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EVALUATION OF THE EFFICACY OF DIFFERENT FIXATION TECHNIQUES IN CANINE APPENDICULAR SKELETAL FRACTURES REPAIR: A RETROSPECTIVE STUDY FROM 1996 TO 2002

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SUMMARY

Three hundred and fifty four dogs of different ages, weights and breeds suffering from different types of fore and hind limbs fractures were admitted to the surgery clinics faculty of veterinary medicine, Cairo university during the period from June, 1996 to June, 2002. All dogs were subjected to clinical and radiographical examination to determine the fractured bone and the fracture type and environment (open vs. closed), the degree of fracture displacement and the fracture forces present. Different fixation techniques were evaluated in reconstruction of the fractured bones. These techniques included external coaptation using plaster of Paris and dyna cast (77 cases), external skeletal fixation using type Ia unilateral uniplanar acrylic external fixator (67 cases) and Internal fixation (210 cases). Internal fixation included different fixation devices which are intramedullary bone pinning (single pin, stack-pins and cross pinning), bone plate and lag screws. The combination of more than fixation devices were used in repair of unusual types of fractures, such as the use of intramedullary pin in conjunction with cerclage wire and external skeletal fixator and the use of bone plate together with lag screws. The clinical and radiological results were analysed using scoring system. Finally, the present study emphasized on the necessity of early surgical intervention and selection of suitable fixation device or devices which are capable of neutralizing all fracture forces in order to achieve rigid and stable environment necessary for facture healing and subsequently early return of full limb function.

1. INTRODUCTION

Bone fractures constitute a major problem in small animal practice particularly in dogs. Prior to selecting the appropriate method of fracture repair, the patient and the intended fracture should be carefully assessed. Patient assessment should include signalment, history, physical and orthopedic examination. However, the fracture assessment inculdes the type of fracture, the fracture environment (open vs- closed), concurrent soft tissue injuries, the degree of fracture displacement and the fracture forces present (Brinker, Hohne and Prieur, 1984; Perren, 1991; Gautier, Perren and Gauze, 1992).

Various reconstructive methods have been adopted for management of different types of canine long bone fractures, which may include external coaptation, external skeletal fixation and internal fixation (Brinker, Piermattei and Flo, 1983; Gautirer et al. 1992; Egger, 1993; Piermattei and Gretchen, 1997).

External coaptation either with cast or splint is still of great use in veterinary practice. Plaster of Paris bandage has been the most widely used casting material in orthopedic surgery (Egger, 1991). Recently a number of practical alternatives have been introduced such as Hexcelite (Cotton mesh impregnated with a thermoplastic polymer), Dyna cast P (polypropylene substrate impregnated with resin), Dyna cast E (Fibreglass substrate impregnated with resin) and Turbocast (Thermoplastic sheets) [Langley-Hobbs, Abercromby and Pead, 1996].

External skeletal fixation (ESF) devices are considered as versatile means for stabilization of long bone fractures (Tomlinson & Constantinescu, 1991, Aron, Dewey,1992, Andreson, Mann and Wagner-Mann 1993 and Langley-Hobbs, Carmicheal and Macertney, 1997). The linear ESF included type I (a or b) is the most commenly used for long bone fracture repair. The basic external fixator is composed of stainless steel threaded or non- threaded Steinmann pins placed percutaneously and attached to an external clamp to immobilize bone fragments. The external clamps are connected by bars or an acrylic column. The threaded pins may have an end thread for half-pins or a mid-shaft thread for full pins (Longley-Hobbs et al., 1997; Egger, 1998; Johnson & Decamp, 1999).

Internal fixation was introduced by the AO/ASIF group in Swizerland 1958. The chief aims of the AO/ASIF are anatomical reduction of the fracture fragment, preservation of the blood supply to the bone fragments, rigid fixation and early recovery of full function of the limbs (Perren, 1991; Gautirer, et al, 1992 and Piermattei and Graetchen, 1997).

The principals of the ASIF techniques are based on two biomechanical principles which are interfragmentary compression and rigid bone splinting. Interfragmantary compression could be achieved by the use of lag screw, cerclage wire, tension wire band and dynamic compression plate (Whitney & Schrader, 1987 & Shwarz, 1991). Bone splinting is performed by means of intramedullary pins and Buttress plate fixation (Perren, 1991; Gilmor, 1998; Mclaughin, 1999).

In certain types of shaft fractures particularly oblique and butterfly fractures a combination of interfragmentary compression and bone splintage is necessary (Lewis and VanEe, 1993).

The aim of the present study is to evaluate the efficacy of different fixation techniques in repair of different types of appendicular skeletal fractures in dogs over 6 years time period from 1996 till 2002.

2. MATERIALS AND METHODS

Three hundred and fifty four dogs of both sexes and different breeds, ages (3 months to 5 years) and body weight (10- 60 kg. b. wt.) were admitted to the surgery clinic, faculty of veterinary medicine, Cairo university during the period from June 1996- to June 2002. The history showed that these dogs were suffering from different types of long bone fractures. All cases were clinically and radiographically examined to determine the fractured bone and the suitable mean/means for fixation (table 1).

2.1. Anaesthesia and control

All dogs were anaesthetized using intravenous anaesthetic cocktail which involved atropine sulfate[R1] (0.05mg/kg), diazepam[R2] (0.5mg/kg), Ketamine Hcl[R3] (10 mg/kg) and Xylazine[R4] (1mg/kg). The anesthetic depth was maintained with 2.5% thiopental sodium[R5] at a dose of 20- 30 mg/kg (Schmidt- Ochtering and Alef, 1995). All dogs were restrained in lateral or dorsal recumbency.

Different fixation techniques were used for stabilization of the fractured bones.

R1: Atropin sulfate: 1mg/ml Misr, Med. Co. A.R.E
R2: Neuril: 0.5% Sol. Memphis Co. pharm & Chem. Ind. Cairo, A.R.E.
R3: Ketalar: 5% Sol. Park-Davis and Co. USA
R4: Rompun: 2% Sol. Bayer LeverKusen. Germany.
R5: Nesdoual: Specia paris.

Table (1): Distribution of the fractured bones in relation to the methods of reconstruction.

