RESEARCH ARTICLE

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Treatment of Orthopedic Problems with Epoxy-Pin External Fixator in Cats and Dogs

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Abstract

The aim of this study was to present 6 dogs and 2 cats treated with handmade external fixator. The animals included in the study had 3 cases of non-union, 1 case of luxation, and 4 cases of fracture. All the cases were successfully treated with a handmade external fixator which was made from an endotracheal tube and epoxy. There were no complications developed except for light leakage in the pin site in one case. All of the animals had started to use their extremities in the early postoperative period, except for one case. As the fixator provided the opportunity for weight-bearing, increasing stability in the fracture line in the early postoperative period, this provided some beneficial effects on healing. The external fixator made using an endotracheal tube and epoxy can be selected as an inexpensive treatment method for cats and dogs.

Keywords: Epoxy fixator, femur, tibia, radius, ulna.

INTRODUCTION

Extremity fractures are seen very often in veterinary orthopedic practice. These extremity fractures, especially in small animals, create a large problem for physicians (Gadallah et al. 2009). The rate of cases requiring orthopedic surgery is extremely high in all surgical cases (Appari et al. 2013; Altuğ et al. 2017). In cats and dogs, fractures are caused due to traffic accidents, falls from height, firearms injuries, and attacks from other animals (Kraus and Salzer 2017; Fossum 2013).

Several techniques can be used in fracture healing such as intramedullary nailing, plate osteosynthesis, and osteosynthesis with external skeletal fixation (ESF) (Kraus and Salzer 2017). More rigid osteosynthesis obtained using ESF or plate provides better fracture healing because of relatively lower complication rates compared with other techniques (Şen and Sağlam 2020).

ESF systems have been described in different configurations for application in several bone fractures. Although these systems are used extremely often in bones such as the antebrachium and tibia, which have less soft tissue support, ESF is also used in bone fractures where there is higher soft tissue support, such as the femur and humerus (Palmer 2012; Wander 2019). ESF configurations such as Type IA, Type IB, Type II, and Type III have been described for use in the treatment of fractures. Type IA is generally applied to the medial radius and tibia, and to the lateral parts of the humerus and femur. Type IB is usually applied in tibia fractures by placing the carrying bars on the medial and cranial surfaces of the tibia (Wander 2019). Type II configurations are used primarily on the tibia and the radius due to the proximity of the body wall. These configurations are usually placed in the mediolateral plane. Type III ESF can only be applied to the tibia and radius as the medial surfaces of the femur and humerus are close to the shaft. ESF configurations that can be applied to the humerus and femur may not be able to provide sufficient rigidity for the stabilization of the fractures. Therefore, intramedullary pins can also be used in addition to the fixator. This intramedullary pin can be combined with the fixator (Wander 2019).

This study aims to examine the durability and effect of the previous successful epoxy pin external fixation method by including an intubation tube in it on cats and dogs. This study hypothesizes that the combination of intubation tube and epoxy-pin provides a sufficiently rigid fixation in cats and dogs.

MATERIALS AND METHODS

The study was conducted on 6 dogs and 2 cats of different breeds, ages, and sex, which were brought to the Veterinary Faculty Surgery Clinics of Aydın Adnan MenderesUniversity with the complaint of not being able to use their extremities and were diagnosed with fracture or dislocation as a result of clinical and radiological examinations.

Cefazoline sodium (20-25 mg/kg, IM, 12h, 7 days; Iespor, Turkey) and meloxicam (0.2 mg/kg, SC, 24h, 4 days, Maxicam, Turkey) were administered before and after the operation. General anesthesia was administered by using propofol (6 mg/kg, IV) and maintained with 2-3% isofluorane in oxygen. All of the patients were prepared in sterile conditions for aseptic surgery.

The ESFs were planned before the operation is specific to each animal. An endotracheal tube, epoxy, and pin were used in all cases. The pins used for fixation varied between 1.5 and 3 mm. The intubation tubes used ranged from size 4 to 8. The fracture case assessment score (FCAS) (Palmer, 2012) was used in the selection of fixation methods. Postoperatively, a gauze dressing soaked in Baticon (antiseptic solution) was placed around the pins and changed twice a day.

