RESEARCH ARTICLE

Comparison of Intramedullary Pin Tie-In Configuration and Type Ia ESF With Double Connecting Bars for Tibial and Humeral Fractures in Dogs

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Abstract

The current study of intramedullary pin Tie-in configuration (Group I) and Type Ia ESF with double connecting bars (Group II) were evaluated for repair of tibial and humeral fractures in dogs. The study was conducted in 12 dogs divided into two groups of six each evaluated for 60 days. Lameness grading done on the post-operative day 1st, 15th, 30th and 60th showed a gradual decrease in lameness score and progressed to barely noticeable to no lameness on the 60th day. Orthogonal radiographs taken on the 15th post-operative day revealed callus formation in the majority of the cases in both groups. On the 60th post-operative day, orthogonal radiographs revealed cortical continuity in the majority of the cases. Complete removal of the fixator was around 70 days. Two cases in Group II had major complications. All the dogs recovered uneventfully in Group I. The intramedullary pin in Tie-in configuration as well as a second connecting bar both increased the stiffness of Type Ia ESF.

Key words: Canine, Humerus, IMP Tie-in, Long bone, Tibia, Type Ia ESF.

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Introduction

Increasing human population coupled with urbanisation has caused a drastic increase in the number of pets and vehicles. This results in increased interactions between dogs and various environmental hazards, traffic-related risks and limited safe space for exercise. More dogs living in urban and semi-urban areas have a greater risk of traffic accidents (Vani *et al.,* 2022). Fracture of long bone is one of the most common conditions encountered by veterinary practitioners. Treatment of fractures varies depending on the conditions, available infrastructure, availability of implants etc (Kumar *et al.,* 2020). Long bone fractures in dogs can be treated by many methods depending on the type, location and severity of the fracture involved.

External skeletal fixation is a surgical technique involving fixation pins, clamps and connecting bars used to stabilise the fracture. In cases of compound fractures, the presence of open wound at the fracture site increases the risk of infection, hence external fixation allows for wound care and offers very little to no interference to wound healing at the fracture site. External fixators provide a variable degree of stability based on the configuration of the construct. It allows for early weight bearing and maintains mobility in animals. The lower cost of the implants and versatility of construct stiffness are added advantages of external fixation. Type Ia external fixator is well tolerated in dogs and can be constructed with minimal soft tissue trauma. An additional connecting bar in Type Ia ESF increases the stiffness of the construct. Type Ia ESF paired with an intramedullary pin applied in the Tie-in configuration is known to increase the stiffness and it has the mechanical advantage of the intramedullary pin and it also prevents pin migration which is one of the major complications of intramedullary pinning (Radke *et al.,* 2006; Reaugh *et al.,* 2007; Pardeshi and Ranganath, 2009). The present study was conducted to evaluate the efficacy of intramedullary pin Tie-in configuration and Type Ia ESF with double connecting bars for tibial and humeral fractures repair in dogs.

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Materials and Methods

The techniques were evaluated in 12 dogs affected with fractures; the dogs were randomly selected for the techniques in group I and group II**.** Dogs with a history of gait

abnormality or trauma were examined for soft tissue injuries and then further proceeded with orthopaedic examination. Dogs were examined for loss of function, swelling, pain, crepitus, change in angulation, open wounds, infections, and exudates from wounds. Lameness grading scores were recorded according to the scale given by Vasseur (1998). Based on the results of physical examination orthogonal radiographs were taken and examined for signs of fracture. In cases of the fractured bone, the site, location and type of fracture were categorised and noted. AO classification of fracture was done as per Unger *et al*. (1990). Post-operative radiographs were taken in orthogonal views to examine for apposition, alignment & position of the implant immediately after the operation, followed by the days 15th, 30th and 60th.

On the day of the presentation, the limb was temporarily stabilised with a modified Robert Jones bandage or by Thomas splint and advised to give cage rest. Dogs were fasted for 12 h and water was withheld for 6 h prior to surgery. On the day of surgery, the cephalic vein was cannulated using an intravenous cannula of suitable size. The affected limb was prepared aseptically by clipping the hair. Aseptic preparation of skin was done with 7.5% povidone-iodine solution followed by surgical spirit. All dogs were administered with inj. Ceftriaxone (Xone*, Alkem health science, Sikkim) at 25 mg/kg b. wt. i/v, and inj. Meloxicam (Melonex®, Intas Pharma) at 0.2 mg/kg b. wt. i/v, 1 h before surgery. Inj. Butorphanol (Butrum®-2, Aristo Pharma) at 0.2 mg/kg b. wt. was given intravenously 30 min before surgery for the management of pain.

