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COMBIND DIFFERENT FIXATION SYSTEM FOR RECONSTRUCYION OF COMMINUTED DIAPHYSEL FEMORAL FRACTURES INDOGS

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SUMMARY

Combined Intramedullary Pinning and External Skeletal Fixation (CIPEF) together with open reduction approach were successful in repair of comminuted diaphyseal femoral fractures in heavy weight breeds of dogs (N= 15 and weight > 55 kg). In the present study comminuted fractures were classified into two types; short and long. In the former, the seat of comminution restricted only on one third of the femoral diaphysis. While in the latter the seat of comminution was started at mid-shaft and extended to a short distance proximally or distally. The results emphasized on the necessity of 4 to 5 external fixator pins combined with two intramedullary pins for reconstruction of long comminuted fracture. However, in short type, 3 external fixator pins combined with two intramedullary pins were sufficient to achieve rigid stability at the fracture site. The use of CIPEF and open reduction approach gave very promising results in terms of, adequate alignment without deformities, rigid stability with minimal callus formation and early return to full limb function without fracture disease.

INTRODUCTION

In dogs, the femoral diaphysis is the midportion of the bone that curves craniocaudally and lies between the articular extremities. (Piermattei and Flo, 1997). Femoral fractures are usually traumatic due to automobile accidents and occasionally pathologic as a result of primary or metastatic bone tumors (Ozsoy and Altunatmaz, 2005). Comminuted diaphyseal femoral fractures with or without bone loss always present a therapeutic surgical challenge (Henry and Wadsworth,1981). Various reconstructive methods have been recommended for repair of such type of fractures which include intramedullary pins (Hulse and Aron, 1994), Interlocking nails (Muir and Johnson, 1996), Intramedullary pins plus external skeletal fixation (Aron et al., 1991),. IM pins plus cerclage wiring (Howard, 1991), external skeletal fixation alone (Carmichael, 1997), buttress bone plates (Aron et al., 1995) and via an entire segment of EO sterilized cortical bone allografts (Gad Allah, 1998).

Interamedullary pinning provides excellent resistance to bending but does not resist rotational forces or axial loading (Brinker et al., 1989). Additional implants must be used to provide appropriate mechanical support. Combining different fixation methods can be helpful in situations when maximum strength or rigidity of fixation is required (Lewis et al, 2001).

External fixators are occasionally used to support internal fixation and are frequently applied using a closed reduction approach (Foland and Egger, 1991; and Mclaughlin and Roush 1999). External skeletal fixation has several advantages such as causing minimal damage to the injured region, maintaining bone length, allowing complete weight bearing on the healing bone and minimizing soft tissue trauma at the fracture site (Egger, 1998 and Lewis et al., 2001).

The aim of the present study was to evaluate the efficacy of combined intramedullary pins and external skeletal fixators for reconstruction of comminuted diaphyseal femoral fracture in some clinical cases.

MATERIALS AND METHODS

Fifteen dogs of different breeds (4 Boxer, 6 German shepherds, 2 Doberman Pinscher and 3 Rottweilers) , age (18 months to 3 years) and body weight (55-65kg) were admitted to the Surgery Clinic , Faculty of Veterinary Medicine Cairo University during the period from June 2006 to June 2008. They were found in good condition with non weight bearing on their pelvic limbs and suffered from simple comminuted diaphyseal femoral fractures. All cases were subjected to clinical and radiological examinations.

All animals were sedated, prepared for aseptic surgery and received a general injectable anaesthetic regimen after Schmidt-Ochtering and Alef, (1995).

An open reduction with a lateral approach was the technique of choice for diaphyseal femoral fracture repair. Two or three circlage wires (1mmϕ) were placed at first to reduce the fissure at the proximal or distal diaphyseal fragment. Then the fracture was stabilized by using two Steinmann pins of appropriate size (2-3mm ϕ) inserted in a retrograde manner in the proximal and distal bone fragments. After maintaining an optimal alignment at the fracture site, another 2-3 cerclage wires were placed to collect the large fragments at the fracture site in order to minimize bone loss. Directly after intramedullary fixation, a type Ia acrylic external skeletal fixation was applied using 3-5 external fixator pins (4mm ϕ) depending upon the length and degree of comminution. In short comminuted fracture 3 external fixator pins were used while in long one, 4-5 pins were inserted. The operation site was lavaged using sterile saline solution, then the muscle and subcutaneous tissue were closed as usual. Following closure of the skin, the dental acrylic was prepared and rolled to a rod of appropriate diameter and this soft rod was impaled on the fixation pins and molded firmly around the pins by digital pressure. Following hardening of the acrylic, the pins were cut short. Immediate post-operative radiographs were made to confirm the fracture alignment and the stability of fixation device using radiographic potentials of 48-52 kVp, 15 mAs and 70 cm FFD. All operated dogs received antibiotics course of cefotaxim sod. (cefotax. EPICO, A.R.E) at a dose of 4-5 mg/kg b.w. I.V immediately post-operatively and continued every 8 hours I.M for 5 days postoperatively.

