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### RESEARCH ARTICLE

#### USE OF TIE-IN CONFIGURATION TECHNIQUE IN THE REPAIR OF FEMORAL AND HUMERAL DIAPHYSEAL FRACTURES IN DOGS.

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#### Abstract

In this study Tie-in pin configuration technique was employed in the stabilization of 5 femoral fractures and 1 bilateral humeral fracture in dogs. Immediate postoperative radiographs revealed good alignment and apposition of the fracture fragments in all the dogs. The mean time of sufficient callus formation was  $43.16 \pm 4.46$  days. Postoperative radiographs showed restitution of cortico-medullary continuity by 45<sup>th</sup> to 55<sup>th</sup> postoperative day in all the dogs. The complete weight bearing was ranging from 32<sup>nd</sup> - 90<sup>th</sup> postoperative day. The fixator was found rigid and stable till the completion of bone healing in all the dogs. The mean time of the fixator removal was  $43.16 \pm 4.46$  days. Pin tract infection with appearance of granulation tissue in one dog was seen at the intramedullary pin exit site. Tie-in pin configuration technique was well suited for the repair of femoral and humeral diaphyseal fractures in dogs with a few negligible minor complications

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#### Introduction:-

Long bone fractures are common in dogs. Among all long bone fractures, femoral fractures are frequently encountered (Ben Ali, 2013 and Simon *et al.*, 2010). Humeral fractures are less common (Aitha *et al.*, 1999). These fractures usually occur due to the trauma in the form of road side accidents. Intramedullary Pinning (IM) is still most frequently used method of femoral and humeral fracture fixation in dogs (Piermattei *et al.*, 2006 and Fossum, 2007). Intramedullary pins have biomechanical advantage of neutralizing bending forces acting on the fracture fragments (Johnson 2007). However, intramedullary pins cannot counter the torsional and axial compressive loads effectively. Intramedullary pinning may be supplemented with Type Ia External Skeletal Fixator (ESF) to resist these forces. Without tie-in of intramedullary pin with Type Ia ESF, the intramedullary pin may migrate proximally and lead to instability of fracture fixation. Hence the Type Ia ESF may be tied in to a small (in diameter) intramedullary pin that fills approximately 40-60% of the medullary cavity which is called a tie-in configuration (Aron, 1998; Denny and Butterworth, 2006; George *et al.*, 2006; Radke *et al.*, 2006; Adamiak *et al.*, 2007, Worth, 2007; Allah *et al.*, 2009; Ayyappan *et al.*, 2009; Boghossian and Boghossian, 2010, Pisani *et al.*, 2010, Fossum, 2013 and Toombs, 2014). These frames are generally applied to the lateral aspect of femur and humerus. Tie-in configuration neutralizes the bending forces and also controls such rotational forces and so provides excellent stability. It also prevents proximal migration of IM pin as well.

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Hence Tie-in pin configuration can be used clinically to manage diaphyseal fractures of femur and humerus. The objective of the present study was to evaluate the efficacy of Tie-in pin configuration in the repair of femoral and humeral fractures of dogs.

#### Materials and Methods

Six dogs of different breed, age, sex and body weights were presented to the Veterinary Clinical Complex, P.V. Narsimha Rao Telangana Veterinary University(PVNRTVU), Hyderabad, Telangana state, with fractures of long bones (femur and humerus), were first examined as a clinical routine and if any soft tissue injuries were present also recorded. The dogs were also observed for loss of function, abnormal mobility, deformity or change in angulation of the affected limb, signs of local swelling, pain and crepitation at the fracture site (Fig.1). Neurological status of the dog was assessed and the dogs with neurological signs were excluded from the study.

The dogs were prepared aseptically for the surgery and general anaesthesia was induced with Ketamine and Xylazine at the rate of 10 mg/ Kg and 1.0 mg/Kg body weight, respectively, intramuscularly and the anaesthesia was maintained by giving incremental doses of Propofol at the rate of 4 mg/Kg body weight intravenously.

