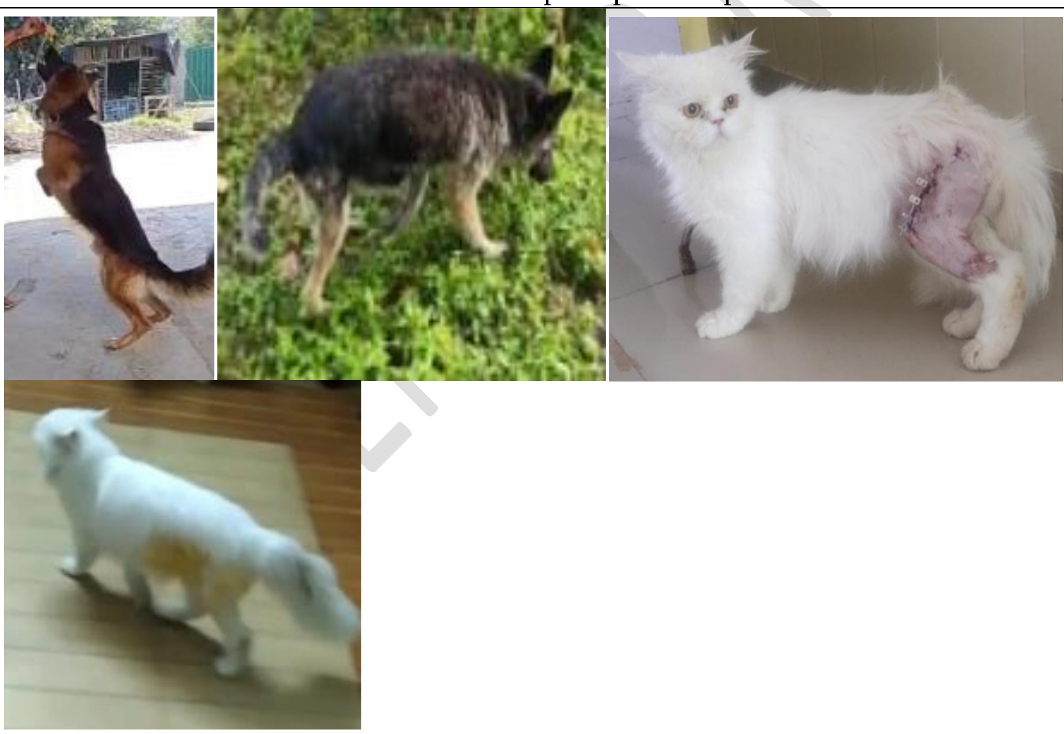

Fig.20 Weight bearing status after internal and external fixation in postoperative period