The fracture healing was assessed radio graphically with sequential radiographs taken regularly (once per month) during the post-operative period which extended up to 6 months. Also all operated dogs were observed clinically for weight bearing capacity of the operated limb. The external fixator pins were removed in all cases which showed sufficient callus formation (4-6 week post-operatively). While removal of the IM pins were postponed until complete disappearance of the fracture lines had occurred. The results of clinical and radio graphical assessment were analyzed in relation to the length of comminuted fracture and the degree of comminution using the scoring system stated by (Gad Allah et al., 2002).

RESULTS

Treatment with combined intramedullary pinning and external skeletal fixation (CIPEF) using an open reduction approach was evaluated in all the screened animals. The clinical and radiological examinations revealed that, all animals were suffering from comminuted diaphyseal femoral fracture of two different types. Type 1; short comminuted fracture (10 cases), the seat of comminution restricted only at one third of femur diaphysis (Fig. 1,A, B & C). The second type of comminuted fracture is called long comminuted fracture (5 cases); the seat of comminution started at the mid-diaphysis and extended to a short distance proximally (3 cases) and distally (2 cases) (Fig. 1 D). The degree of comminution was also evaluated in all these cases; comminuted fracture with large butterfly fragments were recorded in 4 cases, those with multiple small fragments were observed in 3 cases and lastly with large and small fragments (8 cases). In short comminuted fractures, the use of two Steinmann pins (2-3mm ϕ), Cerclage wire (1mm ϕ) and 3 external skeletal fixator pins (4mm ϕ) gave satisfactory results (10 Cases). While in long comminuted fractures, the use of cerclage wire, two intramedullary pins and at least 4-5 external skeletal fixation pins gave also an encouraging result (5 cases).

The obtained results were illustrated in (Table 1). Moreover, figures 2,3,4,5 and 6 showing the clinical and radiographic picture of some selected cases before and after reconstruction.

In all operated dogs, the external fixation pins were removed after 4 weeks particularly in those which had short comminuted fracture while in those which had long comminuted fracture, the best time for removal was 6 weeks P.O, during that period the fracture fragments were united with hard callus. On the other hand, intramedullay pins were also removed at 8 to 12 weeks post-operatively.

The recorded complications of combined external skeletal fixations and intramedullary pinning were premature pin loosening in 3 cases (# 4,11 and 13), pin binding one case (#15) and infection in one case (#9).