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RESULTS

The study included 6 dogs and 2 cats, ranging from 1.5 to 9 years in age. In the 7 examined fracture cases; 1 had a fracture in the femur, 3 had a fracture in tibias, 2 had a fracture in radius-ulna, and 1 had a fracture in metatarsus. One (1) of the examined cases had luxation at the accessory carpal bone, radiocarpal, and radius-ulna bones. 5 of the cases (nos. 2, 3, 4, and 7) had previous operations before the animals were brought to our clinic with a complaint of not being able to use their extremities and a non-union diagnosis. The other 3 cases (nos.1, 5, 6, and 8) were referred to our hospital with a suspected fracture after emergency treatment.

Upon clinical examination of case no. 1, open fractures were found in proximal metatarsals II, III, and IV. The wound was smaller than 1 cm. In case no. 2, a distal diaphyseal femur fracture and broken plate were diagnosed on the preoperative radiograph. When all the screws and the broken plate were removed in the operation, it was seen that the femur was broken into 3 fragments. In case no. 3, it was seen that the pin from the proximal of the radius-ulna had emerged through the skin. In the preoperative radiological examination, it was seen that while the pin was within the medulla in the proximal fragment, it was outside the distal fragment. In cases 5 and 6, a tibia fracture was found in the preoperative radiographs. In case no. 6, luxation of the accessory carpal bone, radio-carpal, and radio-ulnar bone was diagnosed in the clinical and radiographic examinations. Case no. 7 had an operated at another center for a tibia fracture but was brought to our clinic due to not being able to use its extremity for a long time. Non-union was found in the preoperative clinical and radiographic examinations. In case 8 radius-ulna fracture was found in clinical and radiographical examinations.

Three of the dogs (cases 2, 3, and 7) had operated on and brought to our clinic due to non-union. The other patients were referred to the faculty veterinary hospital for fracture treatment after the emergency interventions had been made.

All of the cases were able to use their extremities after 1-14 days after their operations. In case no. 1, although it was an open fracture, the wound healed quickly as it was fresh. Secondary fracture healing occurred in all cases. Fracture healing in eight cases ranged from 1 to 5 months. No complications were seen in the cases. The detailed results of the cases are summarized in the tables below (Tables 1-3).

Table 1. Age, gender, breed, weight information, and localization of lesions of the cases.

Case No	Age, breed	Weight, gender	Fracture
1	3 years, English Setter, dog,	M, 27 kg	Proximal metatarsal open fracture. Metatarsalis II, III and IV.
2	9 years, Yorkshire Terrier, dog	M, 3.5 kg	Comminuted femur fracture. It had undergone fixation by a plate the previous year. Brought to the hospital due to broken plate and non-union.
3	2 years, Yorkshire Terrier, dog	F, 1.2 kg	Radius-ulna fracture, distal diaphysis. It was operated with an intramedullary pin 2 months prior. Brought to the hospital due to non-union. The pin was only in the distal fragment. The other front extremity of the dog had been amputated at another center 1 year prior.
4	Mixed breed, dog	F, 18 kg	Comminuted tibia fracture.
5	7 years, Terrier, dog	M, 14 kg	Tibia fracture, oblique diaphyseal.
6	3 years, Mixed breed, cat	F, 3 kg	Luxation of the accessory carpal bone, radio-carpal, and radio-ulnar bone,
7	1.5 years Mixed breed, cat	M, 2.5 kg	Tibia fracture. Operated on with intramedullary pin in a private clinic 6 weeks prior. Brought to the hospital due to non-union.
8	5 years Mixed-breed dog	M, 30 kg	Radius-ulna fracture, diaphyseal.

Table 2. Fixation types and pins used in the cases.

Case No	External fixation method	Pins	Fixator body.
1	Type IA unilateral uniplanar	Steinman pin - 2, 2.5, and 3 mm	Body formed with Steinman pins and placed in an intubation tube.
2	Type IA unilateral uniplanar	Steinman pin - 2 mm	Body formed with Steinman pins and placed in an intubation tube. Light material.
3	Type IA and Intramedullary pin	Steinman pin - 2 mm	Body formed with cable, fixed with metal paste.
4	Type II bilateral	Steinman pin - 3 mm	Body formed with Steinman pins and placed in an intubation tube. The inside of the intubation tube is filled with epoxy.
5	Type II bilateral	Steinman pin - 2 and 3 mm	Body formed with Steinman pins and placed in an intubation tube. The inside of the intubation tube is filled with epoxy.
6	Type II bilateral	Steinman pin - 1.5 mm	Body formed with Steinman pins and placed in an intubation tube. The inside of the intubation tube is filled with epoxy.
7	Type II bilateral and Intramedullary pin	Steinman pin - 1.5 mm	Body formed with Steinman pins and placed in an intubation tube. The inside of the intubation tube is filled with epoxy.
8	Type II bilateral	Steinman pin - 3 mm	Body formed with Steinman pins and placed in an intubation tube. The inside of the intubation tube is filled with epoxy.