Inj. Atropine sulphate @ 0.045 mg/kg b. wt. (Tropine, Neon Lab) was administered subcutaneously, and Inj. Xylazine (Xylaxin®, Mesko Pharma) @ 1 mg/kg b. wt. intramuscularly to the dog. Anaesthesia was induced with Inj. Propofol (Neorof®, Neon Lab) @ 4 mg/kg b. wt. administered intravenously. Endotracheal intubation was done with an endotracheal tube of appropriate size. Maintenance of anaesthesia was done by 1-2% Isoflurane with Oxygen. The isoflurane precision vaporiser was used with a closed-circuit during maintenance.

Aseptic preparation was done by hanging the affected limb for a minimum of 20 min and draping. All the dogs were positioned on lateral recumbency with affected limb on top in cases of humerus and with affected limb below in cases of tibial fractures. In group I (n=6) the fracture stabilisation was done using IMP Tie-in technique and in Group II (n=6) the fracture stabilisation was done using Type Ia ESF with double connecting bars. Humerus was approached by standard craniolateral incision by a limited or a mini approach for the reduction of fracture fragments. With the help of a low-speed electric drill and Steinmann pin occupying approximately 30% of the shortest diameter of the medullary canal was driven into the proximal segment until it exits through the greater tubercle. Then the pin was introduced into the distal segment in retrograde manner towards the medial epicondyle. At the proximal segment leaving 2 cm from the joint a nick incision was made on the lateral aspect using BP blade no 11 and muscles were dissected by blunt dissection. Pre-drilling was done with the help of a drill guide and drill bit of 0.5 mm lesser diameter than the planned diameter of the Schanz screw. With the help of the Schanz screw introducer Schanz screw, approximately 25-30% of the bone diameter, was introduced into the predrilled hole engaging both cortices. The same procedure was repeated for the introduction of Schanz screw at the distal-most part of the bone 1.5-2.0 cm away from the distal joint. A connecting bar was placed and Schanz screws nearer to the fracture site were introduced to the pre-drilled hole of appropriate size. The medullary pin was bent to a 90° angle and connected to the connecting bar by using an AO mini clamp. The incision was closed by suturing the insertions of the superficial pectoral and brachiocephalicus muscle to the superficial fascia of the brachialis muscle distally and deltoideus proximally. The insertion point of the lateral head of the triceps was attached to the brachiocephalicus muscle with polyglactin 910 of size 2-0 in interrupted suture pattern and brachial fascia, subcutaneous fascia was sutured in separate layers by simple interrupted pattern using polyglactin 910 size 2-0. The skin was opposed to using polyamide black sutures of size 2-0 by apposition suture pattern (Johnson, 2013).

In case of Group I animals, shaft of the tibia was approached by medial incision to suit the site of fracture. A hole was made on the proximal aspect of the tibia on the medial surface close to the tibial crest, with the help of a low-speed drill angled perpendicular to the bone. After passing near the cortex drill-bit was directed towards the distal segment by angling to 45° and projected in the same orifice. The diameter of the drill bit chosen was 1.5 mm larger than the planned size of the intramedullary pin. The intramedullary pin was inserted in normograde manner through the orifice and directed to the distal fragment. Ancillary fixation with orthopaedic wires was done in cases of long oblique fractures. The medullary pin was connected to the Type Ia assembly with mini-AO clamps. The procedure as described above was followed to construct the Type Ia ESF frame. The crural fascia was sutured with polyglactin 910 of size 1-0 and subcutaneous tissue was sutured using the same. The skin was opposed by using polyamide black sutures of size 2-0 with cross mattress pattern (Johnson, 2013; Dias *et al.,* 2018)

In Group II, humerus was approached with mini-incision on craniolateral aspect to bring the fracture fragments into opposition. Open reduction was avoided in the case of the tibia as the lower mass of musculature enabled external manipulation and closed reduction. The additional fixation with orthopaedic wire was done wherever necessary by mini-incision at the site of fracture.

