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Use of type IA external skeletal fixation with or without using cerclage wiring in the repair of Radius-ulna and Tibial fractures in dogs

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Abstract
Type Ia External Skeletal Fixation (Type Ia ESF) was employed in the stabilization of 4 radius-ulna and 2 tibial fractures in dogs. Immediate postoperative radiographs revealed good alignment and apposition of the fracture fragments in all the dogs. The complete weight bearing was ranging from 45^{th}-55^{th} postoperative day. The fixator was found rigid and stable till the completion of bone healing in all the dogs. The mean time of sufficient callus formation was 59.33 ± 2.41 postoperative days. The mean time of the fixator removal was 59.33± 2.41 postoperative days. Slight valgus deformity was observed in one dog and synostosis of radius-ulna was observed in another dog as coplications which did not affect the clinical outcome. Type Ia ESF was well suited for the repair of radius-ulna and also in the repair of long oblique tibial diaphyseal fractures which were supplemented with cerclage wiring in dogs and resulted in good clinical patient outcome with a few negligible minor complications.

Keywords: Type Ia external skeletal fixation, radius-ulna and tibial fractures, dogs

Introduction
Long bone fractures usually occur due to the trauma in the form of road side accidents. Forelimb of the dog as a main weight bearing organ had experienced trauma frequently leading to fracture. Higher fracture incidence of radius- ulna (31.40 %) followed by that of tibia and fibula (30.40 %) and femur (14.70 %) [22]. The main concept in fracture treatment is to achieve the fastest possible healing and enable the patient to use the affected limb for walking early [1, 21]. There are many methods for fixation of long bone fractures in dogs like intramedullry (IM), pinning, bone plating, interlocking nailing [6, 20] etc. Each fixation system has its unique advantages and disadvantages and no single fixation system is preferred in all instances [23]. Most of the internal fiation techniques are highly invasive and may disturb the biological fracture healing. That is why the external fixation techniques of fracture fixation of long bones gaining importance in small animal practice. ESF system provides better opportunity to maximize the biologic potential for healing within the fracture zone as both closed and minimally invasive procedures are possible [23]. External Skeletal Fixators (ESF) are affordable, versatile biomechanically, easy in application and removal, and allow different configurations in the frame structures in the treatment of long bone fractures in dogs [15]. External Skeletal Fixators require trans cutaneous placement of transfixation pins in to the fractured bone fragments and are connected to the externally placed connecting bar or rod with linkage devices (clamps). This assembly is called a frame or splint and this frame along with the bone is called a construct or montage [20]. The present study was undertaken to apply Type Ia external skeletal fixation (Type Ia ESF) with or without using cerclage wiring in the repair of radius-ulna and tibial fractures in dogs in order to evaluate the efficacy of the fixation and fracture healing.

Materials and Methods
Six dogs of different breed, age, sex and body weights were presented to the Veterinary Clinical Complex, PVNRTVU, Hyderabad, Telangana state, with fractures of radius-ulna and tibia, 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.

Pre-operative radiographic examination of the dogs were performed in two orthogonal views ie. medio-lateral and anterio-posterior views including the joints for complete evaluation [17].

Four dogs with radius-ulna fractures and two dogs with tibial fractures were subjected to Type Ia ESF.

The dogs were prepared aseptically for the surgery and general anaesthesia was induced with Ketemine 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 [7, 12, 20, 23]. The dogs with radial and tibial fractures were positioned in dorsal recumbency and the fractured limb was secured at the paw with bandage cloth and was suspended from an intravenous infusion stand. The limb was pulled up sufficiently tight to allow the limb to be suspended by the animal's own weight to achieve indirect reduction of fracture [7, 24]. Limited open approach was used in all the cases of radius and ulna (4) and tibial (2) fractures [11, 17, 20, 24]. The bone diameter measured on the radiograph and the body weight of the animal was considered for selecting the size of the pins [3]. The fracture fragments were reduced by traction or cerclage wiring for anatomical reduction wherever necessary [18]. Stab incisions of the skin and soft tissues were made with a BP blade no 11 where the pins have to be drilled. Two to three trocar pointed positive profile half pins of 2.0-3.0 mm size were drilled medio-laterally [17, 20, 21] through each fracture fragmentn. The pins were drilled through both the cortices of the particular bone perpendicular to the long axis of the bone, in such a way that the taper of the pins just exited the far cortex.

The proximal and the distal most half pins were drilled first. Low speed, high torque power drill (150 to 400 rpm) was used to drill the pins. Following their placement, the proximal and distal most pins were connected by a connecting bar of 4mm diameter and 150 mm length over which, the required number of connecting clamps were preplaced. Before tightening of the proximal and distal pin clamps, the fracture reduction was rechecked for proper anatomical alignment. The half pins were applied perpendicular to the long axis of the bone sequentially guided through the preplaced clamps on the connecting bar and drilled through the bone. Care was taken to see that the half pins only penetrated the skin and the two cortices of the bone.