Patient preparation and positioning was done as per the standard procedure outlined by Harasen (2003), Piermattei *et al.* (2006), Fossum (2013) and Toombs (2014). The femoral fractures were reduced with open approach in all the dogs on lateral recumbency with the affected limb up. Tie-in configuration method was employed for fixation of humerus and femoral fractures. For Tie-in configuration, the bone diameter visualized on the radiograph along with the body weight of the animal was considered for selecting the size of the pins (Butterworth, 1993). Trocar pointed stainless steel Steinmann pins of appropriate size so as to fit 40% of medullary canal were used as intramedullary pins and Jacob's chuck was used to place the IM pin in retrograde manner to align and appose the fractured segments of concerned bones and cerclage wiring was used wherever necessary to reduce the fracture fragments. The linear type Ia external skeletal fixator was applied on the lateral aspect of the femur by placing trocar pointed two or three 2.0-3.0 mm positive profile pins after making releasing skin and soft tissue incisions using no.11 scalpel blade in such a way that they pass through both the cortices till the trocar point of the pin just exited from the opposite cortex of the femur. The pins were connected to the connecting rod of 4 mm size with clamps. The linear type Ia fixator was then tied to the projected IM pin by a small connecting rod with clamps to complete Tie-in configuration. The pin cutter was used to cut the excess length of transfixation pins, IM pin and connecting bars. In one dog with bilateral humeral fracture, the patient preparation, positioning and approach for humerus was adopted as per the standard procedure outlined by Harasen (2003), Piermattei *et al.* (2006), Fossum (2013) and Toombs (2014). The material and the procedure of application of tie-in construct was as specified by Fossum (2013) and Toombs (2014).

In fractures of humerus, open approach was followed in all the cases for reduction and IM pin application. The incision was made on the cranial border of the tubercle of the humerus to the lateral epicondyle distally. The subcutaneous fat and the brachial fascia were incised along the same line. The cephalic vein was carefully isolated and protected. The brachial fascia was incised along the cranial border of the brachiocephalicus muscle and the lateral head of the triceps muscle. The radial nerve was visualised and isolated. An incision was made through the periosteal insertion of the superficial pectoral and brachiocephalicus muscles of their insertion on the humeral shaft. These two muscles and brachialis muscle were reflected caudally and exposed the humeral shaft. Further to gain access of the distal shaft of the humerus the brachialis muscle was reflected cranially and the lateral head of the triceps muscle caudally. The origin of the extensor carpi radialis muscle was reflected from the ridge of the lateral epicondyle of the humerus for minimum exposure. The fracture fragments were reduced by placing IM pin in retrograde fashion. The linear external skeletal fixator was applied on the lateral aspect of the humerus by placing trocar pointed two or three 2.0 -3.0 mm positive profile pins after making releasing skin and soft tissue incisions using no.11 scalpel blade in such a way that they pass both the cortices till the trocar point of the pin just exited from the opposite cortex of the humerus. The pins were connected to the connecting rod of 4 mm size with clamps. The linear fixator was then tied to the IM pin by a small connecting rod with clamps. The brachiocephalicus and superficial pectoral muscles were sutured to the fascia of the brachialis muscle. The subcutaneous tissue was sutured using No. '0' chromic cat gut. The skin was sutured using No. '0' synthetic polyamide with horizontal mattress sutures (Fossum, 2013 and Toombs, 2014).

In the present study, cleaning with normal saline and dressing of the pin and skin interface with 5% povidone iodine pads was found effective in rendering the sites clean and sterile in all the groups of dogs and Inj.

CefetoximeSodium<sup>1</sup> was administered at the rate of 20mg/kg body weight as intramuscular injection twice daily for one week post operatively. Antibiotic therapy was prolonged for 3 to 5 more days whenever needed. Inj. Meloxicam<sup>2</sup> was administered at the rate of 0.2 mg/ kg body weight as intramuscular injection once daily pre operatively and post operatively for four days and was prolonged for 3 to 5 more days whenever needed. Owners were advised to monitor the position of construct and to restrict the movement of the animal for 2 weeks after surgery and then to allow leash walking.

Clinical evaluation was routinely carried out at periodical intervals for the signs of swelling, exudation, weight bearing and stability of the fixator in all the dogs. Radiographs were obtained immediately after Tie-in configuration of femoral and humeral diaphyseal fractures and on 15<sup>th</sup>, 30<sup>th</sup>, 45<sup>th</sup> and 60<sup>th</sup> postoperative day and whenever possible on later dates, to evaluate bone healing. The external skeletal fixator was removed when primary callus was formed leaving the IM pin in-situ after cutting the pin to the skin level till the completion of bone healing as a part of staged disassembly or the entire fixator was removed as one time removal after sufficient callus formation.

