Treatment of extremity fractures in dogs using external fixators with closed reduction and limited open approach

S. Özsoy[1], K. Altunatmaz[1]

[1]Surgery Department, Faculty of Veterinary Medicine, Istanbul University, Istanbul, Turkey

ABSTRACT: *Humerus, tibia* and *antebrachium* fractures determined in 30 dogs of different breed, age, weight and gender were treated using Type I and II external fixators. Meynard and handcuff clamps were used in the external fixators. Limited open approach was applied in 6 of the cases and closed reduction techniques in 24. In cases where closed reduction and stabilisation was done, the patients were seen to use their leg within 3–10 days post-operatively and that walking was reasonably good after 20 days. In cases to which a limited open approach had been applied, use of leg was achieved in a period close to the closed method.

Keywords: dog; fracture; external skeletal fixation; closed reduction; limited open approach

The primary aim of fracture treatment is to achieve the fastest possible healing and enable the patient to function normally by allowing early walking (Aron, 1998; Shahar, 2000). For this, the aim is to produce anatomical unity between the joints above and below the fractured bone and functioning of the extremity (Piermatei and Flo, 1997). In the treatment of *radius* and *tibia* fractures in dogs, external fixation methods are primarily suggested (Johnson *et al.*, 1989; Font *et al.*, 1997; Palmer, 1999). External fixators are used either primarily or as a support for internal fixation and are frequently applied using a closed method (Foland and Egger, 1991; McLaughlin and Roush, 1999).

External fixators are used extensively in both human and veterinary orthopaedics as a treatment option in severely comminuted and open fractures, infected non-union cases, arthrodesis, for bone-lengthening and also correcting growth disorders (Harari, 1992; Aron *et al.*, 1995; Altunatmaz and Yucel, 1999).

External fixators can be applied either with an open approach or closed reduction. In the fracture treatment with an open approach, manipulations necessary during the operation will cause secondary trauma in the injured region and the blood circulation of the bone will be damaged, causing a delay in the healing period (Dudley *et al.*, 1997; Lauer *et al.*, 2000).

In severely comminuted and dislocated diaphyseal fractures, reconstruction is known to be very difficult. However, during surgery, priority should be given to establishing anatomical structure and protecting vascularisation of the bone rather than to its reconstruction. This kind of an approach is the basis of biological osteosynthesis (Aron *et al.*, 1995; Johnson *et al.*, 1998; Palmer, 1999).

External fixation has advantages such as causing minimal damage to the injured region, maintaining bone length, minimising the atrophy forming in the bone and soft tissues, allowing complete weight-bearing on the healing bone and keeping soft tissue trauma at the fracture line at the lowest (Johnson and Decamp, 1992; Egger, 1998; Lewis *et al.*, 2001).

Healing in fractures treated using external fixation occurs mainly via endostal callus rather than a periostal one (Harari *et al.*, 1996). Some cases however, heal primarily. Researchers (Johnson *et al.*, 1989; Harari *et al.*, 1996; Egger, 1998) report that healing takes place in 3–12 weeks with this application. As well as healing, delayed healing and non-union cases have also been reported (Aron *et al.*, 1986; Carnmicheal, 1991; Harari, 1992; Rudd and

Whitehair, 1992). In fractures to which they applied external fixation, Johnson *et al*. (1989) observed that, bone healing or duration of union occurred at the same time or earlier compared to those treated with internal fixation.

In external fixation applications, complications such as pin loosening, pin-base infection, pin breaking, non-union or delayed union are frequently encountered (Johnson *et al.*, 1989; Anderson *et al.*, 1993; Lewis *et al.*, 2001).

MATERIAL AND METHOD

The material for this study comprised of 30 dogs of different breed, age, gender and body weight, brought to the Istanbul University Veterinary Faculty Surgery Department with a complaint of lameness or inability to use the leg (Table 1).

In the clinical examination, cause of the fracture, location of the fractured bone, whether the fracture was open or closed and other injuries were determined. A 2-way (AP, ML) radiograph was taken of the area and the reduction technique (limited open or closed) to be applied was decided.

Patients were sedated and the operation site was shaved and disinfected. Following this the animals were put under general anaesthesia. A Type I external fixator (unilateral-uniplanar) was used in cases with a *humerus* fracture and a Type II external fixator (bilateral-biplanar) was used in cases with *tibia-fibula* and *radius-ulna* fractures. Straight Steinmann pins were used for fixation in all cases (Table 2).