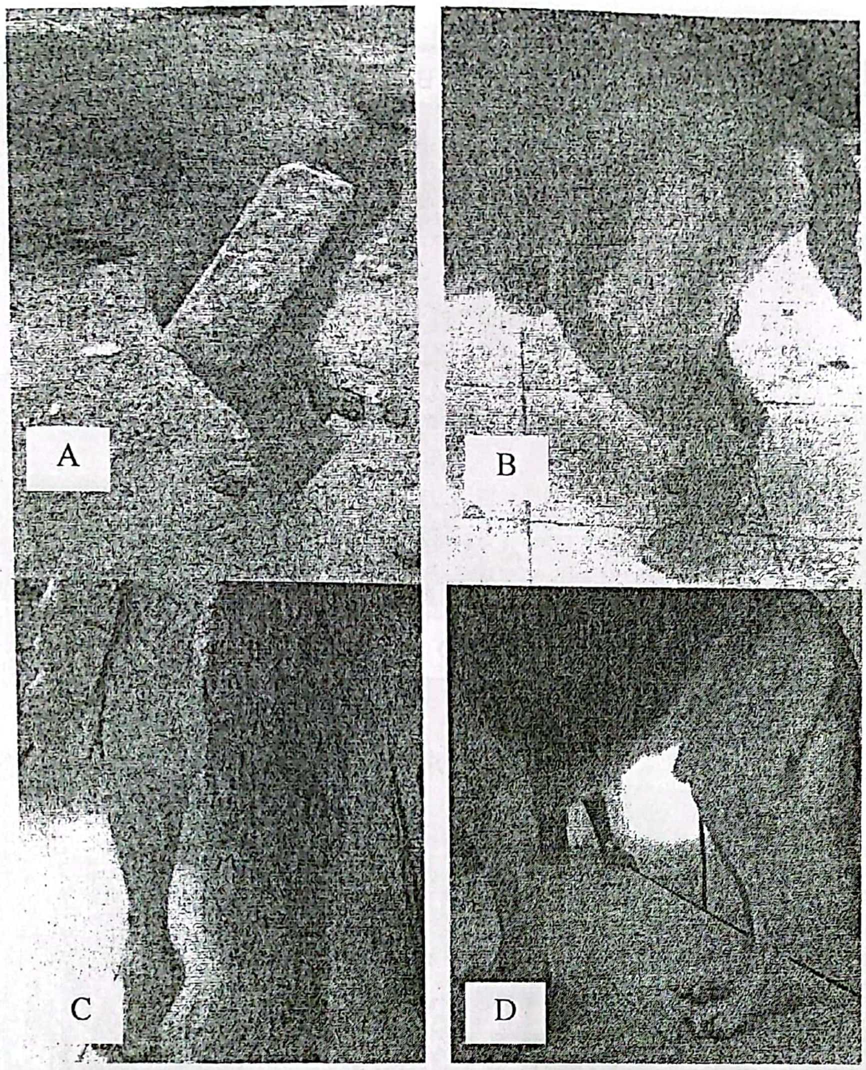

Fig. (1): Comminuted femoral fracture in two large size breeds of dogs.
(A &C) At 3 weeks post-operatively before removal of acrylic external fixator. Note that both dogs bear weight on the operated limbs.
(B & D) At 6 weeks post-operatively, the same dogs after removal of acrylic external fixators. Note that both dogs showed full limb function.

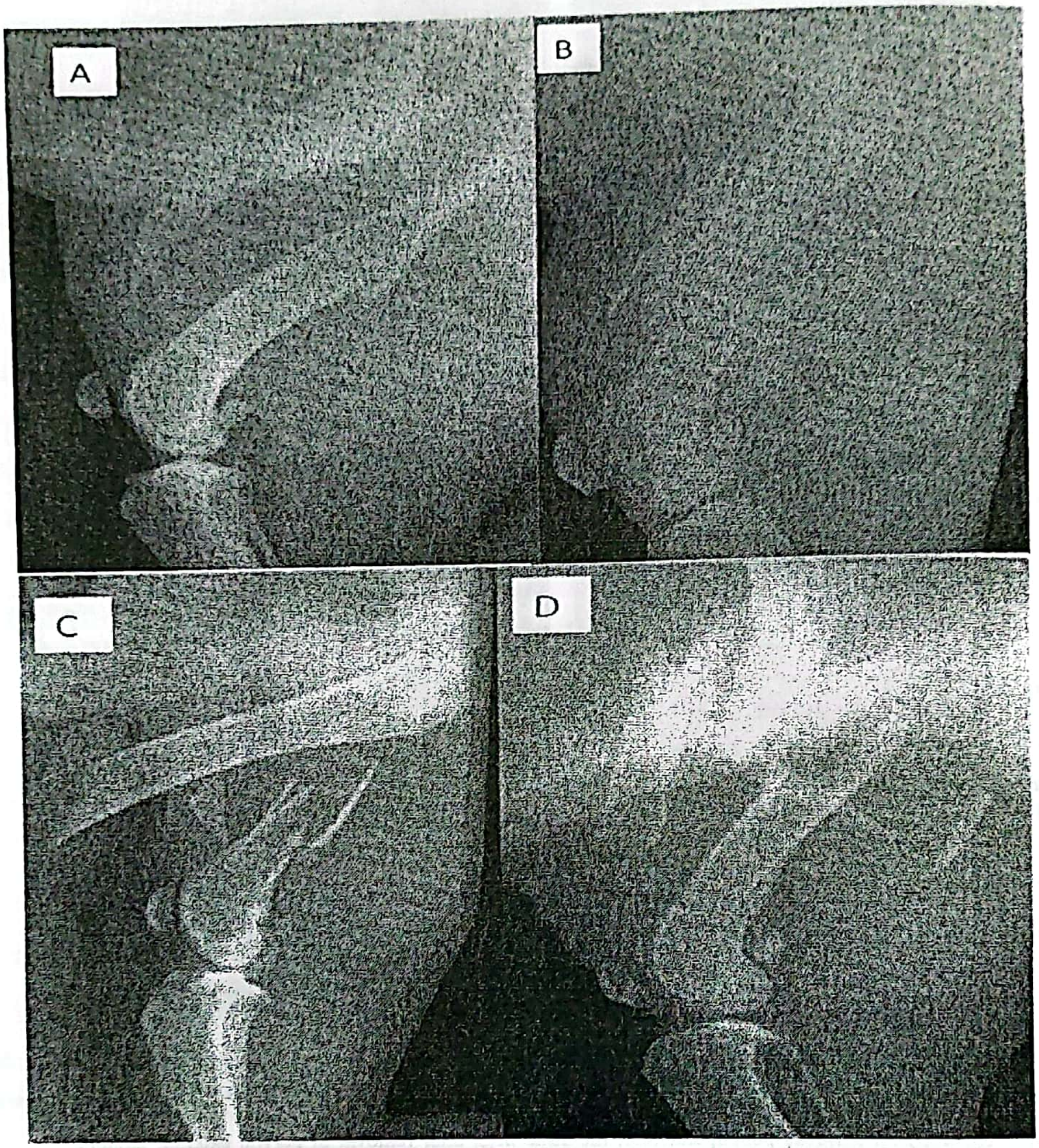

Fig. (2) Later medial radiographs showing different varieties of comminuted femoral fractures.
(A) At the proximal 1/3 of the femur's shaft
(B) At the mid-diaphysis.
(C) At the distal 1/3 of the femur's shaft
(D) At the mid shaft and extend for a short distance proximally.