### Results and Discussion:-

In this study Tie-in configuration was combined with intramedullary pinning in reduction of fracture fragments in femoral and humeral fractures and it was tied-in with Linear type Ia ESF (Ayyappanet al., 2009; Boghossian and Boghossian, 2010, Pisani et al., 2010 and Toombs, 2014)

1. Taxim injection – Alkem laboratories Ltd. Mumbai.
2. Melonex injection - Intas Pharmaceuticals Ltd. Ahmedabad.

Preoperative radiographs of the 6 dogs revealed transverse fractures of femur in 2 dogs, femoral neck fracture of femur in one dog, proximal comminuted fracture of femur in one dog and oblique fracture of femur in one dog and bilateral oblique fracture of humerus in one dog. All the dogs had closed fractures. Lateral approach for femur and humerus, found appropriate for the easy application of linear fixator (Type Ia) and tie-in with the IM pin thereafter. Good anatomical reduction was achieved by applying IM pin alone in 5 dogs and by applying IM pin and cerclage wire in 1 dog. Fossum (2013) also suggested use of cerclage wire to support long oblique fractures and spiral fractures. Discharge from pins, decreased after few days postoperatively. Discharge from IM pin exit site observed in one dog till the removal of the fixator. The tolerance of fixator was good in all the dogs. The stability of the fixator was good in all the dogs (Van Ee and Geasling., 1992), Butterworth, (1993), Harari et al., 1998) and George et al., 2007).

The dogs in this study showed partial weight bearing from 3<sup>rd</sup> – 6<sup>th</sup> postoperative day in all the dogs. Fixator dependent lameness observed in 3 dogs due to pain and all the dogs showed complete weight bearing 3-5 days after removal of the fixator. All the dogs exhibited pain because of the movement of the IM pin as it was loose and tied to the ESF (George et al., 2007 and Vedpathaket al., 2011). The complete weight bearing was ranging from 30<sup>th</sup> -90<sup>th</sup> postoperative day (Fig.2). The mean time of complete weight bearing was ranging from 41.33±4.33 day (Harari et al., 1996) Table 1.

Immediate postoperative radiographs revealed good alignment and apposition of the fracture fragments in all the dogs (Langley-Hobbs 2003 and Piermattei et al., 2006) (Fig.3 and 4). The immobilization of fracture fragments was good in all the cases. Progressive bone healing was observed in post operative radiographs (Fig.5). Callus formation was seen on 15<sup>th</sup> post-operative day with distinct fracture line. Primary callus formation was seen from 30<sup>th</sup> – 45<sup>th</sup> postoperative day. At this time the linear fixator ie. Type Ia ESF was removed. Appearance of callus with adequate radio-density was observed from 30<sup>th</sup> day to 55<sup>th</sup> post-operative day. At this time the IM pin was removed (Allah et al., 2009 and George et al., 2006). The mean time of sufficient callus formation in this group was 43.16 ± 4.46 days (Ayyappanet al. 2009, Boghossian and Boghossian, 2010 and Pisani et al. 2010).

Staged disassembly was performed in two cases on 30<sup>th</sup> and 45<sup>th</sup> postoperative day, where linear external skeletal fixator was removed after formation of primary callus and the intramedullary pin was removed 2 weeks there after (Hurov and Seer, 1968; George et al. 2006; George et al. 2007; Shales 2008a and Vedpathaket al., 2011). The tie-in configuration was removed between 30 days to 55 days with mean time of removal 43.16± 4.46 days. In the present study, the entire tie- in construct was removed in 4 cases without staged disassembly under general anaesthesia (Ayyappanet al. 2009, Boghossian and Boghossian, 2010 and Pisani et al. 2010). The day on which the ESF assemblies were removed is presented in table 2.

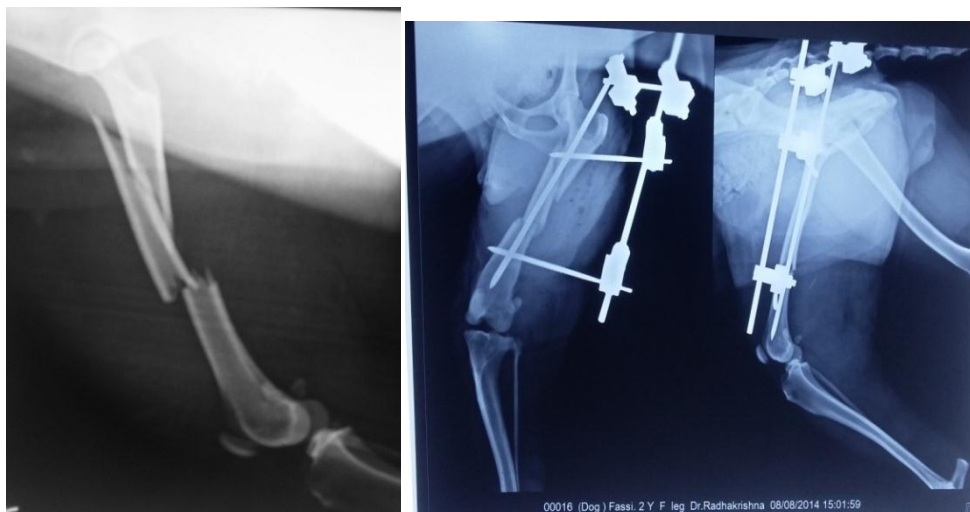
Complications noticed were discharge from IM pin exit site till linear fixator removal was observed in one dog which decreased and stopped thereafter. In one dog, the discharge was seen till the entire tie-in construct removal (Ayyappan *et al.*, 2009 and Boghossian and Boghossian, 2010). Minor pin tract discharge with growth of granulation tissue at IM pin exit site was noticed in one dog which subsided afterwards (Kraus *et al.*, 2003). Wounds due to the pressure exerted by the fixator were observed in one dog (Kraus *et al.* 2003). Migration of IM pin was seen in one dog with femoral fracture and in one dog with bilateral humerus fracture after staged disassembly. These were minor complications and did not affect the outcome of the patient.