Bone affected	No. of Cases	Methods of Reconstruction										
		External Coaptation		External skeletal fixation	Internal Fixation							
		Plaster of Paris	Dyna Cast	Acrylic External Skeletal Fixator	Single I.M. Pinning	Stack Pinning	Cross Pinning	Bone Plate	Lag Screw	I.M. Pinning & Cerclage wiring	Bone Plate & Lag screw	I.M. Pinning & Ext. skeletal fixation
Humerus	55	-	-	18	5	9	-	6	6	7	4	-
Radius and ulna	81	12	11	18	11	14	-	10	-	5	-	-
Femur	122	-	-	17	12	20	24	20	1	15	11	2
Tibia and Fibula	69	20	12	14	10	5	-	3	-	5	-	-
Metacarpal and Metatarsal	27	7	15	-	3	-	-	2	-	-	-	-
Total	354	39	38	67	41	48	24	41	7	32	15	2

2.2 Fixation techniques:

2.2.1. External coaptation

Seventy-five fractures were immobilized by external coaptation. After closed reduction; plaster of Paris was used for fixation of 39 cases (12 radial, 20 tibial and 5 metacarpal and 2 metatarsal fractures). While dyna cast was used for stabilization of 38 fractures (11 radial, 12 tibial, 10 metacarpal and 5 metatarsal fractures). Both casting materials were applied and modulated to the contours of the limbs according to Langley et al. (1996).

2.2.2 External skeletal fixation (ESF)

After closed reduction and strict aseptic measures, acrylic external fixatior with type Ia uniplaner splint was used for reconstruction of 67 fractures (18 humeral, 13 radial, 17 femoral and 14 tibial fractures). Threaded Steinmman pins of suitable size (3.5 mm to 5 mm) were selected according to the size of the animal. The pins were inserted percutaneously, and transcortically through the fractured bone fragments with low power speed pneumatic drill, the inserted pins were fixed together externally in an acrylic rod. At least 4 pins were used two on either side of the fracture line.

2.2.3 Internal fixation

After an open reduction under strict aseptic measures, different types of internal fixation were used for repair of 210 cases of fractures.

2.2.3.1 Intramedullary pinning

Single Steinmman pin was used for repair of 41 cases (5 humeral, 11 radial, 12 femoral, 10 tibial and 3 metacarpal fractures). While multiple pins (stack pins) were used in repair of 48 cases (9 humeral, 14 radial, 20 femoral and 5 tibial fractures). Pins of suitable sizes were selected (2 mm to 5 mm) according to the diameter of the medullary canal. The selected pins were introduced using low power speed pneumatic drill. The pins were introduced either in retrograded or normograded manner. In 24 supracondylar femoral fractures lateral parapatellar arthrotomy and cross-pinning technique were used for reconstruction according to Franczuski, Chalm & Butler (1986).

2.2.3.2 Bone Plates and screws

Dynamic compression plates of a 3.5 and 4.5 mm and suitable lengths were used in stabilization of 41 cases (6 humeral, 10 radial, 20 femoral, 3 tibial and 2 metacarpal fractures). Transolecranon approach and lag screw fixation was used in repair of 6 condylar humeral fractures while lag screw and single Steinmann pin inserted from the lateral condyle of the femur were used in repair of one case of supracondylar/intercondylar femoral fracture.

The combination of more than one fixation device was used for reconstruction of certain types of unusual fractures. Intramedullary bone pinning in comibination with cerclage wiring was used in 32 cases (7 humeral, 5 radial, 15 femoral and 5 tibial fractures). While bone plate and lag screw were used in 15 cases (4 humeral and 11 femoral fractures).

Also external skeletal fixation and intramedullary bone pinning were used in two femoral shaft fractures.

2.3 Post-operative care:

Immediate post-operative radiographs were made to confirm the fracture alignment and the stability of fixation device. All operated dogs were received an antibiotic course of cefotaxime R[6] at a dose of 4.5 mg/kg b.wt administered I.M. immediately post-operatively and continued every 12 hours for 5 successive days.

Sequential radiography of the affected limb was encouraged every two weeks to assess the process of the fracture healing till radiographic union has been ensured. Also the operated dogs were observed clinically for weight bearing capacity of the operated limb. After complete healing the fixation device was removed in every case.

The results of clinical and radiographical assessment for each type of fixation in relation to fracture location and condition within an individual bone were analyzed according to the following scoring system:

Excellent: Optimal alignment, rigid fixation, primary bone healing (minimal callus formation) and full limb function.

Good: Adequate alignment, stable fixation, secondary bone healing (excessive callus formation) and slight degree of lameness.

Poor: Mal-alignment, unstable fixation, delayed union, nonunion, lameness.

RESULTS

Three hundred and fifty four dogs were included in the present study. Of the 354 fractures 311 fractures were fresh that were less than one-week-old. The others 43 fractures were old fractures that were more than one week old. In all old fractures the process of reduction was difficult and needed excessive effort until muscle fatigue occurred.

The results of clinical and radiographical assessment of each type of fixation in relation to the fractured bone and the fracture type, location and condition within an individual bone were analysed and illustrated in tables, 2, 3, 4, 5 and 6. Moreover, plates 1 to 10 showed the radiographical pictures of the fore and hind limb fractures before and after reconstruction.

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Table (2): The results of acrylic external and internal fixations in repair of different types of humeral fractures.

Type of fracture	No. of Cases	State of fracture		Methods of Reconstruction																				
				Ext. Skeletal fixation			Internal Fixation																	
		Fresh fracture < week old	Old fracture > week old	Acrylic External Skeletal Fixator			Single I.M. Pinning			Stack Pinning			Bone Plate			Lag Screw			I.M. Pinning & Cerclage wiring			Bone Plate & Lag screw		
				Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor
Transverse diaphyseal	17	14	3	-	-	-	1	3	1	6	3	-	2	1	-	-	-	-	-	-	-	-	-	-
Oblique diaphyseal	8	8	-	-	3	-	-	-	-	-	-	-	-	1	-	-	-	-	2	2	-	-	-	-
Spiral diaphyseal	8	8	-	-	4	-	-	-	-	-	-	-	1	-	-	-	-	-	3	-	-	-	-	-
Comminuted diaphyseal	9	9	-	3	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Condylar	10	10	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	-	4	-	-
Compound	3	3	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	55	52	3	3	14	2	1	3	1	6	3	-	3	2	-	6	-	-	5	2	-	4	-	-

Excellent: Optimal reduction & alignment, rigid fixation, primary bone healing with minimal callus, full limb function (28 cases).
Good: Adequate alignment, stable fixation, and secondary bone healing with excessive callus formation, slight degree of lameness (24 cases).
Poor: Mal-alignment; unstable fixation, delayed union, nonunion or malunion, lameness (3 cases).

Table (3): The results of external and internal fixation in repair of different types of radial and ulnar fractures.