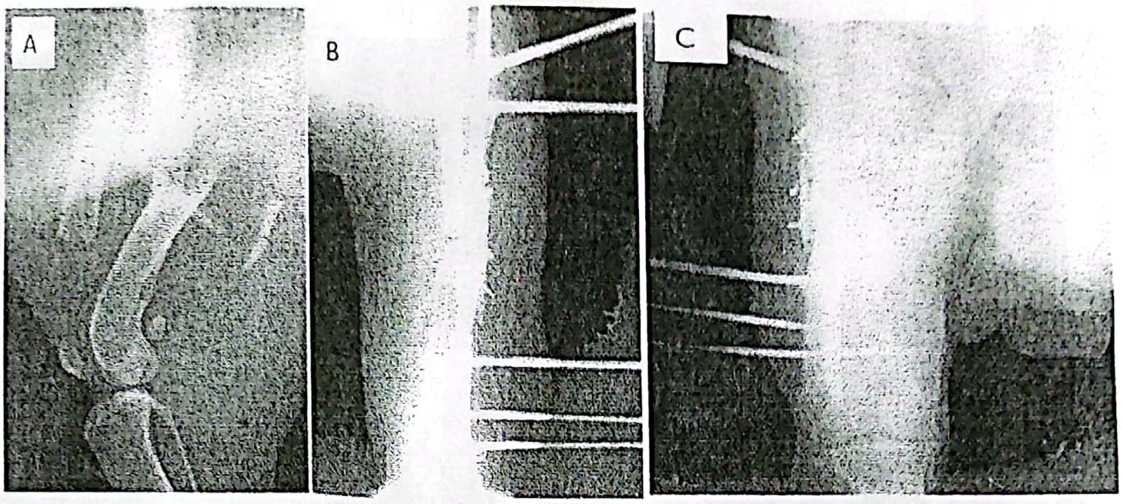

Fig. (3): Long comminuted femoral fracture in 18 month old Rottweiler before and after reconstruction.

(A) Mediolateral radiograph showing the seat of comminution include mostly the proximal 1/3.

(B) A/P radiograph immediately post-operatively; the fracture was reconstructed using 2 intramedullary pins, 4 cerclage wire and 5 fixator pins. A/P radiograph at one month post-operatively showing absence of periosteal callus, presence of endosteal callus crossing the fracture gap and uniting the proximal and distal fragment. The stability of fixation device is good except at the distal fragment as the third and fourth pins were bended.