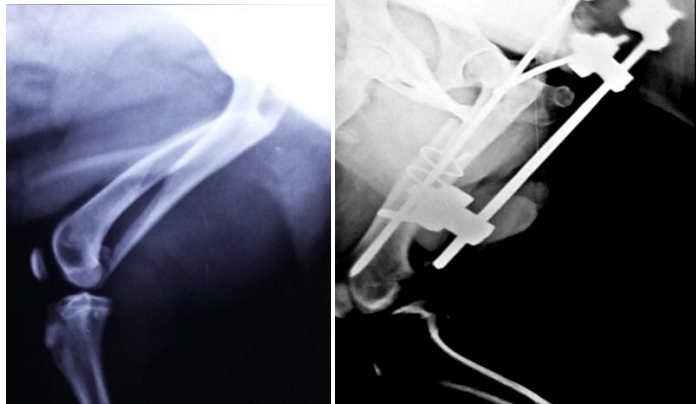
**Fig. 1:-** Dog showing dangling and non weight bearing on hind limb.



**Fig. 2:-** Postoperative complete weight bearing.



**Fig.3:-** Pre and post-operative radiographs of comminuted femoral fracture in a GSD dog showing proper alignment



Long oblique fracture of femur, showing, proper alignment of fracture Fragments  
**Fig.4:-** Pre and Post-operative Radiographs of long oblique Femoral Fracture Showing Proper Alignment



**Fig.5:-** Pre and post-operative radiographs of femoral fractures showing progressive bone healing  
Radiograph showing completed bone healing and progressive establishment ofcortico-medullary continuity after removal of IM pin in Tie-in pin configuration on 45<sup>th</sup> post-operative day



**Fig. 6:-** Progressive bone healing in Bilateral Humerus Fracture in a Labrador Pup

**Note.** Gradually disappearing fracture line and the bridging callus becoming radio-dense

**Table 2:-** Table showing postoperative details of lameness score

Case No.	Pre-operative	Post-operative Weight Bearing at the end of				
		1 Week	2 Week	4 Week	6 Week	Full weight bearing observed
1.	1	2	3	4	4	45th day
2	1	2	3	3	4	90th day
3	1	2	3	3	3	60th day
4	1	2	3	2	2	37th day
5	1	2	3	3	4	32nd day
6	1	2	3	4	4	42nd day
Mean	1.0 ± 0.0	2.0±0.0	3.0±0.0	3.16±0.30	3.5±0.34	41.33±4.33day

1. No functional limb usage; limb carried most of the time,
2. Slight functional limb usage; limb carried during running but set down when walking,
3. Moderate functional limb usage and partial weight bearing; lameness evident,
4. Complete, normal functional limb usage.

**Table3:-** Table showing time of removal of fixator.

Case No.	Group III	
	Days of ESF Removal	
	ESF	IM pin
1	32	32
2	53	53
3	30	39
4	45	55
5	50	50
6	30	30
Mean	40.00 ±4.31	43.16±4.46

### Conclusions:-

The Tie-in configuration was well tolerated by all the dogs and showed remarkable improvement in limb function with good fixator stability till the completion of bone healing. Use of cerclage wiring improved the stability of the fracture fragments in long oblique fractures of femur in the study. The Tie-in configuration can be considered for fracture stabilization of femoral and humeral fractures in dogs. This is a biomechanically versatile technique and easy to apply, well tolerated by the patient, easy to disassembly, counteracts bending and rotational forces acting on fracture fragments.

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