Type of fracture	No. of Cases	State of fracture		Methods of Reconstruction																				
				External coaptation						Ext. Skeletal fixation			Internal Fixation											
		Fresh fracture < week old	Old fracture > week old	Plaster of Paris			Dyna Cast			Acrylic external skeletal fixator			Single I.M. bone pinning			Stack pinning technique			Bone Plate			I.M. Pinning & Cerclage wiring		
				Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor
Minimally displace diaphyseal	23	20	3	3	7	2	3	6	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Displaced diaphyseal	44	42	2	-	-	-	-	-	-	-	4	-	5	4	2	11	3	-	8	2	-	4	1	-
Comminuted diaphyseal	11	8	3	-	-	-	-	-	-	3	6	2	-	-	-	-	-	-	-	-	-	-	-	-
Compound fracture	3	3	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	81	73	8	3	7	2	3	6	2	3	12	3	5	4	2	11	3	-	8	2	-	4	1	-

Excellent: Optimal reduction & alignment, rigid fixation, primary bone healing with minimal callus, full limb function (28 cases).
Good: Adequate alignment, stable fixation, and secondary bone healing with excessive callus formation, slight degree of lameness (24 cases).
Poor: Mal-alignment; unstable fixation, delayed union, nonunion or malunion, lameness (3 cases).

Table (4): The results of different fixation techniques in repair of different types of femoral fractures.

Type of fracture	No. of Cases	State of fracture		Methods of Reconstruction																										
				Ext. Skeletal fixation			Internal Fixation																							
		Fresh fracture < week old	Old fracture > week old	Acrylic External Skeletal Fixator			Single intramedullary pinning			Stack Pinning			Cross pinning			Bone Plate			Lag Screw			I.M. Pinning & Cerclage wire			Bone Plate & Lag screw			I.M. Pinning &Ext. Skeletal Fixation		
				Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor
Femoral neck fracture	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Transverse diaphyseal	52	46	6	-	-	-	2	7	3	16	4	-	-	-	-	15	3	2	-	-	-	-	-	-	-	-	-	-	-	-
Oblique diaphyseal	13	11	2	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	6	1	-	-	-	-	-	-
Spiral diaphyseal	13	11	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	2	1	3	1	-	2	-	-
Comminuted diaphyseal	14	11	3	2	4	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	3	-	-	-	-
Supracondylar	24	22	2	-	-	-	-	-	-	-	-	-	18	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Condylar	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Compound	4	2	2	-	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	122	105	17	2	11	4	2	7	3	16	4	-	18	6	-	15	3	3	1	-	-	5	8	2	6	4	-	2	-	-

Excellent: Optimal reduction & alignment, rigid fixation, primary bone healing with minimal callus, full limb function (28 cases).
Good: Adequate alignment, stable fixation, and secondary bone healing with excessive callus formation, slight degree of lameness (24 cases).
Poor: Mal-alignment; unstable fixation, delayed union, nonunion or malunion, lameness (3 cases).

Table (5): The results of external and internal fixation in repair of different types of tibial and fibular fractures.

Type of fracture	No. of Cases	State of fracture		Methods of Reconstruction																				
				External Coaptation						External Skeletal fixation			Internal Fixation											
		Fresh fracture < week old	Old fracture > week old	Plaster of Paris			Dyna cast			Acrylic external skeletal fixator			Single I.M. pinning			Stacked pinning			Bone Plate			I.M. Pinning & Cerclage wiring		
				Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor
Minimally displaced	32	27	5	4	14	2	5	6	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Displaced	26	24	2	-	-	-	-	-	-	-	3	-	2	4	2	4	1	-	2	2	1	4	1	-
Comminuted	7	5	2	-	-	-	-	-	-	2	4	1	-	-	-	-	-	-	-	-	-	-	-	-
Compound	4	4	-	-	-	-	-	-	-	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-
Total	69	60	9	4	14	2	5	6	1	2	10	2	2	4	2	4	1	-	2	2	1	4	1	-

Excellent: Optimal reduction & alignment, rigid fixation, primary bone healing with minimal callus, full limb function (28 cases).
Good: Adequate alignment, stable fixation, and secondary bone healing with excessive callus formation, slight degree of lameness (24 cases).
Poor: Mal-alignment; unstable fixation, delayed union, nonunion or malunion, lameness (3 cases).

Table (6): The results of external coaptation and internal fixation in rapair of different types of metacarpal and metatarsal fractures.

Type of fracture	No. of Cases	State of fracture		Methods of Reconstruction											
				External Coaptation						Internal Fixation					
		Fresh fracture < week old	Old fracture > week old	Plaster of Paris			Dyna cast			Single I.M. pinning			Bone Plate		
				Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor	Excellent	Good	Poor
Minimally displaced	16	14	2	2	3	-	3	8	-	-	-	-	-	-	-
Displaced	5	4	1	-	-	-	-	-	-	2	1	-	1	1	-
Comminuted	6	4	2	-	1	1	-	4	-	-	-	-	-	-	-
Total	27	22	5	2	4	1	3	12	-	2	1	-	1	1	-

Excellent: Optimal reduction & alignment, rigid fixation, primary bone healing with minimal callus, full limb function (28 cases).

Good: Adequate alignment, stable fixation, and secondary bone healing with excessive callus formation, slight degree of lameness (24 cases).

Poor: Mal-alignment; unstable fixation, delayed union, nonunion or malunion, lameness (3 cases).