Clamps and connecting bars were positioned close to the skin however far enough away to allow for tissue swelling i.e., 10 mm. All the clamps were tightened with T-wrench taking care that the fractured fragments remained in anatomical alignment and apposition. Following this, the excess length of the transfixation pins and connecting bars were cut close to the clamps. The pointed cut ends of half pins were made blunt using orthopaedic file (Fig.2).

Any skin tension around the transfixation pins was relieved by extending the stab incision. The subcutaneous tissue was closed in a row of continuous sub-cuticular sutures using 2-0 chromic catgut and the skin incision was closed with a row of horizontal mattress sutures of 1-0 synthetic polyamide. The limb thus far suspended from the i/v stand was untied and the animal was allowed to lie in lateral recumbency.

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 dogs and Inj. cefetoxime Sodium was administered at the rate of 20 mg/kg body weight as intramuscular injection twice daily for one week post operatively. Antibiotic therapy was prolonged for 3 to 5 days whenever needed. Inj. meloxicam 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. 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. The postoperative day on which the dog started weight bearing was noted and it was graded as per lameness scoring [10].

Radiographs were obtained immediately after stabilization with Type Ia ESF of radius-ulna and tibial diaphyseal fractures and on 15^{th}, 30^{th}, 45^{th} and 60^{th} postoperative day and whenever possible on later dates, to evaluate bone healing. The external skeletal fixators were removed when post-operative radiographs and clinical signs of bone union were confirmed. Complications if any like post-operative swelling at the operative site, pin tract discharge, any deviations of the fractured bone fragments and frame etc. were recorded post-operatively.

Results and Discussion

The dogs presented for treatment were Nondescript 3, Spitz 1, Dachshund 1 and Pashmin hound 1. The mean age of the dogs was 1.94 ± 0.90 years with range 5 Months to 6 Years. The body weights of the dogs ranged from 7-35 Kg with a mean of 14.66 ± 4.44 kg. Fractures of radius-ulna were encountered in 4 dogs and tibial fractures were seen in 2 dogs. All the fractures were closed fractures. Preoperative radiographs revealed transverse fractures in 4 dogs and long oblique fractures in 2 dogs (Fig.3 &4).

The surgical procedure for application of Type Ia ESF was found effective in all the dogs and the post-operative radiographs revealed proper alignment of fracture fragments. Cerclage wiring improved the stability of reduction of fracture fragments in two dogs with long oblique tibial fractures [17]. All the dogs tolerated the external skeletal fixators well. Post-operative swelling and discharge from the pin tracts were observed initially but stopped after a few days [3, 4, 19, 24]. The wounds of the surgical incision and the pin tracts were found to be dry and healthy. The fixators were observed to be firmly in place in all the dogs.

Out of 6 dogs, 5 dogs showed partial weight bearing from 5^{th} postoperative day. Moderate limb usage was observed from 30th day onwards. One dog with tibial fracture showed complete weight bearing from 30^{th} postoperative day onwards (Fig.5). Complete limb usage was noticed from 40^{th}-55^{th} post-operative day with a mean of 43.66±3.17day (Table. 1).

The stability of the fixators employed was good in all the dogs and the fixator was well tolerated by the patients as was also observed by [3, 11, 24, 25]. The fracture fragments were stable in all dogs except in two dogs where in one dog there was slight caudal angulation of the fracture fragments of the radius and in other dog there was slight medial angulation of the radius observed due to the less rigidity of the fixator.

Immediate post-operative radiographic evaluation revealed proper placement of the fixator, apposition, and alignment of

the fracture fragments in all 6 dogs [18] (Fig.3&4). Immobilization was good in all the cases except in two cases of radius-ulna fractures. Bone healing was seen as early as 15th postoperative day. Evidence of callus formation and faint fracture line between fracture fragments was observed on 30th postoperative day and callus formation with adequate radio-density was noticed on 45th postoperative day. Fracture line disappeared and showing restitution of cortico-medullary continuity by 50th and 60th post-operative day respectively (Fig.6). The mean time of sufficient callus formation in these dogs was 59.33 ± 2.41.
The radiographs of a nondescript pup, on 15th post-operative day, showed caudal angulation of distal fragment of radius causing malunion of fracture fragments of radius-ulna which could have been due to improper care and over activity of the pup. However, fracture line, gradually disappeared and the bridging callus appeared radio dense and the margins of fracture fragments became smooth on 60th postoperative day [1, 17]. Caudal angulation of distal fragment of radius causing malunion of fracture of radius-ulna resulting in synostosis13 was noted on 80th postoperative day. The bone healing was in progress and this did not affect the limb function whereas in a Pashmin hound medial angulation of healed up fracture fragments was noted with valgus deformity.
Complications like slight pin tract drainage was observed in all the dogs for 2-5 days. Minor pin tract infections were noticed among one [9, 14, 18]. Wounds due to the pressure exerted by the fixator were observed in one dog [15, 16]. Slight valgus deformity of radius-ulna was seen in one dog [5, 14, 19]. In a nondescript pup the radiographs on 15th day showed synostosis. It was surmised that the synostosis was consequent to the owner's noncompliance and over activity of the dog being a young one which could be the chief exciting factor causing disturbed alignment of fracture fragments resulting in malunion [2, 9, 13, 15]. These minor complications did not affect the clinical outcome.
The fixator can be easily removed under general anaesthesia [3]. It was removed as one time removal without any staged disassembly in all the dogs. The fixator was removed in the six dogs of this study between 52 days to 65 days with mean time of 59.33± 2.41 days [8] (Table.2).