Table 3. Intraoperative and postoperative results of the cases.

Case No	Intraoperative	Extremity Use	Fracture healing	Union/healing Time
1	Pin implementation; 3 to the distal tibia, 1 to proximal fragments, and 3 to distal fragments of the metatarsus. (Figures 1 and 2)	On the second day after the operation	Secondary	2 months
2	The broken plate was removed; the femur was in 3 fragments and there were 8 screw holes. The distal fragment was up to 1/5 of the femur. Steinman pins were implemented to the proximal femur, the distal condyles, and the proximal tibia. Support was provided with bone cement.	On the first day after the operation	Secondary	3 months
3	Misapplied pins were extracted. There was a material loss in the bone tissue. Support was provided with bone cement. Pins were implemented; 2 in the proximal and 1 in the distal.	On the second week after the operation	Secondary	5 months
4	Pin implementation; 3 to the proximal and 2 to the distal.	On the second week after the operation	Secondary	2 months
5	Pin implementation; 3 to the proximal and 2 to the distal.	On the same day as the operation	Secondary	2 months
6	Pin implementation; 3 to the proximal and 3 to the distal.	On the first week after the operation	Secondary	1 month
7	Misapplied pins were extracted. Pin implementation; 3 to the proximal and 3 to the distal.	On the first week after the operation	Secondary	1.5 months
8	Pin implementation; 2 to the proximal and 2 to the distal.	On the first day after the operation	Secondary	1 month

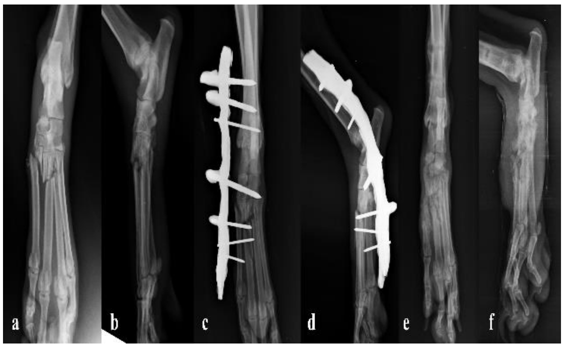

Figure 1. Case no 1, treatment of metatarsal fracture with ESF. a-b: Radiographic views of metatarsus II, III, and IV fracture. c-d: Postoperative radiographs. e-f: Radiographs after the removal of the ESF.

Figure 2. Case no 1, Clinical appearance of the patient after the fractures are healed.

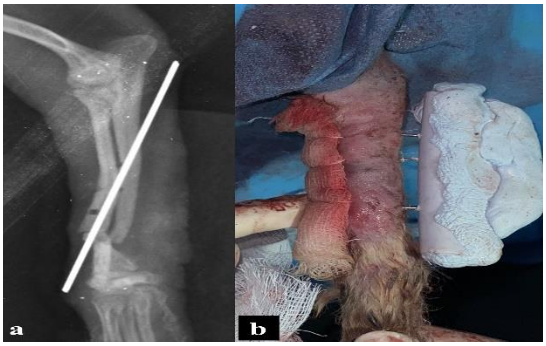

Figure 3. Case no 3, a: Preoperative radiography. The intramedullary pin was within the medulla in the proximal fragment, it was outside the distal fragment. b: Radius-ulna osteosynthesis with ESF.

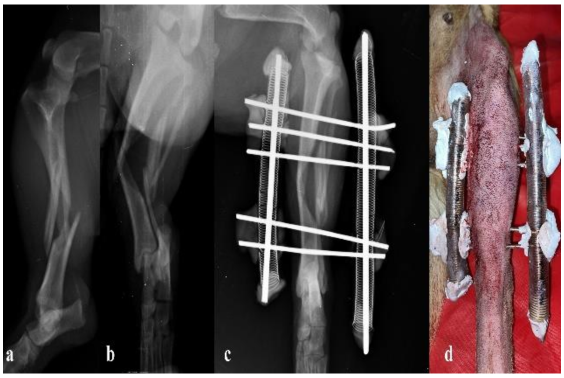

Figure 4. Case no 4, Treatment of comminuted tibial fracture with ESF. a-b: Preoperative radiographs of the tibial fracture. c: Postoperative radiography. d: Fixation with epoxy-pin and tube ESF.