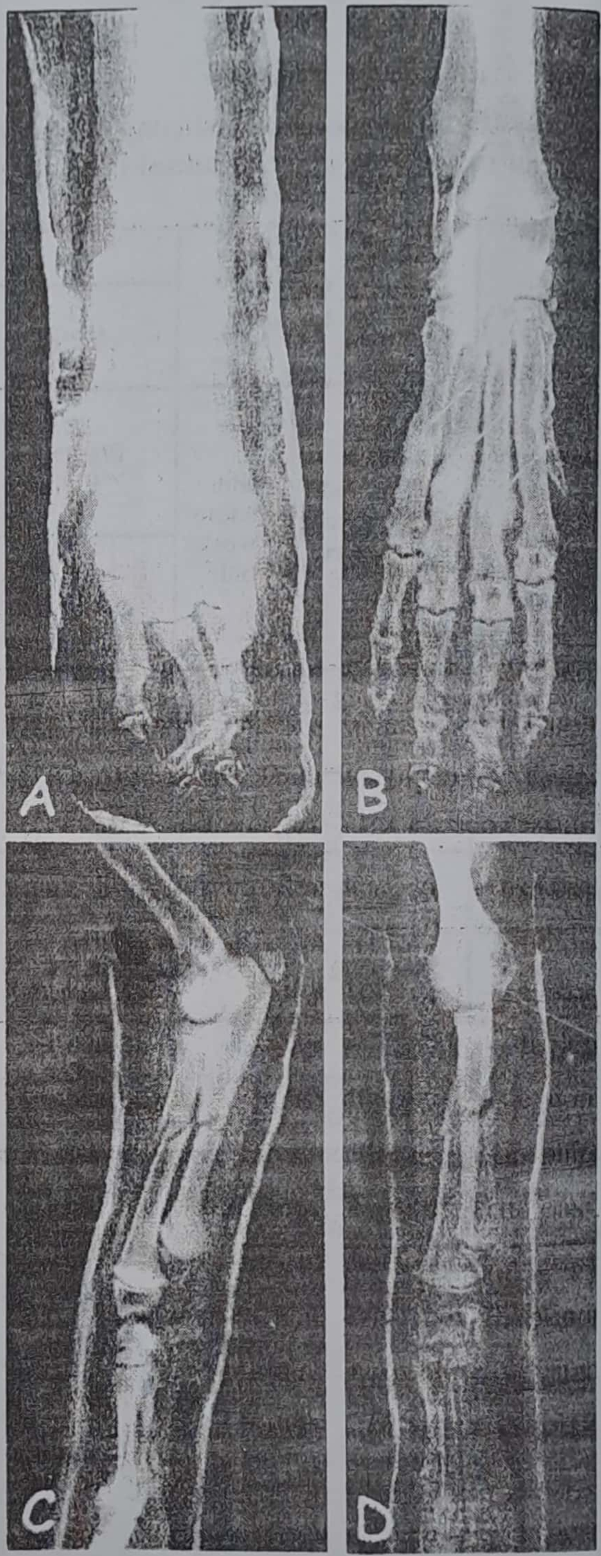


Plate (1):

Craniocaudal radiograph showing a transverse fracture of the 3rd, 4th and 5th metacarpal bones in 8 months old dog.

(A) After reduction and stabilization with plaster of Paris (B) after removal of plaster of Paris 6 weeks P.O. Note that bony union has occurred (arrows).

Mediolateral radiograph damonstrating a transverse diaphyseal radial and ulnar fractures in 6 months old dog. (C) After reduction and fixation with dyna cast. Note that the dyna cast appeared more radiolucent than plaster of Paris. (D) Craniocaudal radiograph for the same case immediately P.O.

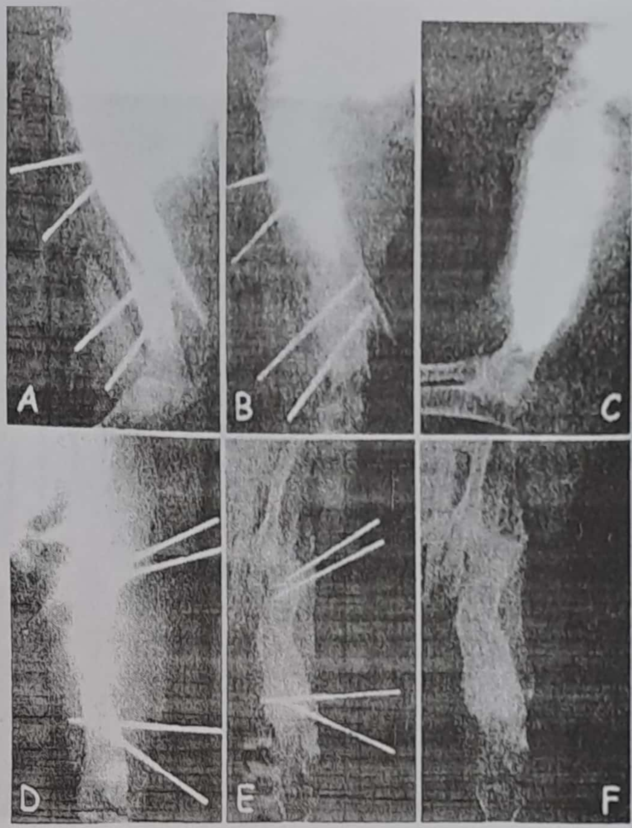


Plate (2):

Mediolateral radiographs demonstrating a comminuted fracture of the humerus in one year old dog. (A) Immediately PO. the fracture is fixed with type Ia unilateral uniplanar acrylic external fixator (B) At 8 weeks P.O., note that formation of bridging callus indicating bone union (C) After removal of the trans-skeletal pins, at 14 weeks P.O., note that complete bone healing with starting radiographic signs of remodeling. (D) craniocaudal radiograph showing a comminuted femoral fracture fixed with acrylic external fixator. (E) at 12 weeks P.O., note that the fracture lines were almost disappeared and the radiographic signs of remodeling started. (F) After removal of the trans-skeletal pins at the 16th week P.O. Note complete bone healing and remodeling.

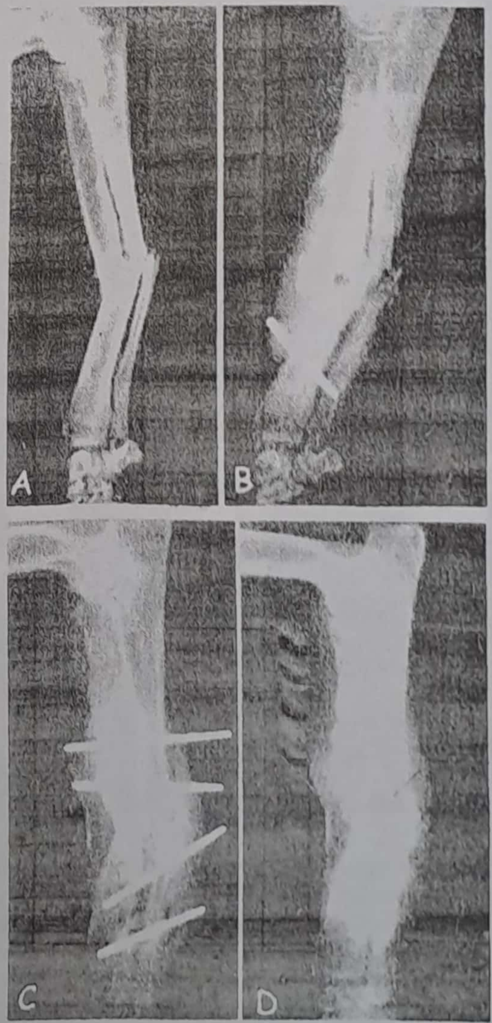


Plate (3)

Mediolateral radiograph demonstrating a comminuted radial and ulnar fracture in 3 years old dog. (A) Before reconstruction. (B) At 4 weeks P.O., note that formation of bridging callus indicates bone healing. (C) At the 8th week P.O. the fracture lines were almost disappeared. (D) At the 12th week P.O., note that the trans-skeletal pins were removed, the fracture lines were disappeared with the beginning of radiographic signs of remodeling.