Two different types of clamp (Meynard and handcuff clamps) were used to attach the pins to the fixator. Due to the small diameter of the bar, the handcuff clamp was only used in dogs weighing under 10 kg.

The fixation procedure was carried out using the limited open method in 6 fractures and via closed approach in 24. In 1 case where an external fixator was applied to the *radius* using the closed method, an intramedullary pin was placed in the *ulna* using an open approach. In 2 cases which had open fractures in the distal diaphysis of the *tibia-fibula*, the fixator was applied in transarticularly. In 1 case, which had been given an internal fixation but in which complications had developed due to osteomyelitis, an external fixator was applied using a closed approach. In one severely dislocated case (No. 9), distraction was used to bring the bone fragments closer together using the closed method. In one other case with an open fracture in the distal diaphysis of the *tibia-fibula*, the fixator was removed and plate osteosynthesis was carried out due to non-union.

In the cases to which an external fixator was applied using the limited open approach, the incision was kept minimal. The incision was closed after the bone fragments were aligned and fixation was complete.

In open and infected fractures, an external fixator was applied after debridement and thorough irrigation of the area using sterile saline solution.

Postoperative antibiotics were given to all cases. The fixator was dressed using a large amount of cotton-wool and the area was covered.

Immediately after fixation, the fractured bone was radiographed and re-positioning was checked for alignment. Distances between the bone fragments were also recorded.

The condition of the callus was evaluated with radiographs taken regularly during the postoperative period. The fixator was removed in cases which showed sufficient callus formation.

RESULTS

Treatment with external fixation and results after the treatment were evaluated in a total of 30 dogs in which, after clinical and radiological examination, *radius-ulna* fractures were determined in 6, *tibia-fibula* fractures in 14 and *humerus* fractures in 3 (Tables 1 and 2).

Fourteen of the dogs, which had been diagnosed with a fracture and had been treated were adults and 9 had not yet completed their growth. The bodyweight of the cases ranged between 4–48 kg.

In the 6 cases with *radius-ulna* fractures, the fracture was in the mid-diaphysis in 3 cases and in the distal diaphysis in the remaining 3.

Of the *tibia-fibula* fractures 2 were located in the proximal diaphysis, 2 in the mid-diaphysis, 9 in the distal diaphysis and 1 in the distal epiphysis. All of the *humerus* fractures were located in the mid-diaphysis.

Of the fractures that were treated with external fixation, 3 were open fractures (*tibia-fibula* fractures). One of these cases (Case No. 11) was an old fracture and necrosis was present in a 3 cm-long part of the bone.

Type I external fixation was applied to cases with humerus fractures (Figure 1) and Type II external

Table 1. Findings of cases managed with external skeletal fixators

Case No.	Breed	Age	Gender	Weight (kg)	Bone and type of fracture	Fracture type	Reduction technique
1	SiberianHusky	3 mo	F	10	*radius-ulna* distal 1/3	close	closed
2	Crossbred	3 mo	M	13	*humerus* midshaft	close	limited open appr.
3	Crossbred	3 yrs	M	15	*tibia-fibula* distal 1/3	close	closed
4	Crossbred	2.5 mo	F	9	*tibia-fibula* distal 1/3	open	limited open appr.
5	Crossbred	2.5 mo	F	7	*humerus* midshaft	close	limited open appr.
6	Cocker Spaniel	8 mo	M	10	*radius-ulna* Midshaft	close	closed
7	Boxer	6 yrs	M	26	*tibia-fibula* distal 1/3	close	closed
8	Anatolian Shepherd	2 yrs	F	36	*radius-ulna* midshaft	close	closed (i.m. pin to *ulna*)
9	German Shepherd	3 yrs	M	27	*radius-ulna* midshaft	close	closed
10	Siberian Husky	6 mo	M	18	*tibia-fibula* midshaft	close	closed
11	Crossbred	4 yrs	M	22	*tibia-fibula* distal 1/3	open	closed
12	Anatolian Shepherd	5 yrs	F	32	*tibia-fibula* distal 1/3	close	closed
13	Anatolian Shepherd	7 mo	F	17	*tibia-fibula* distal 1/3	close	closed
14	Crossbred	3.5 mo	M	4	*humerus* midshaft	close	limited open appr.
15	Setter	1 yrs	F	15	*tibia-fibula* distal 1/3	close	closed
16	Crossbred	3 yrs	F	14	*tibia-fibula* distal 1/3	close	closed
17	Doberman Pinscher	3 yrs	M	23	*radius-ulna* distal 1/3	close	closed
18	Napolitan Mastif	9 mo	M	48	*tibia-fibula* proksimal 1/3	close	closed
19	Boxer	8 yrs	M	25	*tibia-fibula* midshaft	close	closed
20	Yorshire Terrier	11 yrs	M	8	*tibia-fibula* distal 1/3	close	closed
21	German Shepherd	2 yrs	F	23	*tibia-fibula* distal 1/3	close	limited open appr.
22	Crossbred	2 yrs	M	15	*radius-ulna* distal 1/3	close	closed
23	Crossbred	3 mo	M	8	*tibia-fibula* proksimal 1/3	close	closed
24	Doberman P.	9 mo	M	27	*tibia-fibula* midshaft	close	closed
25	Colie	2 yrs	F	19	*radius-ulna* distal 1/3	close	closed
26	German Shepherd	8 mo	M	24	*tibia-fibula* proksimal 1/3	close	closed
27	German Shepherd	2 yrs	M	28	*tibia-fibula* proksimal 1/3	close	closed
28	German Shepherd	9 mo	M	24	*tibia-fibula* proksimal 1/3	close	closed
29	PitBull terrier	2 yrs	M	25	*tibia-fibula* midshaft	close	closed
30	Crossbred	10 yrs	M	15	*tibia-fibula* distal 1/3	close	closed