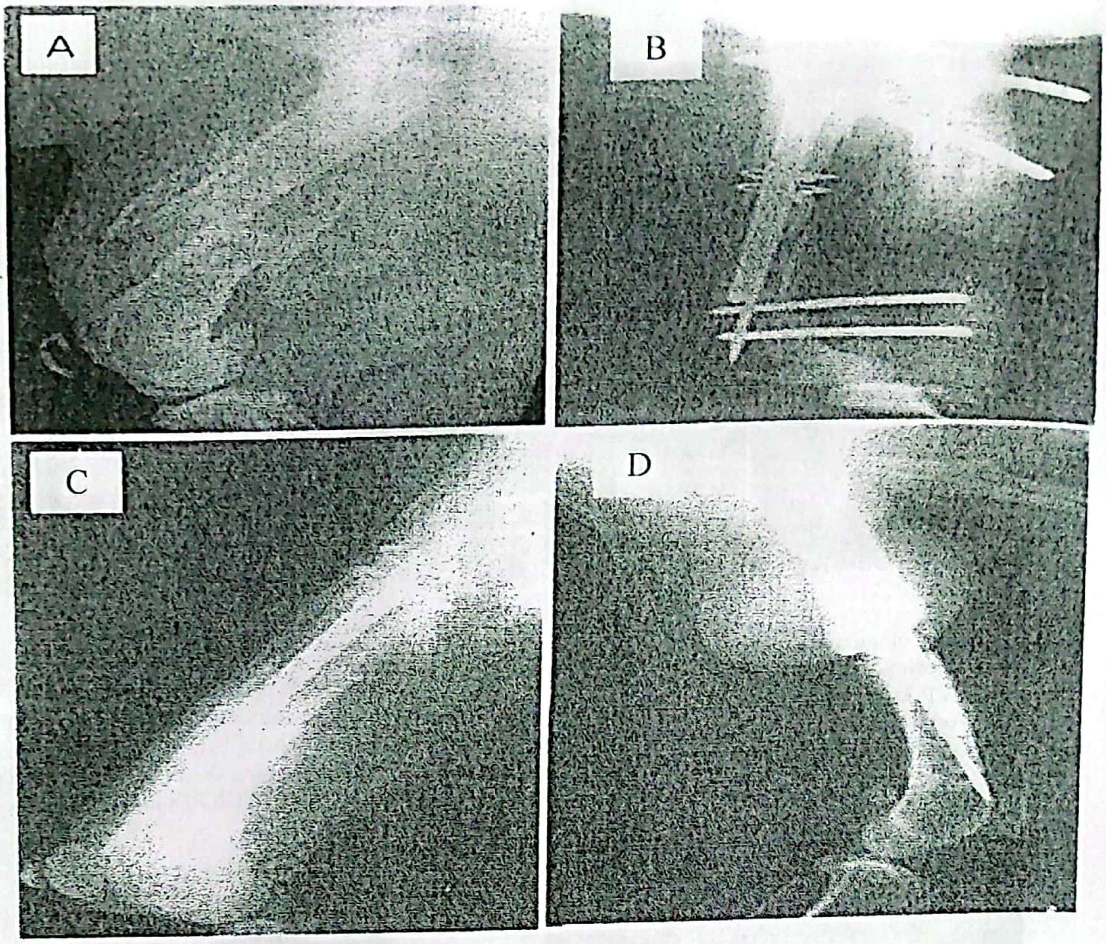

Fig. (4): Short comminuted femoral fracture in 2 years old German shepherd before and after reconstruction.

(A) M/L radiograph, showing the seat of comminution restricted only at the mid-shaft.

(B) M/L radiograph immediately post-operatively.

(C) M/L radiograph at one month post-removal of acrylic fixator pins showing absence of periosteal callus, presence of bridging endosteal callus crossing the fracture gap at the caudal and cranial cortex.

(D) M/L radiograph at 2 months post-removal of ESF pins showing prescence of both periosteal and endosteal callus, bridging the fracture gap with starting of radiographic signs of bone remodeling.

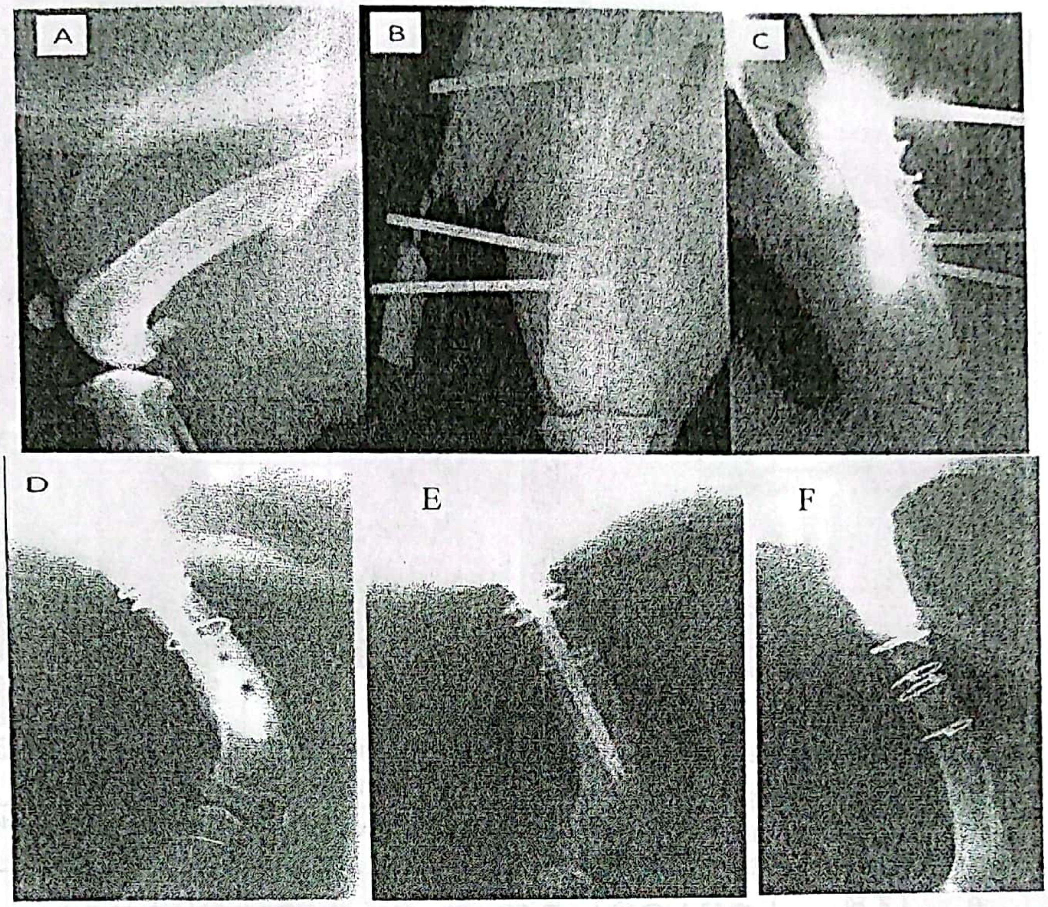

Fig. (5): Short comminuted femoral fracture in 2 years old Boxer before and after treatment