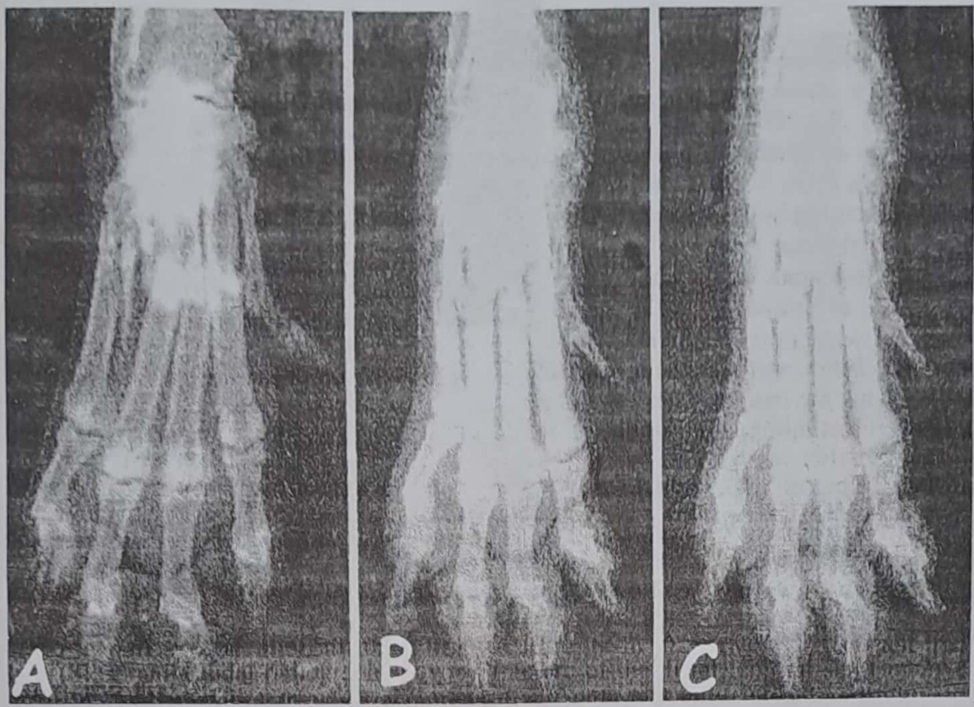


Plate (4): Craniocaudal radiograph showing overlapped fractures of the 2nd, 3,th, 4th, and 5th metacarpal bones in an 18 month old dog. (A) before reconstruction. (B) Immediately P.O. after fixation with single Steinmann pins. (C) At 6 weeks P.O. the fracture lines were almost disappeared.

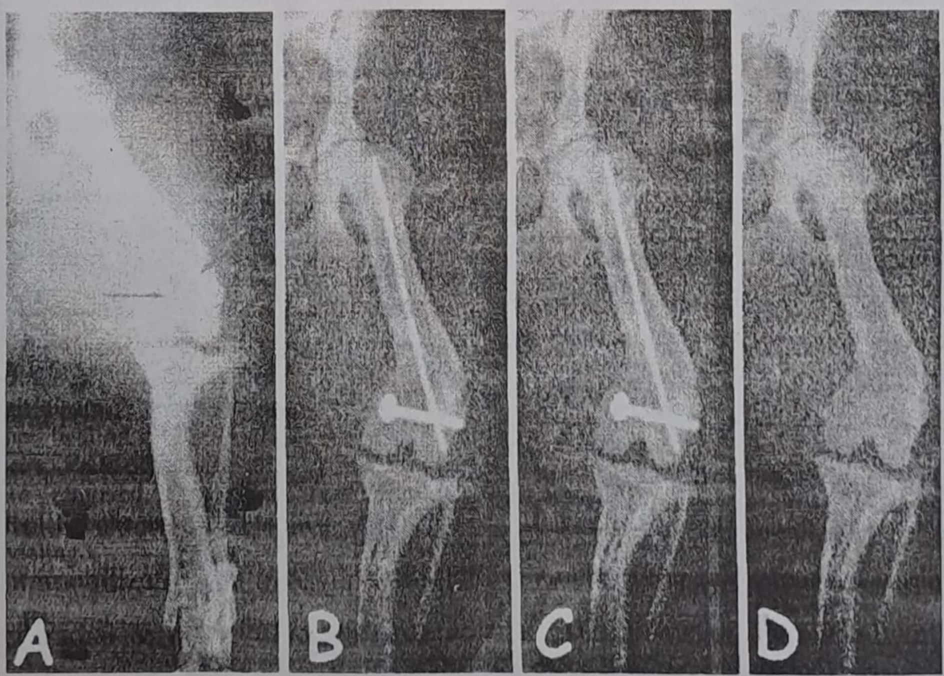


Plate (5): Craniocaudal radiograph demonstrating supracondylar and intercondylar femoral fractures (arrows) in 2 years old dog. (A) Beftore reconstruction (B) Immediately after reconstruction using lag screw and single I.M. pin inserted from the lateral condyle of the femur. (C) At 6 week P.O., the fracture line was completely disappeared. (D) At 10 weeks the implants were removed and complete bone healing and remodeling was observed.

Plate (6): Carniocaudal radiograph showing supracondylar femoral fracture in one year old dog. (A) Before fixation. (B) Immediately after fixation using cross pin technique. (C) At 10 weeks P.O., the pins were removed. Note that the fracture line was disappeared indicating complete bone union.