Conclusions

The Type Ia external skeletal fixator was well tolerated by all the dogs, showed good fixator stability till the completion of bone healing and improved the limb function remarkably. The Type Ia external skeletal fixation can be considered for fracture stabilization of radius-ulna and tibial fractures in dogs. This study also recommends cerclage wiring with type Ia external skeletal fixation in case of long oblique fractures of tibia as this improved the stability of the fracture fragments.

Authors' contribution

JRKR carried out the case study and analysis. VGK participated in scientific discussion, wise counsel and concrete suggestions. He also drafted and revised the manuscript. TMR participated in scientific discussion, coordination, sample collection and analysis.DPK, KCSR participated in scientific discussion. All authors read and approved the final manuscript.

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Fig 1: Dogs showing dangling and abnormal angulation of the limbs

Fig 2: (A) Post-operative appearance of radius-ulna (B) Post-operative appearance of tibia

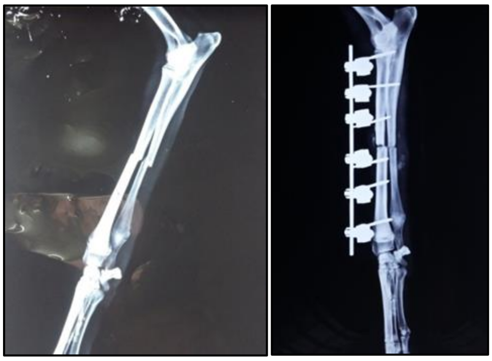


Fig 3: Pre and immediate post-operative radiographs of transverse mid shaft fracture of Radius-ulna fracture in a Pashmin hound

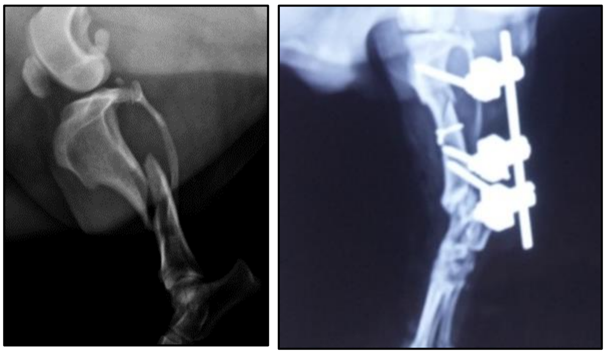
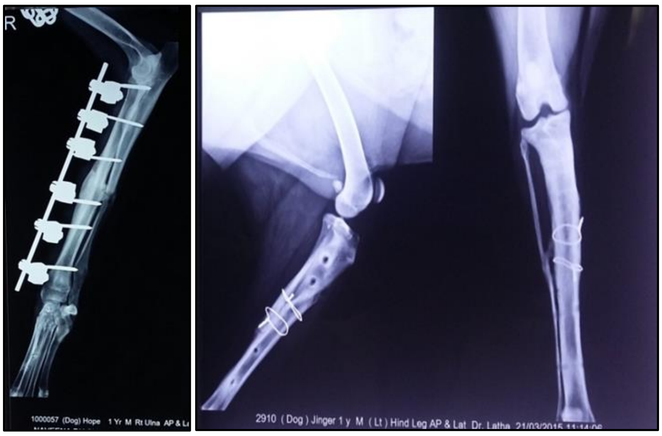


Fig 4: Pre and Post-operative Radiographs of long oblique tibial Fractures Showing Proper Alignment

Fig 5: Postoperative complete weight bearing



50th and 60thpost-operative day

Fig 6: Postoperative radiograph of radius-ulna and tibial fractures

Radiograph showing completed bone healing and progressive establishment of cortico-medullary continuity after removal of Type Ia ESF on 50th and 60th post-operative day in radius-ulna and tibial fractures respectively.

Fig 7: Synostosis of radius with ulna

Table 1: Table showing post-operative 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	2	3	4	45th day
2	1	2	2	3	4	40th day
3	1	2	3	3	4	55th day
4	1	1	2	3	4	37th day
5	1	2	3	4	4	35th day
6	1	2	2	3	4	50th day
Mean	1.0±0.0	1.83±0.16	2.33±0.21	3.16±0.16	4.00±0.00	43.66±3.17day

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.

Table 2: Removal of Type Ia External Skeletal Fixator

Case No.	Days of ESF Removal
1	52
2	52
3	64
4	65
5	63
6	60
Mean	59.33 ±2.41

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