(A) M/L radiograph showing the seat of comminution restricted proximally.
(B) A/P radiograph immediately after reconstruction.
(C) A/P radiograph at one month post-operatively showing periosteal and endosteal bridging callus.
(D) M/L radiograph at one month post-removal of acrylic external fixator showing the fracture gap was nearly disappeared with starting of radiographic sings of remodeling.
(E) M/L radiograph at two months post-removal of acrylic external fixator showing that, the fracture gap completely disappeared with complete remodeling
(F) M/L radiograph immediately after removal of intramedullary pin showing complete disappearance of fracture gap and remodeling

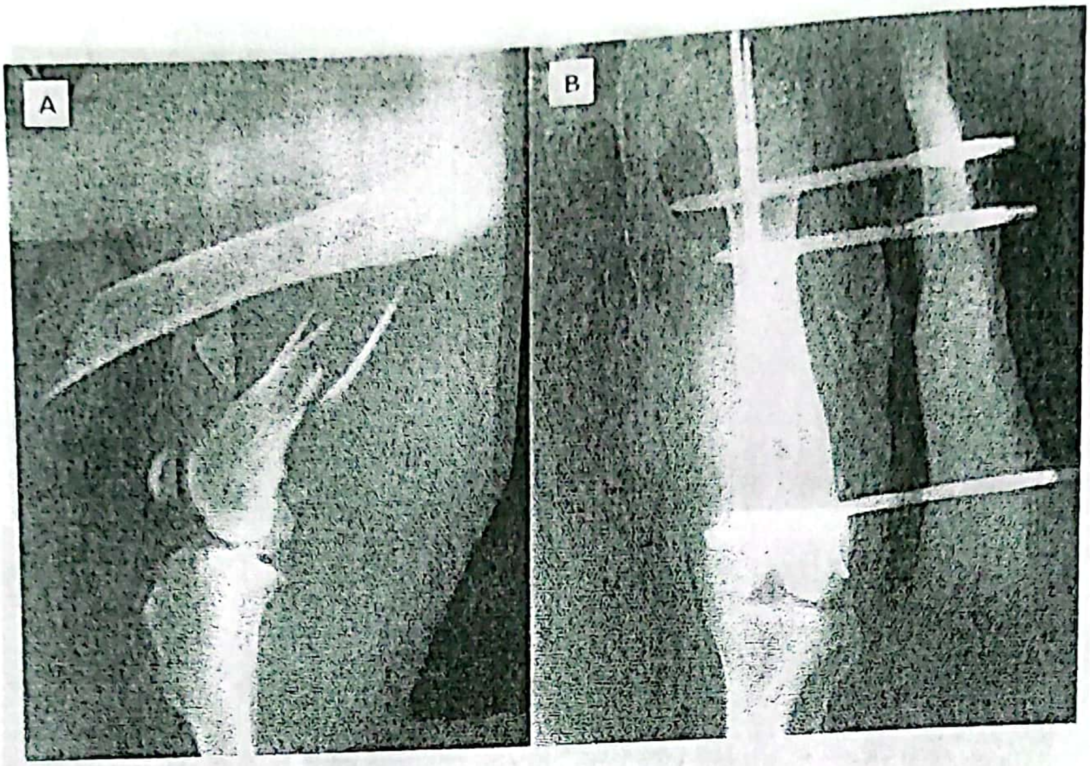

Fig. (6): Short comminuted femoral fracture in 2 years old German shepherd

(A) M/L radiograph showing the seat of comminution restricted distally (distal 1/3) .

(B) A/P radiograph immediately post-operatively showing rigid fixation with 2 Steinmann pins inserted distally via parapatellar arthrotomy and 3 external fixator pins.

Table (1): Descriptive details of 15 cases of different types of comminuted diaphyseal femoral fractures treated by Combined Intramedullary Pinning and external Skeletal Fixation (CIPEF)