The incision line was dressed with 5% povidone-iodine solution and sterile mops. Sterile dressing pads were used to protect the pin skin interphase and the assembly. All the mops including the assembly was wrapped with a roller gauze and secured with adhesive tape. All the dogs were administered with Tab. Cefpodoxime @ 10 mg/kg body

weight orally once daily for 10 days and Tab. Carprofen @ 4.4 mg/kg body weight was administered for 5 days once a day to manage pain. Frequency of dressing change was reduced to alternate days based on discharge. Sutures were removed after healing of the incision line 11-15 days post-operatively. All the animals were kept under cage rest for 15 days, thereafter short leash walk was advised till the removal of the fixator.

The serial radiographs were taken on post-operative day 0, 15th, 30th and 60th to assess the fracture healing (Plate 1 to 4). Removal of the external fixator assembly was performed under deep sedation after the radiographic and clinical confirmation of bone union. The pin skin interphase was thoroughly cleaned with 5% povidone-iodine solution and the clamps and connecting bar were removed. The bone was manipulated to assess the stability at the fracture site. After confirming the union, the Schanz screws were removed with the help of Jacob T. chuck.

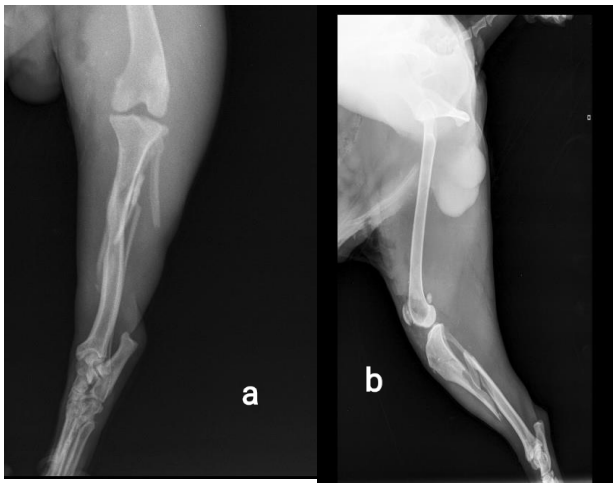

Plate 1: $G_1$3 Preoperative (a) cranio-caudal and (b) mediolateral radiographs showing long oblique comminuted fracture of tibial diaphysis

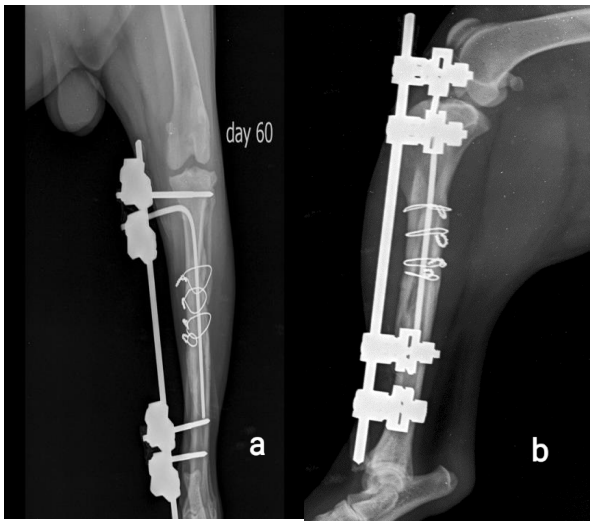

Plate 2: $G_1$3- Postoperative Day 60 cranio-caudal (a) and mediolateral (b) radiographs showing bridging of callus and construct in-situ

Plate 3: $G_2$2 Preoperative radiograph (a) cranio-caudal and (b) mediolateral view showing complete oblique diaphyseal fracture of tibia

Plate 4: $G_2$2 Postoperative day 30 radiograph (a) cranio-caudal and (b) mediolateral view showing bridging of intramedullary and intercortical callus, faintly evident fracture line

Results And Discussion

Statistically, there was no significant difference between the body weight of the dogs selected for Group I (18.33 ± 1.82 kg) and Group II (21.37 ± 4.14 kg). The results of preoperative radiographic evaluation are recorded in Table 1. Lameness grades were in concurrence with the findings of Rao (2016) (Table 2). The age of the dogs belonging to Group I was 1 to 7 years and in Group II 1 to 10 years, majority of the dogs were below 2 years of age.

In the majority of the cases of Group I and Group II by the 15th post-operative day, the periosteal reaction was noticed at the fracture site and all the pin insertion sites and the fracture line was evident. The blurring of margins of fracture fragments was noticed.