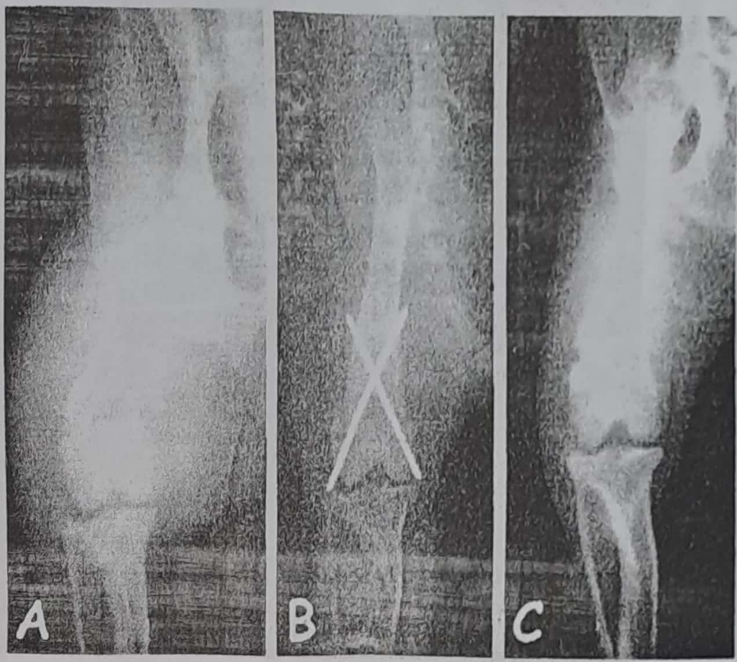
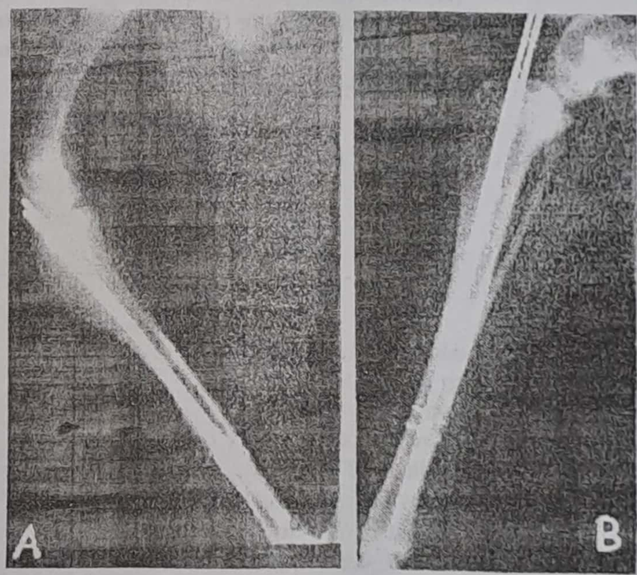
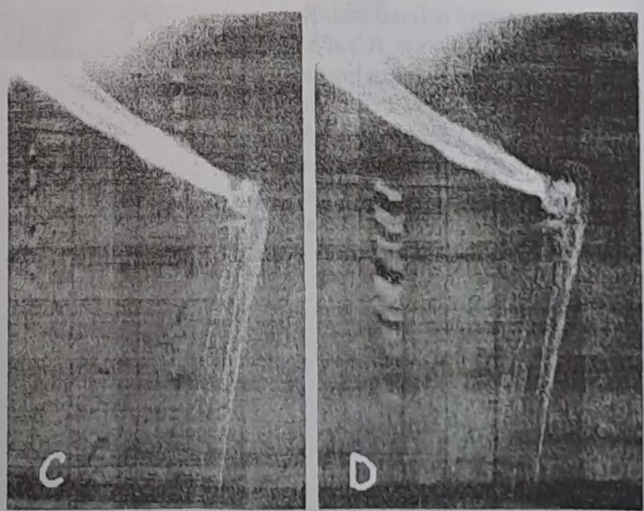


Plate (7): Mediolateral radiograph showing an oblique tibial fracuture in 2 years old dog (A) Immediately after fixation using stacked pin technique and cerclage wiring. (B) At 6 weeks P.O. the fracture line was disappeared with starting of radiographic signs of remodeling.



Mediolateral radiograph showing an oblique humeral fracture in 18th month old dog. The fracture was fixed with stacked pin technique and cerclage wiring. (A) 6 weeks P.O. Note that the fracture line was almost disappeared with starting of radiographic signs of remodeling. (B) At 8 weeks P.O. the implants were removed. Note that complete bone union and remodeling.



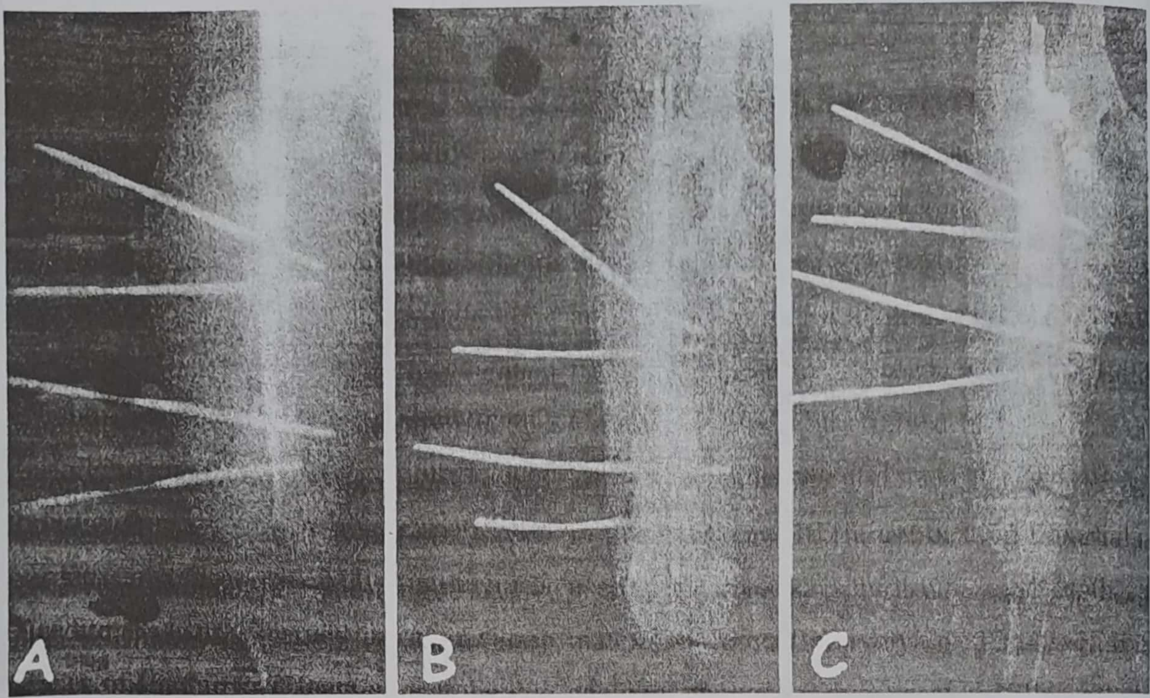


Plate (8): Craniocaudal radiograph showing fracture of the distal femoral shaft in 2 years old dog (A) Immediately P.O. , the fracture was fixed with stacked pin technique and type Ia uniplanar acrylic external fixator (B) At 6 weeks P.O. Note that formation of bridging callus indication bone union. (C) At 8 weeks P.O. Note that complete bone healing with starting radiographic signs of remodeling.