fixation was used in those with radius-ulna and *tibia-fibula* fractures (Figure 2).

After the fracture was stabilised using a fixator, measurements showed the distance between the bone fragments to differ between 0.5–1.5 mm.

In postoperative radiographic check-ups (observation of sufficient mineralised callus formation) the fractures were observed to heal in between 16–40 days. Although there was no contact with external surroundings, the healing period in 3 *humerus* mid-diaphyseal fractures treated using a limited open approach was seen to be approximately the same as those treated using the closed method.

Table 2. Results of cases managed with external fixator

Case No.	Fracture type	Type of external fixator	Distance between the bone fragments (mm)	Time of sufficient callus presence (days)	Time of fixator removel (days)	Postoperative complications
1	close	Type II	1	21	21	
2	close	Type I	2	23	23	
3	close	Type II	15	40	40	pin loosening
4	open	Type II	2	20	20	
5	close	Type I	1	16	21	
6	close	Type II	1	27	34	
7	close	Type II	0.5	21	36	
8	close	Type II	6	18	24	pin track discharge
9	close	Type II	9	25	52	pin track discharge
10	close	Type II	11	23	29	
11	open	Type II	5	–	33	non-union
12	close	Type II	1	21	60	tarsal valgus
13	close	Type II	1	27	27	
14	close	Type I	0.5	15	20	
15	close	Type II	3	21	31	tarsal valgus
16	close	Type II	6	28	45	
17	close	Type II	2	26	39	pin loosening
18	close	Type II	11	23	23	
19	close	Type II	14	40	40	pin track discharge
20	close	Type II	3	36	42	
21	open	Type II	1	26	178	ankylosis
22	close	Type II	2	22	22	
23	close	Type II	0.5	24	24	
24	close	Type II	9	28	40	
25	close	Type II	10	38	38	
26	close	Type II	4	35	35	
27	close	Type II	7	43	43	
28	close	Type II	4	35	40	
29	close	Type II	5	25	35	
30	close	Type II	6	35	44	

All the cases that were treated (except case No. 11) were seen to make slight ground contact with the leg 3–10 days after external fixation and to function close to normal within 20 days with full weight-bearing on the fractured leg.

The fixator was removed in cases which had sufficient mineralised callus formation and which could bear weight on the leg. While this period was approximately between 20–30 days, it was also delayed due to the late appearance of the patient owners (178 days).

In the radiographs taken 24 days later of case No. 8, in which a fixator was applied to the *radius* using the closed method and an intramedullary pin a

b

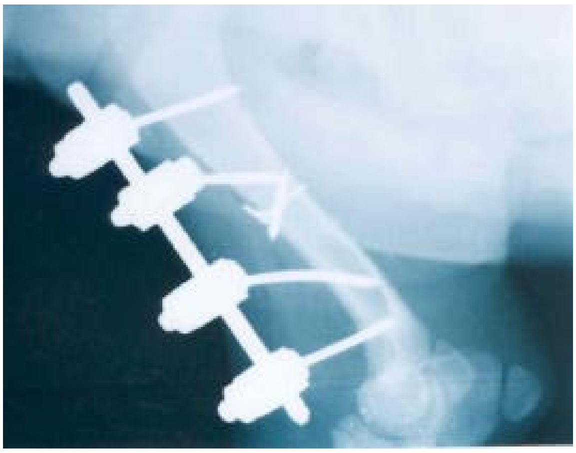

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Figure 1. Radiographic view of midshaft *humeral* fracture belonging to a crossbreed dog, to which limited open approach was applied. a – radiographic view before surgery, b – immediately after surgery, c – radiography 20 days after surgery and healing via endostal callus, before removal of fixator

was placed in the *ulna* using an open approach, while there was sufficient healing in the *radius*, the union in the *ulna* was seen to be insufficient.