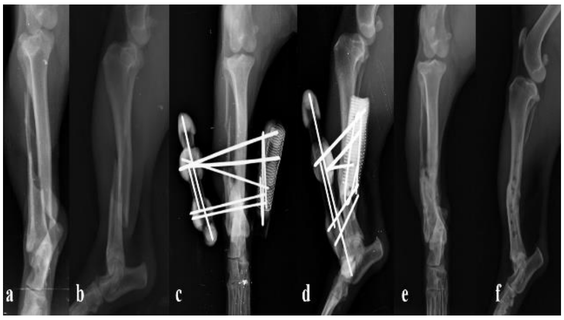

Figure 5. Case no 5, Treatment of distal tibial fracture with ESF. a-b: Preoperative radiographs of tibial fracture. c-d: Postoperative radiographs. e-f: Radiographs after removal of the ESF.

Figure 6. Case 5, Postoperative early weight-bearing regain.

DISCUSSION AND CONCLUSION

The most diagnosed orthopedic problem is fracture and cats and dogs are among the most common patients (Altuğ et al. 2017; Pamuk et al. 2009; Altunatmaz et al. 2004). In veterinary medicine, the choice of surgical treatment for fractures depends on several factors. ESF is preferred more in open, infected, and fragmented fractures in both human and veterinary orthopedics. The ESF is also widely used in arthrodesis and corrective osteotomies (Petfield et al. 2017; Gülaydin and Sarierler 2018; Altuğ, Tayer, et al. 2017; Şen 2020). ESF can be used in infection, open fractures, firearms injuries, or degloving injuries. It is a method that allows regular wound care while supporting bones in the healing process (Wander 2019; Petfield et al. 2017). Rather than steel alloys in a heavy structure providing rigid fixation, ESF components are generally prepared from light but less resistant materials such as aluminum, or light but expensive materials such as carbon fiber. In these "standard" fixators, the fixation of the pins is adjusted according to the size and location of rings or clamps (Aithal et al. 2019). Conventional external fixators are costly and require equipment-specific tools. For this reason, the epoxy-pin-tube ESF method, which is thought to be easier to obtain and apply, was considered. External fixation using epoxy-pin and tube is a low cost, easy to use, and durable method. Bars and clamps required in other external systems are not necessary for this technique. The fixators in this study were disposable, were not used on other patients, and their costs were lower.

Cement gun tubes, multiple pins, methylmethacrylate external fixation, and handmade external fixators were mentioned in the literature. ESF systems that use acrylic and epoxy are advantageous in terms of cost (Walter and Papandrea 2011; Aithal et al. 2019; S K Tyagi et al. 2015). Several biomechanical studies have shown that systems using acrylic and epoxy are strong enough to provide rigid fixation in bone fractures of small animals (Leitch and Worth 2018; S K Tyagi et al. 2015; Surbhi Kuldeep Tyagi et al. 2014; Şen 2018). Acrylic tie-pin ESF applications have been reported to be low-cost and easy-to-apply in fracture treatment of cats and dogs. (Saglam et al. 2016). Most of the traditional external fixators for cats and small dogs are both heavy and large. The use of acrylic and epoxy ESF has many advantages, including; price, weight, and flexibility (Sağlam and Çetinkaya 2010). In acrylic ESF applications, the ends of the Steinmann pins that are implanted in the bone are passed through the plastic tube and fixed by filling acrylic into the tube. The possibility to use this ESF type in many types of fractures and its low cost has caused its widespread use in veterinary orthopedics (Altuğ et al. 2017). In this study, the ends of Steinman pins implanted in the bone are passed through the tube and fixed with epoxy, after that they are shaped by hand and left to dry. The tubes were used as shapeable bars. Epoxy is easy to prepare and shape. A smooth malleable putty which sets rigid in 6-8 minutes is formed by mixing the inner and outer layers by hand. In this study the use of the epoxy and tube was considered more advantageous due to its cost and usage areas.

Surgical operation is required to treat; open fractures, dislocated and comminuted fractures, metatarsals III and IV fractures that bear the burden of the extremity, and when there are more than 2 metatarsal fractures in one extremity. Treatment options include external coaptation, intramedullary pinning, tension band, cerclage or interfragmentary wiring, lag screws, bone plates, and external skeletal fixation (Kapatkin et al. 2000; Perry and Woods 2018). In case no. 1 there were open metatarsals II, III, and IV fractures. In this case, ESF was used due to the open fracture. Rigid fixation was provided with Type 1A unilateral uniplanar ESF (Fig. 1 and 2).