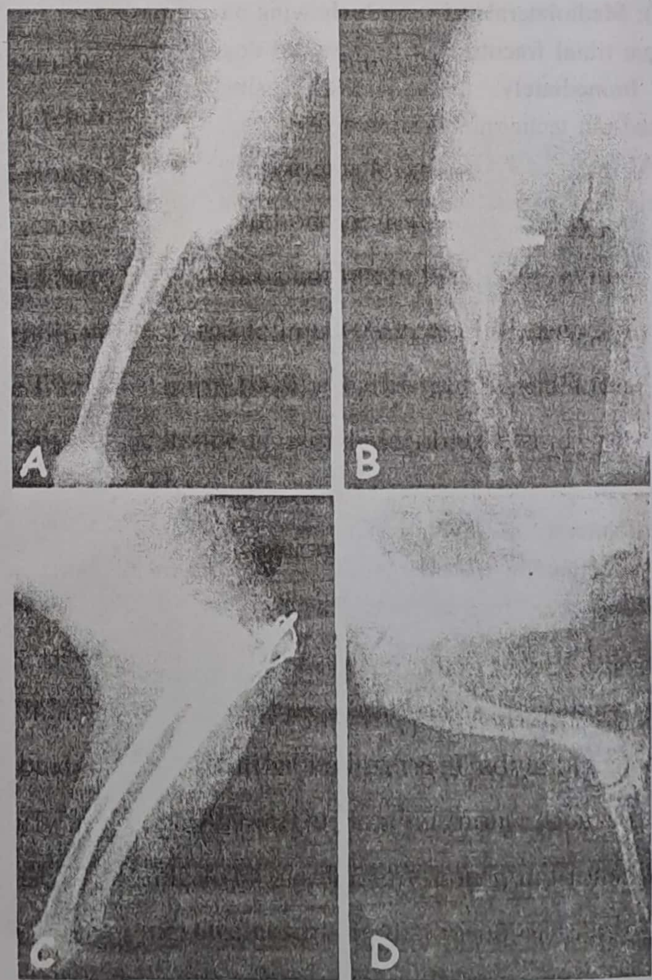


Plate (9): Craniocaudal radiograph showing condylar humeral fracture in 2 years old dog. (A) Before reconstruction (B) Immediately P.O. Note that a trans-olecranon approach was used for exposure of the fracture site. The fracture is fixed with K-wire and lag screw. (C) at 8 week P.O. the fracture line was almost disappeared indicating bone healing (D) At 12 weeks P.O., the implants were removed. Note that complete bone union and remodeling.

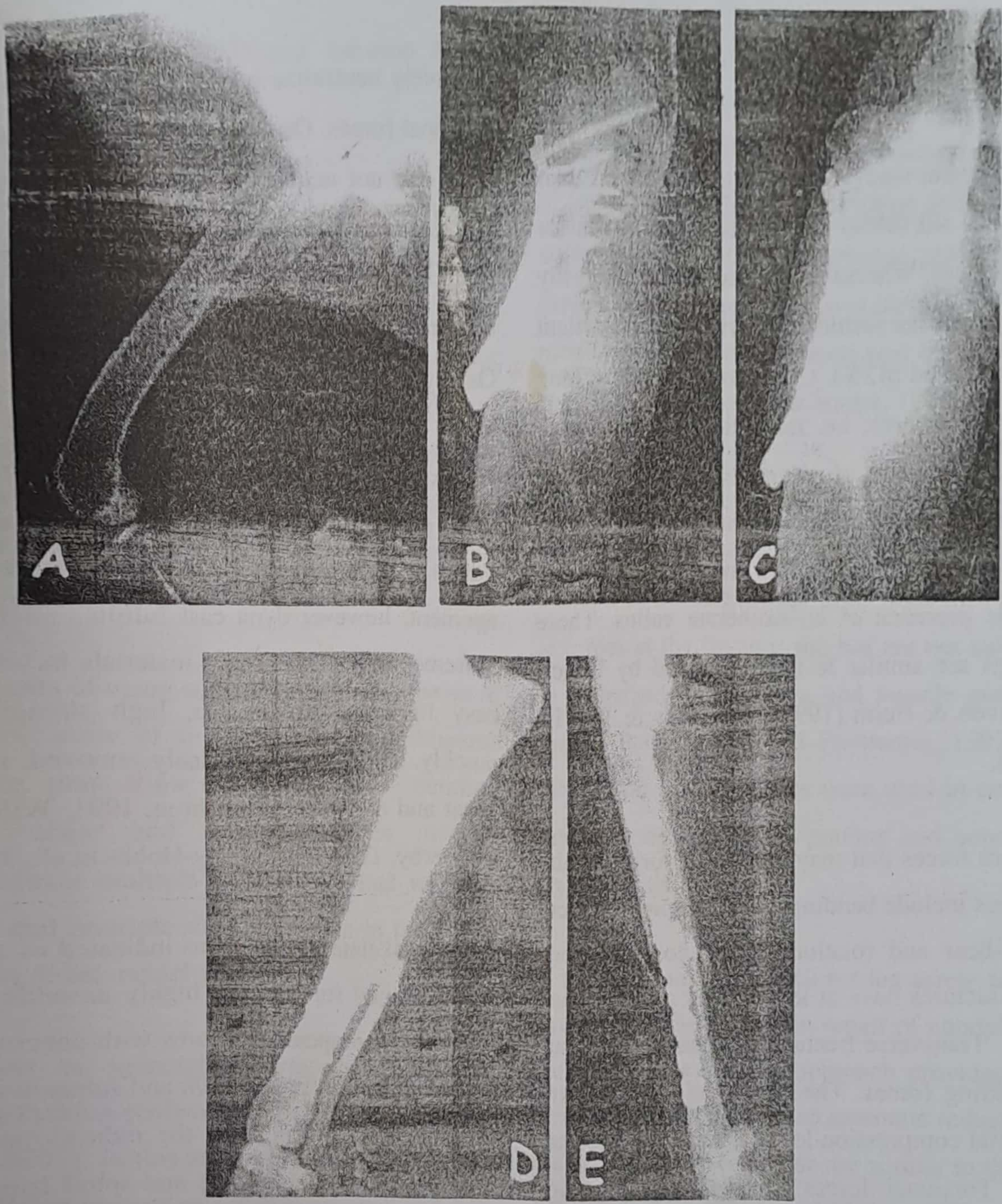


Plate (10): Mediolateral radiograph demonstrating femoral neck and proximal shaft fractures (arrow). (A) Before fixation (B) Immediately P.O. Note that the fractures were fixed 4.5 mm DCP plate and 3 cortical lag cortical screws 3.5 mm (arrows) (C) At 8 weeks P.O. Note that the fractures line was almost disappeared.