Various complications were seen in the cases included in our study which were; pin loosening in 2, pin-base infection in 3, valgus deformation in 2, non-union in 1 and ankylosis in 1 case. Pin loosening and pin-base infection was usually seen in pins placed in the proximal fragment. In a case which had an open and infected fracture, the infection was seen to disappear after application of a fixator. However, as non-union was present, the fixator was removed and treatment was carried out with plate osteosynthesis.

DISCUSSION

When treating fractures in immature animals, it is very important to protect the growth plates and provide early return to function (Altunatmaz and Yucel, 1999; Lewis *et al.,* 2001). Ten cases, to which we applied external fixation, had not yet completed their development. During fixation utmost care was taken not to damage the growth plates and in the postoperative follow-ups no complications were encountered relating to obstruction of growth in these cases.

Type II external fixators can be applied to *tibia-fibula* or *radius-ulna* fracture cases of all ages and bodyweight (Aron *et al.,* 1995; Aron, 1998; Kraus *et al.,* 1998; Lewis *et al.,* 2001). Likewise in this study, location of the fracture did not cause any problems with respect to application of the fixator. The fact that 6 *radius-ulna* and 11 *tibia-fibula* fracture cases, to which a fixator was applied using the closed method, and 3 *humerus* fracture cases fixed using an open approach healed in a short period without complication, once again proved the significance of biological fixation (Toombs, 1992; Johnson *et al.,* 1998; Palmer, 1999).

The fact that the patients were able to walk by touching the fractured leg on the ground within 3–10 days after application of the fixator and that they could use their leg to a great extent within 20 days, are important developments with respect to a

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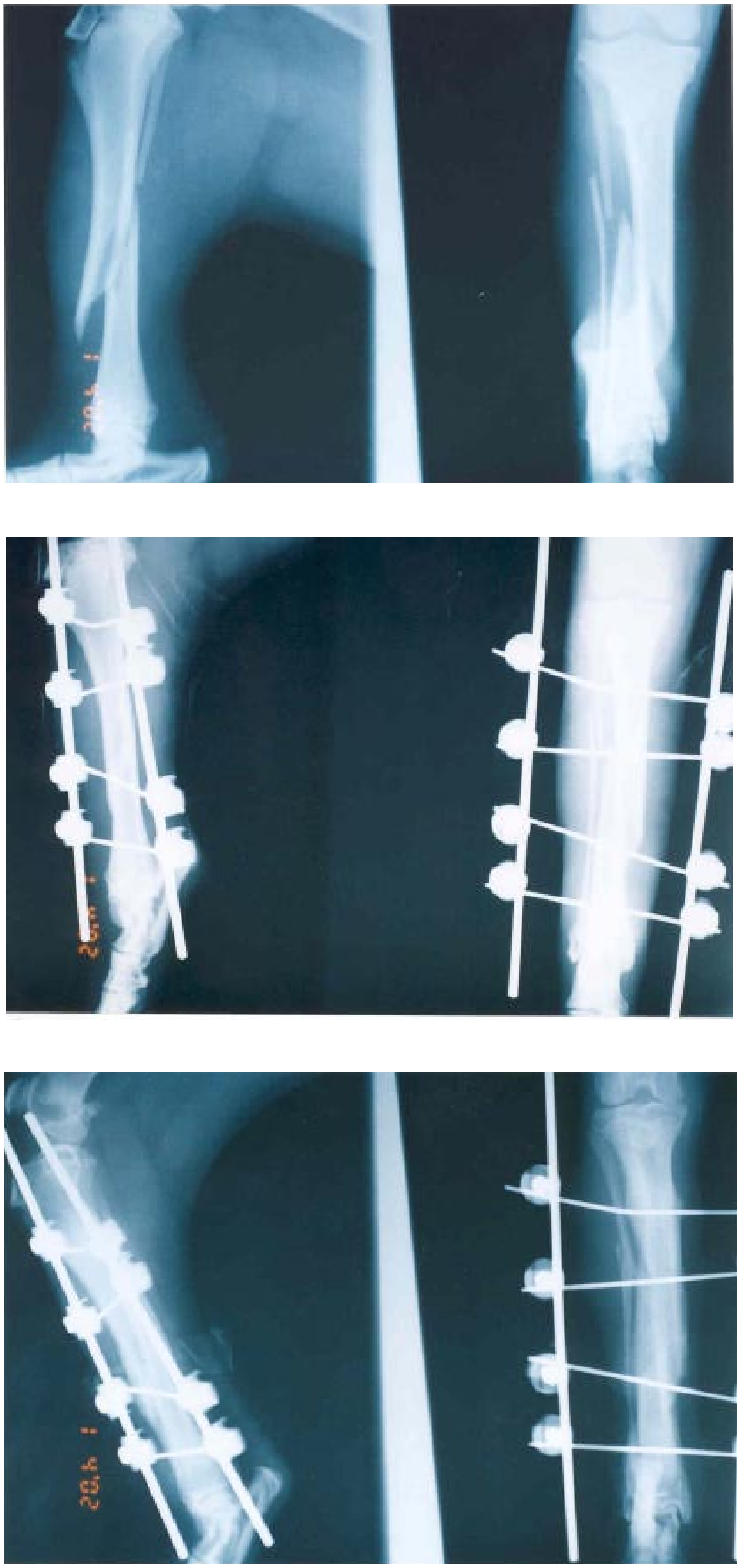