When the FCAS (Palmer 2012) is considered in the treatment with ESF, the method with the highest score is the femur Type 1A and IM pin tie-in. In case no.2, Type IA ESF was selected but IM pin was not used. While high scores were obtained for the FCAS due to this case being a small breed and good-tempered, the fact that the case was adult and had previous surgery was disadvantageous. As the femur of this patient had 8 screw holes in it for one year and the bone was in 3 fragments the bone tissue was extremely weak, thus than an intervention in the medulla, support was provided with bone cement. In this case, more rigid fixation was obtained by applying pins to the tibia as the case had a very small amount of healthy bone tissue. Joint stiffness, muscle atrophy, and osteoarthritis preventing joint movement are seen in fixations (Mcalister and Sems 2016). Femur fractures are common in dogs and cats, accounting for 20-25% of all fractures in these animals and many fixation methods can be applied to femur fractures (Libardoni et al. 2018; Piermattei et al. 2006), but in this case, it was concluded that ESF would provide the least contact with the bone surface. It was intended to affect the blood supply minimally. The joint movement was prevented but it was a negative aspect that had to be risked.

In case no.3, the biological FCAS (Palmer 2012) was high for small patient size, moderate for radius-ulna fracture, and low for severe tissue damage and loss, but as the animal only had a single front leg, it was necessary to provide immediate weight-bearing before operation. It was decided that ESF was the most suitable method for early weight-bearing, minimizing bone contact, and affecting the blood supply minimally. In radius-ulna fractures, the score of Type IA is 10 (FCAS) (Palmer 2012). As it was unilateral and uniplanar the ESF body was light in this case (Fig. 3). In toy breed dogs such as Yorkshire terriers, limited soft tissue coverage and weak intraosseous circulation are factors in delayed healing (Cappellari et al. 2014; Piras et al. 2011). ESF was preferred in order to minimize bone contact and to affect the blood supply minimally. The fracture healing took a long time (3 and 5 months) in 2 of the current cases (cases 2, and 3). Pin migration was not observed in cases 2 and 3 which underwent unilateral fixation, although Steinman was applied instead of Shanz.

Type II ESF was preferred for the tibia and radius, and it was placed in the mediolateral plane (Wander 2019). Among the cases where the Type II ESF was applied; 3 of them (cases 4, 5, and 7) had tibia fracture (Figures 4 and 5) and one (case 6) had radio-ulnar and accessory carpal luxation.

One of the main advantages of ESF is that the weight-bearing function of the related extremity can be regained in a short time. Studies have shown that epoxy-pin fixation provided stable fixation with early regain of weight-bearing (Kumar et al. 2012; Aithal et al. 2019; Surbhi Kuldeep Tyagi et al. 2014). Functional limb usage and partial weight-bearing regain were reported at 1-2 weeks (Rao et al. 2017; Şen 2020). In this study, postoperative weight-bearing started between 1 to 14 days (Fig. 6). According to the results obtained, ESF made with epoxy-pin and tube enabled early weight-bearing due to its lightweight and rigid fixation.

Only in case no. 3 slight pin tract discharge was observed. The extremity was immersed twice a day in a warm povidone-iodine solution diluted to 50%, and no discharge remained on the 5th day. Pin tract sepsis and osteolysis, which are the most common complications of external fixators, were not observed in any of the current study cases.

ESF is a minimally invasive osteosynthesis method, which can be rapidly applied to fragmented fractures, non-union, and infected cases, and allows weight-bearing on the affected extremity in a short time (Fig. 6). The epoxy's easy-to-shape and fast freezing qualities allowed an easy application. Instead of using a metal rod and easily deformable clamps, an ESF using epoxy can be useful for the treatment of bone fractures and luxations in small animals as it is mechanically strong, light, and inexpensive, and pins can be oriented in any direction according to the clinical status.

Conflict of Interest

The authors declare that they have no competing interests.

Authorship contributions

Concept: B.K.K., Design: B.K.K., Data Collection or Processing: B.K.K., Z.B.S., Analysis or Interpretation: B.K.K., Z.B.S., Literature Search: B.K.K., Z.B.S., Writing: B.K.K., Z.B.S.

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Ethical Approvel

The ethical approval of the study was provided by the University's Institutional Animal Care and Use Committee (ADU HADYEK-64583101/2022/003). In this study, a signed information confirmation form was obtained from the patient owners.

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