By the 30th post-operative day fracture fragments were in proper apposition and no changes were observed in alignment and angulation. The evident periosteal reaction was present at proximal and distal first pin insertion sites. The fracture line was faint but could be distinguished easily. Bridging of the callus was noticed at the fracture site in both the groups.

By the 60th post-operative day fracture fragments were in apposition and proper alignment. No angulation was noticed. Osteolysis was noticed around the proximal first pin and a periosteal reaction was noticed at the pin insertion site. Cortical continuity was noticed at the fracture site in all cases of Group I and in four cases of Group II. Fracture healing scores of individual cases are shown in Table 3. Findings are in concurrence with the observations of Nagaraju (2009) and Subhash (2010).

The mean ± SE time of fixator removal in Group I was 66.5±5.97 days and in Group II 67.5±3.35 days. Dynamization was done on the 45th post-operative day by removing the intramedullary pin as there was minimal callus formation at the fracture site in case $G_1$2. In case the $G_1$5 fracture line was evident on the 60th day post-operative radiograph with callus formation. The assembly was dynamized by disconnecting external fixator and IMP. On the 45th day dynamization was done in case $G_1$6 by disconnecting the IMP from the external fixator. In cases, $G_2$1 and $G_2$6 removal of the Schanz screws was done nearer to the fracture site on the 60th post-operative day. The fixator removal times of Group I and Group II are tabulated in Table 4. Similar to the current study, the implant removal time for Tie-in configuration reported by Peirone

Table 1: Details of radiographic examination

Case number	Bone affected	Type of fracture	Location of fracture	AO Classification	Closed / Compound
Group I					
$G_1$1	Left Tibia	Long oblique	Proximal 1/3rd Diaphysis	42A2	Closed
$G_1$2	Right Humerus	Transverse	Middle Diaphysis	12A3	Closed
$G_1$3	Left Tibia	Long Oblique	Middle Diaphysis	42A2	Compound
$G_1$4	Left Tibia	Long Oblique	Proximal 1/3rd Diaphysis	42A2	Closed
$G_1$5	Left Humerus	Transverse	Distal 1/3rd Diaphysis	12A3	Compound
$G_1$6	Right Tibia	Long oblique	Middle Diaphysis	42A2	Closed
Group II					
$G_2$1	Left Humerus	Transverse	Middle Diaphysis	12A3	Closed
$G_2$2	Left Tibia	Short Oblique	Distal 1/3rd Diaphysis	42A2	Closed
$G_2$3	Left Humerus	Transverse	Middle Diaphysis	12A3	Compound
$G_2$4	Right Tibia	Spiral fracture	Proximal 1/3rd Diaphysis	42A2	Closed
$G_2$5	Left Tibia	Short Oblique	Middle Diaphysis	42A2	Closed
$G_2$6	Right tibia	Comminuted	Middle Diaphysis	42C3	Compound

Table 2: Lameness grading

Case no.	Pre-operative	Post-operative	Day 15	Day 30	Day 60
Group 1					
$G_1$1	6	5	4	2	0
$G_1$2	6	6	5	4	2
$G_1$3	6	5	2	1	1
$G_1$4	6	6	5	2	0
$G_1$5	6	5	4	3	0
$G_1$6	6	6	5	2	1
Mean ± SE	6.0 ± 0.0^{a}	5.50 ± 0.22^{a}	4.17 ± 0.48^{ab}	2.33 ± 0.42^{bc}	0.83 ± 0.79^{c}
Group 2					
$G_2$1	6	6	4	3	0
$G_2$2	6	5	3	1	0
$G_2$3	6	5	4	5	5
$G_2$4	6	5	4	2	0
$G_2$5	6	3	1	1	0
$G_2$6	6	5	3	2	0
Mean ± SE	6.0 ± 0.0^{a}	4.83 ± 0.00^{ab}	3.17 ± 0.48^{c}	2.33 ± 0.61^{bc}	0.83 ± 0.83^{bc}

Lameness Score: 0 – No lameness, 1 - Sound at the walk, but weight shifting and mild lameness noted at trot, 2- Mild weight-bearing lameness noted with the trained eye, 3 - Weight-bearing lameness, typically with distinct "head bob", 4 - Significant weight-bearing lameness, 5- Toe-touching lameness, 6 - Non–weight-bearing lameness. Mean±SE bearing different superscripts between column differ significantly at $p<0.05$.

et al. (2002) was 22 to 60 days with a median of 42 days in cases of humeral and femoral fractures treated with Tie-in configuration. Worth (2007) also had similar findings on implant removal six to nine weeks post-operative. Mathai (2012) reported clinical union time in the case of Type Ia ESF as 65 days ranging from 2 to 9 weeks. Comparable results were also reported by Rao (2016). They found implant removal time in Type I ESF on average as 68 days in tibial fractures.