Figure 2. Radiography of mid-shaft *tibia-fibula* fracture belonging to a Siberian husky, using external fixator with closed reduction. a – before surgery, b – immediately after surgery, c – appearance 22 days after surgery showing problem-free healing

avoiding possible complications, such as bone and muscle atrophy, by allowing early return to function of the extremity. Also easy application of the fixator, its low cost and re-useability are other significant advantages (Carnmicheal, 1991; Aron *et al.*, 1995).

It was not a problem during the healing process that the bone fragments could not be aligned as well as with internal fixation. This result is clear proof that, when anatomical alignment is achieved healing can take place in a short time without the need for perfect positioning of the fragments.

External fixators can be removed after a postoperative period of approximately 3–5 weeks, when the callus tissue has reached the point where it prevents rotation of the bone fragments. However, in intramedullary fixation the pins are removed only after bone healing is completed. In a case to which external fixation had been applied to the *radius* and an intramedullary pin to the *ulna*, although sufficient callus formation was observed in the radiographs taken 24 days after fixation, union was not yet complete in the *ulna*. This is a clear example of early healing in closed treatment with external fixation.

While it had been reported (Johnson *et al.*, 1989; Harari *et al.*, 1996) that fractures treated with external fixators heal with endostal callus rather than periostal callus, in the fractures that were fixed using closed and limited open approaches, healing was observed to take place with the formation of a large callus (both periostal and endostal callus formation) (Figures 1 and 2).

In one clinical study (Aron *et al.*, 1986), it was reported that fixation done using smooth pins only provided a trouble-free fixation for 2.2 months, that this period was 4.3 months for fixation done using smooth and threaded pins together and 4.8 months for fixation with threaded pins alone. However, in this study where only smooth pins were used, the pins were seen not to provide stability for more than 40 days and that pin loosening occurred especially in areas with a thick muscle layer.

Using the drill at high speed during the insertion of pins produces heat related necrosis in the bone and this in turn causes pin loosening and failure in fixation. To avoid this, the process of pin inserting should be done at low speed. A manual drill may be preferred but the oscillation produced is another cause of pin loosening (Anderson *et al.*, 1996; McLaughlin and Roush, 1999). In 2 cases which showed pin loosening and 3 cases in which pin-base infection had developed, the fact that these complications occurred in the pins placed in the proximal fragments suggests that this may be a result of the area being covered with a thick muscle layer.

In one of the cases with an open fracture, although infection was treated, non-union was present, of which the reason was excessive loss of bone. Treating infection is one of the fields of use of external fixation (Harari, 1992; Lewis *et al.*, 2001).

In this study, in which 2 different types of clamps and external fixators were used with a closed or limited open approach, very short healing period, sufficient stability, early return to function in the extremity, easy application and low cost conclude that external fixation with closed or limited open application should be preferred in appropriate cases.

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Corresponding Author

Dr. Kemal Altunatmaz, Surgery Department, Faculty of Veterinary Medicine, Istanbul University, 34851-Avcilar, Istanbul, Turkey
Tel. +90 212 591 69 84, fax +90 212 591 69 76, e-mail: altunatmaz@hotmail.com