Case. No.	Breed	Age months	Weight "Kg"	Type of comminuted fracture	Seat of comminution	Fracture fragments		Combined fixation system	Time of ESF removal	Results	Complications
						No	Size				
1	German shepherd	6	55	Short	Mid-shaft	3	(2) large (1) small	CW (2 proximal) I.P (2pins) ESF (2 proximal +2 distal)	4 weeks	Good	-
2	Rottweiler	18	65	Long	Mid-shaft + prox. 1/3	5	(3) large (2) small	CW (2prox.+3 mid). I.P (2 pins) EsF (2 proximal + 3 distal)	6 weeks	Good	-
3	Boxer	24	55	Short	Proximal 1/3	2	large butterfly fragments	CW (2proximal + 2 distal) IP (2 pins) ESF (2 dist. +one proximal)	4 weeks	Good	-
4	German. shepherd	36	55	Short	Mid-shaft	3	small fragments	IP (2pins) ESF (2prox.+ 2 distal).	4 weeks	Fair	Premature pin loosening
5	German shepherd	18	55	Long	Mid-shaft + distal 1/3	5	(2) large (3) Small	CW (2 mid + 3 distal) I.P (2 pins) ESF (3 proximal + one distal)	6 week	Good	-
6	Boxer	24	60	Short	Distal 1/3	4	Small frag.	IP (2 pins) ESF (one distal and 2 proximal	4 weeks	Good	-
7	Doberman pinscher	18	55	Long	Mid-shaft + proximal 1/3	5	(2) large (3) small	CW (2mid +2 proximal) IP (2 pins) ESF (3distal + 2 proximal)	6 weeks	Good	-
8	German Shepherd	36	62	Short	Distal 1/3	4	(3) small (one) large	I.P (2 pins) ESF (3 proximal + one distal)	4 weeks	Good	-
9	Rottweiler	36	55	Long	Mid-shaft + distal 1/3	5	2 large 3 small	CW (2 mid) IP (2 pins) ESF (2 distal + 3 proximal.	6 weeks	Poor	Infection

Case. No.	Breed	Age months	Weight "Kg"	Type of comminuted fracture	Seat of comminution	Fracture fragments		Combined fixation system	Time of ESF removal	Results	Complications
						No	Size				
10	German shepherd	24	60	Long	Mid-shaft + proximal 1/3	4	(2) large (2) small	CW (2 mid) IP (2 pins) ESF (2 proximal + 2 distal)	6 weeks	Good	-
11	German Shepherd	24	60	Short	Mid-shaft	2	large Butterfly fragments	CW (2mid) IP (2 pins) ESF (2 proximal + 2 distal	4 weeks	Fair	Premature pin Loosening
12.	Doberman Pinscher	18	60	Short	Proximal 1/3	2	Large butterfly fragments	CW (2 prox.) IP (2 pins) ESF (one proximal. + 2 distal)	4 weeks	Good	-
13	German shepherd	24	55	Short	Mid-shaft	2	Large butterfly fragments	CW (2 mid) IP (2 pins) ESF (2 proximal. + 2 distal	4 week	Fair	premature pin loosening
14	Boxer	18	60	Short	Mid-shaft	3	2 large (one) small	Cw (2mid) IP (2 pins) ESF (2 proximal. + 2 distal)	4 weeks	Good	-
15	Rottweiler	36	55	Short	Distal 1/3	4	Small fragments	IP (2 pins) ESF (2 proximal. + one distal)	4 weeks	Fair	Pin bending

CW = cerclage wire **I.P** = Intramedullary pins **ESF**= External Skeletal fixator pins

Good = Optimal alignment, rigid fixation, primary bone healing with minimal callus formation and full limb function

Fair = Adequate alignment, stable fixation, secondary bone healing with excessive callus formation and slight degree of lameness.

Poor = Implant Failure, malalignment, delayed union, non union, infection and severe degree of lameness.

DISCUSSION

The present study classified all recorded cases of comminuted diaphyseal femoral fractures into two types. Type I, with short comminuted fractures which restricted only at one third of the femur diaphysis (proximal 1/3 or middle 1/3 or distal 1/3). While type II, with long comminuted fractures, which started at the mid shaft and extended to a short distance proximally or distally. The degree of comminution was also classified into comminuted fractures with large butterfly fragments and comminuted fractures with small multiple fragments. This was attributed to the length and seat comminution besides the size and number of comminuted fragments. These findings were similar to those of (Foland and Egger 1991 and Johnson et al., 1998).

In this study, open reduction approach is recommended to achieve adequate alignment and to prevent axial collapse at the fracture site through placement of temporary intramedullary pins into the intact proximal segment of bone, across the fracture site, and into the distal segment of the bone. Also this approach assess in collection of the large butterfly fragments to the seat of fracture by using cerclage wire in order to minimize bone loss. These findings are consistent with those reported by Gregory and Della, (2006). In contrary to these findings Aron, et al., (1991), and Farag et al., (2001) preferred closed reduction approach upon open approach, because, the use of closed approach minimizes the damage to the soft tissues at the fracture site and reduces the infection rate.

Intramedullary Pinning is a common method of stabilizing long bone fractures. The use of I.M pins provides an axial alignment and resists bending forces applied on the bone during weight bearing but do not control shear and rotational forces at the fracture site. Additional stabilization must be provided by using another fixation device to control these forces in many of these fractures (Howard, 1991 and Hulse and Aron, 1994).

External skeletal fixation may be used for ancillary support of other forms of internal fixation. It can be effective in control axial rotation and axial collapse at the fracture site when used with intrameduallary pins (Green, 1989).