In Group I only minor complications were noticed among three cases out of six. Pin tract discharge was the minor complication in all three cases of Group I, noticed at the proximal pin skin interphase which persisted till the removal of the fixator. In Group II out of six cases, two cases had major complications such as refracture and premature pin loosening and one case had minor complications which are mentioned as follows. Case $G_2$1 suffered from refracture at the same fracture site 10 days after the removal of the external fixator which was taken up for revision surgery by intramedullary pinning. In case $G_2$3 pin tract infection was noticed from the 35th day post-surgery. On the 60th day pin loosening was noticed at all the pins, except the proximal first pin, and movement could be noticed at the fracture

Table 3: Radiographic fracture healing score

Pre-operative	Post-operative	Day 15	Day 30	Day 60
Group 1				
3	3	1	1	0
3	3	1	2	1
3	3	1	1	0
3	3	1	1	0
3	3	1	1	1
3	3	1	1	0
3.0 ± 0.0^{a}	3.0 ± 0.0^{a}	1.0 ± 0.0^{bc}	1.17 ± 0.17^{b}	0.33 ± 0.21^{c}
Group 2				
3	3	1	1	1
3	3	1	0	0
3	3	1	3	3
3	3	1	1	1
3	3	1	1	0
3	3	1	1	1
3.0 ± 0.0^{a}	3.0 ± 0.0^{a}	1.0 ± 0.0^{b}	1.17 ± 0.40^{ab}	1.00 ± 0.45^{ab}

Healing score: 0 - Complete radiographic healing, 1 - Appropriate progression toward healing, but not completely healed radiographically, 2 - Inappropriate progression toward healing, 3 - No evidence of healing, failure. Mean ± SE bearing different superscripts between column differ significant at $p<0.05$.

Table 4: Complications and final outcome

Case number	Dynamization	Fixator removal days	Complication	Major / Minor	Final outcome
Group I					
$G_1$1	-	71	Pin tract discharge	Minor	Excellent
G_1 2	45th day	90	-	-	Excellent
$G_1$3	-	60	Pin tract discharge	Minor	Excellent
$G_1$4	-	46	-	-	Excellent
$G_1$5	62nd day	90	Pin tract discharge	Minor	Excellent
$G_1$6	45th day	62	-	-	Excellent
		69.83 ± 7.17			
Group II					
$G_2$1	60th day	75	Refracture	Major	Good
$G_2$2	-	60	-	-	Excellent
$G_2$3	-	60	Premature pin loosening Pin tract infection	Major	Poor
$G_2$4	-	75	Pin tract discharge	Minor	Excellent
$G_2$5	-	60	-	-	Excellent
$G_2$6	60th day	75	-	-	Excellent
		67.00 ± 3.35			

Minor complication: Easily resolved with no effect on final outcome. Major complication - Complications affecting final outcome, Excellent – Complete recovery with no signs of lameness, Good – complete recovery with mild lameness, Poor – Non-union with severe lameness.

site in case $G_2$3. Pin tract discharge was noticed only from the proximal second pin skin interphase in case $G_2$4 which was a minor complication. The outcome and dynamization time and complications of Group I and Group II are shown in Table 4. Complications such as pin tract discharge were also reported by Nagaraju (2009) and Rao (2016).

Conclusion

The intramedullary pin Tie-in configuration was effective in fracture stabilisation of the tibia and humerus with excellent results in dogs. Open reduction became necessary in the Tie-in configuration. Whereas Type Ia ESF with double connecting bars gave excellent stabilisation and provided an environment for biological osteosynthesis. Type Ia ESF can be applied in closed or minimally invasive approaches in cases of tibial fractures. IMP Tie in configuration because of its higher mechanical properties can be effectively used for stabilisation of comminuted fractures. Maintenance of pin tract hygiene and regular change of dressing plays a key role in the outcome.

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