Mediolateral radiograph showing a fracture of the radius and ulna, in 5 years old German shephered. (D) Immediately P.O. the fracture is fixed with a 3.5 mm and 10 holes DCP (E) Craniocaudal radiograph for the same case

DISCUSSION

In the present study, fresh fractures; i.e. less than one week old (88%) are the ideal candidates for management. Whereas these fractures were easily reduced and the results are varied from excellent (46%) to good (42%). On the other hand, in long standing fractures; i.e. more than one week old (12%), the process of reduction was difficult and need an excessive effort until muscle fatigue had occurred. This attributed to muscle contractures and the presence of an exuberant callus. These findings are similar to those reported by Unger, Montavon & Heim (1990) and Lewis & Van Ee (1993).

Fracture forces that may be present for particular fractures include bending, axial compression, tension, shear and rotation. The majority of long bone fractures have at least one or more fracture forces. Transverse fractures are usually the result of bending forces. The combination of bending and axial compression leads to short oblique fractures. Torsional forces usually result in spiral fractures around the circumference of long bones (Harari, 1992 and Hulse & Hyman, 1993).

In the present study, external coaptation was used effectively in immobilization of transverse minimally displaced radial & ulnar, tibial & fibular, metacarpal and metatarsal fractures particularly in immature dogs less than one year old. The use of external coaptation in such types of fracture can effectively neutralize bending forces and possibly rotational forces. On the other hand external coaptation can not neutralize compression, shear and distractive force, therefore the use of external coaptation in repair of oblique, spiral and avulsion fractures is contraindicated (Decamp, 1993 and Oakley, 1999).

In this study, two different casting materials were used; plaster of paris and dyna cast. Both casting materials were effectively used in fracture management, however dyna cast fulfills all the requirements of ideal casting materials in terms of easy to apply comfortable, high strength, set quickly, resilient to wear, easily removed, non irritant and radiolucent (Leighton, 1991, Wilson & Vanderby, 1995 and Langley-Hobbs et al., 1996).

External skeletal fixation was indicated as appropriate method for repair of highly unstable comminuted or compound fractures with concomitant soft tissue injury (Egger, 1998 and Johnson & Decamp, 1999). In this study the indications were extended to include oblique and spiral fractures. Also it was used as adjunctive device to intramedullary pinning to overcome rotational instability.

Using of type Ia unilateral uniplanar acrylic external fixation had several advantages in terms of light in weight, strong, non expensive and adaptable to many fracture configurations. These findings were similar to those of Aron & Dewey, (1992), Mattiesen, (1993) and Johnson & Decamp, (1999).

Intramedullary pinning (IM) is a common method of stabilizing long bone fractures, I.M pins provide axial alignment and resist bending forces applied to the bone during weight bearing but do not control shear and rotational force at the fracture site. Additional stabilization must be provided by applying cerclage wires or an external fixator to control these forces in many fractures (Howard, 1991 and Hulse & Aron, 1994).

The results of using stack-pinning technique were exceeded those of single I.M pinning. Whereas multiple pins allow neutralization of bending forces, shear and rotational forces through achievement multiple points of contact with the cortex and multiple sites of fixation in the proximal and distal metaphyses.

I.M pins are inserted in normograded or retrograded fashion (Gibson & Van Ee, 1991 and Howard, 1991). In this study all pins are inserted in retrograded manner except in metacarpal and metatarsal fractures, the used K. wires are introduced in a normograded fashion and the ends of the pins are bent to prevent injury to the digit during weight bearing. Retrograde insertion of pins in these bones would result in joint damage (McLaughlin, 1999).

Cross pin technique and parapatellar arthrotomy were used effectively in repair of supra-condylar femoral fracture. The pins were inserted just lateral and medial to the trochlear ridge and cranial to collateral ligament. This technique provided rigid skeletal fixation and eliminated the possibilities of rotational instability as mentioned by (Frnczuski et al, 1986, Whitney & Schrader, 1987 and Farag, 2002).

Cerclage wires serves as a method of auxiliary fixation in fracture repair. They neutralize specific forces at the fracture site but are not sufficient to withstand load bearing and muscle generated forces (Perren, 1991 and Piermattei, 1993). For this reason cerclage wires were used in conjunction with intramedullary pinning and bone plate fixation in this study.

A transolecranon approach for lag screw fixation gave an excellent result in repair of condylar humeral fractures. As this approach provided good visualization and facilitated anatomic reduction of the articular surface. These are similar to those of (Andreson, Carmichael and Miller, 1990 Deny, 1993; Coughlan and Miller 1998; Shamaa, 1999).

One of the primary objective in the treatment of factures is the early return to full function of the injured limb. Bone plates were ideal for this goal because they have the potential to restore rigid stability to the reconstructed fractured bone when they properly applied (Piermattei & Gretchen, 1997).

Bone plates in combination with lag screws were used effectively in reconstruction of femoral neck fractures, transverse, oblique, spiral and comminuted diaphyseal long bone fractures.

Regarding the complications encountered in this study, mal-alignment, failure of fixation delayed union, nonunion and mal-union are the most common recorded complications. Mal-alignment or improper reduction was observed mostly in long standing cases of fractures. These seems to be due to the contracture of skeletal muscles. However, delayed union, non union and mal-union resulted from implants loosening, breaking or bending, besides improper blood supply specially in cases of highly comminuted fractures with concomitant soft tissue injury (Harari, 1992 and Mclaughlin, 1999).

In conclusion the successful management of any type of fracture depend on two factors: rapid surgical interference and selection of the suitable fixation device or devices which are capable of neutralizing all fracture forces in order to achieve rigid and stable environment necessary for fracture healing and subsequently early return of full limb function.

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