Combining different fixation methods can be enormously helpful in situations where maximum strength of rigidity of fixation is required, as for reconstruction of comminuted fractures (Aron et al., 1991 and Gregory and Della, 2006).

In the present study, combined fixation device consisting of cerclage wire, multiple Steinmann pins and acrylic external skeletal fixator (type Ia) were used successfully for reconstruction of short and long comminuted diaphyseal femoral fracture with large butterfly fragments. However, in comminuted fracture with small multiple fragments, the use of multiple Steinmann pins in conjunction with acrylic external skeletal fixator gave stasifactory results. These findings are in agreement with those reported by Ozsoy and Altunatanza, (2005).

In this study two Intramedullay pins of different sizes were inserted into the medullary canal instead of using single pin. It was found that the use of multiple pins facilitate the application of trans-skeletal fixation pins and minimize rotational instability at fracture site. In this respect Piermattie and Flo (1997) used a small kirschner wire as a feeler pin to identify the angle of insertion for the external fixation pin to avoid intersecting of the IM pins.

Concerning the number of external fixator pins, the present study recommended the use of 3 fixator pins for reconstruction of short comminuted fracture and 4-5 fixator pins in long comminuted fractures. The clinical and radiological assessment revealed rigid stability at fracture site and primary bone healing with minimal callus formation. These results are in agreement with those reported by Kirkby et al., (2008) and at the same time in contrary with some previous results (Carmichael, 1997).

In the present study, the fixator pins were removed at 4-6 weeks post-operatively, the clinical and radiological findings during this period revealed that the dogs started to land on the operated limb and the callus has reached the point where it prevents rotation of the bone fragment (hard callus). These findings are consistent with those reported by Ozsoy and Altumatanaz, (2005).

Premature pin loosening, improper pin size, pin binding were the previously recorded complications of external skeletal fixation and intramedullary pinning (Hararri, 1992; Johnson and Decamp, 1999).

Pin bending and premature pin loosening have been met with in this study in a few number of cases (4 cases) . Good pin placement technique with low speed power drill and the choice of proper size pins in correspondence to the size of the animal should put in concern to avoid these complications (Aron and Toombs, 1984; Egger, 1986 and Jonhson and Decamp, 1999).

In conclusion, the use of open reduction approach and combined intra-medullary pinning and acrylic external skeletal fixation for reconstruction of different types of comminuted diaphyseal femoral fractures in dogs gave very promising results in terms of, adequate alignment without deformities, rigid stability at the fracture site with minimal callus formation and early return to full limb function without fracture disease that include muscle atrophy, Joint stiffness and osteoporosis.

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نظم تثبيت متحدة مختلفة لإعادة بناء الكسور المفتتة لعظمة الفخذ فى الكلاب

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تمت فى هذه الدراسة عمل توليفة من ضم نظامين للتثبيت هما التثبيت الخارجى الهيكلى و التثبيت الداخلى بإستخدام مسامير داخل النخاع و تم تجربة هذه التوليفة فى علاج كسور الفخذ المفتتة فى عدد ١٥ حالة إكلينيكية من الكلاب ذات السلالة الثقيلة الوزن.

تم فى هذه الدراسة تقسيم كسور الفخذ المفتتة حسب طول و مكان الجزء المفتت إلى نوعان أحدهما قصير و الأخر طويل. فبالنسبة للقصير المفتت فإما أن يكون فى الثلث العلوى أو الثلث الوسطى أو الثلث السفلى لعظمة الفخذ و بالنسبة للطويل المفتت فإنه غالباً ما يبدا بثلث الوسط ويمتد بمسافة قصيرة إلى أعلى أو أسفل.

تم توظيف توليفة التثبيت الداخلى بمسامير داخل النخاع و التثبيت الخارجى الهيكلى حسب نوع الكسر المفتت ففى الكسور الطويلة المفتتة فقد استخدم عدد ٤ أو ٥ مسمار من مسامير التثبيت الخارجى الهيكلى بالإضافة إلى عدد ٢ مسمار من مسامير داخل النخاع. و بالنسبة للكسور القصيرة المفتتة فقد تم إستخدام ثلاث مسامير فقط من مسامير التثبيت الخارجى الهيكلى و عدد ٢ مسمار من مسامير داخل النخاع.

أثبتت النتائج الإكلينيكية و الراديولوجية أن إستخدام هذه التوليفة ورد الكسر بطريقة الفتح يؤدى إلى العديد من المميزات منها إستقامة الساق المفتت دون أدنى تشوهات و تثبيت الكسر بطريقة جيدة تساعد على إلتئام الكسور المفتتة دون الحاجة إلى مزيد من التصلب (callus) و عودة القوائم المكسورة إلى حالتها الطبيعية فى أقصر وقت ممكن دون أدنى مضاعفات للكسر.