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VETERINARY ORTHOPEDIC GUIDELINES ON A DOG SKELETAL MODEL IN COMBINATION WITH EDUCATIONAL MULTIMEDIA INTERACTIVE PROGRAM.

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SUMMARY

The present orthopedic guidelines represent a valuable educational aid for students and practitioners especially with the increasing student number and constrained resources. It includes a dog skeletal model on which variable orthopedic techniques were applied for stabilization and fixation of artificially induced fractures at different selected sites. Additionally, selected surgical anatomical approaches were done on dog cadavers for procuring the target bones.

A multimedia interactive computer program has been developed. The program comprised various methods of internal fixation, selected surgical anatomical approaches, and digital images for each reconstructed bone and its corresponding contact radiograph. Quizzes were added for user self-evaluation.

INTRODUCTION

Implementation of various methods of internal fixation in small animal practice has dramatically increased (Withrow and Holmberg, 1977; Withrow, 1980; Brinker, Piermattei and Flo, 1983; Eagger, 1983 and 1993, Brinker, Piermattei, and Flo, 1990).

Throughout the present study, guideline examples were demonstrated to cover most influential types of internal fixation at various selected fractures. Alongside these guidelines, a designed multimedia interactive piece from an educational perspective was included. This program enhances computer assisted learning (CAL) in veterinary education, especially with the increasing students, number and constrained resources.

MATERIALS AND METHODS

2.1 Skeleton Preparation:

A fresh carcass of an adult male dog was skinned, eviscerated, and most muscles were cut off. The carcass was dismembered into pieces of convenient size for the pot. Care was taken for small bones as patella & sesamoids. Bones of each foot was separately tied within a cotton cloth to prevent intermixing. All parts were put in water at room temperature then gradually boiled. Little potassium hydroxide (1-2 %) was added to the water and progress of cooking was checked regularly. Bones slowly cooled and cleaned under the tap, using brushes and scalpel blades. Bones soaked in ammonia & bleached in hydrogen peroxide (1-3%) for 24 hours then dried in air. Artificial fractures were induced in selected bones of right and left sides using a bone saw.

2.2 A workshop equipped with ordinary orthopedic standardized instrument kit and implants was established.

2.3 Various basic procedures of internal fixation were used for bone reconstruction. These procedures included:

2.3.1 Intramedullary pins, multiple (stacked) pins, and crossed pins.

2.3.2 Intrafragmentary wiring

2.3.3 Full cerclage wires

2.3.4 Tension band wiring

2.3.5 Bone screws

2.3.6 Bone plating

2.3.7 External skeletal fixation (unilateral single bar type IA)

The following are some guidelines of various basic procedures used for bone internal fixation. However, there may be exceptions to these guidelines in certain individual cases.

2.4 .Fracture of the Scapula:

2.4.1 Avulsion fracture of the supraglenoid tubercle was fixed with tension band wire, using K. wire (0.6- 1.6 mm) and orthopedic wire (0.64-1.0 mm).

2.4.2 .Oblique fracture of the neck including the glenoid articular surface was fixed with lag screw (3.5- 4.0 mm).

2.4.3 Fracture of the acromion process was fixed with tension band wire using K. wire and cerclage wire.

2.4.4.Fracture of the body was fixed either with interfragmentary wire or a 2.7 mm 4 holes dynamic compression plate (DCP) with Cortical screws 2.7 mm.

2.5 Fracture of the Humerus:

2.5.1 Fracture of the lateral tubercle is fixed with lag screws.

2.5.2 Fracture of the humeral shaft is fixed in the left side with interamedullary Steinmann pin and full cerclage wire, where the pin was inserted retrograde proximally from the fracture site and exits just distal to the lateral tuberosity. In the right side an 8 holes DCP was fixed on the lateral surface of the humerus.

2.5.3 Intercondylar fracture of the distal extremity was fixed with lag screw.

2.6 Fracture of the Radius and Ulna:

2.6.1 fracture of the olecranon process was fixed with tension band wire using K. wire and cerclage wires.

2.6.2 Monteggia fracture; fracture of the ulna, separation of the radius and dislocation of the radial head were fixed with cortical bone screws.

2.6.3 Oblique fracture of the radial shaft was fixed with intramedullary K. wire normograded from the distal end. Full cerclage wires were also used in connection with the intramedullary pin.

2.6.4 Fracture of the distal styloid process of the radius was fixed with lag screw.

2.6.5 Fracture of the distal styloid process of the ulna was fixed with tension band wiring.

2.7 Fracture of the Metacarpal bone was fixed with intramedullary pin introduced from the distal end of the bone.

2.8 Fracture of the pelvis:

2.8.1 Sacroiliac fracture/luxation was fixed with lag screw introduced from the ilial to the sacral body.

2.8.2 Fracture of the shaft of the ilium is fixed with plate and cortical screw.

2.8.3 Fracture of the acetabular rim was fixed by reconstruction plate and cortical screws.

2.8.4 Fracture of the ischium was fixed by interfragmentary wiring while the ischial tuberosity is fixed with K. wire.

2.9 Fracture of the femur:

2.9.1 Fracture of the femoral neck was fixed by lag screw.

2.9.2 Fracture of the greater trochanter was fixed by tension band wiring.

2.9.3 Fracture of the shaft was fixed by multiple stacked pins of different diameters to exit at the trochanteric fossa or with a 3.5 mm 8 holes DCP on the lateral surface.

2.9.4 Supracondylar fracture was fixed by two cross pins combined with tension band wiring at their exits on either side.

2.9.5 Patellar fracture was fixed by tension band wiring.

2.10 Fracture of the Tibia

2.10.1 Fracture of the tibial plateau was fixed by two lag screws.

2.10.2 Fracture of tibial tuberosity was fixed by tension band wiring.

2.10.3 Fracture of the shaft was fixed by mutliple stacked pins, normograded from the proximal end together with full cerclage wiring. While multiple fracture of the shaft was fixed by half K. E splint, (unilateral single bar type IA), using threaded pins.

2.10.4 Fracture of the medial tibial malleolus was fixed by lag screw.

2.11 Fracture of the calcaneal tuber was fixed by tension band wiring.

2.12 Fracture of the metatarsal bones was fixed by intramedullary K. wire or by tubular plate with screws.

2.13 Fracture of the mandible was fixed either by bone plates and wiring the adjacent teeth or by using K. E splint (unilateral single bar type IA) using threaded pins.

2.14 Fracture of the premaxilla was fixed with cross pins combined with tension band wiring at their exits.

2.15 Atlanto-axial subluxation was fixed by two cortical screws introduced through the ventral aspect of their bodies and directed towards the wings of the Atlas.

2.16 Fracture of the bodies of the lumbar vertebrae were fixed by lag screws or reconstrucBAD

2.17. Each manged fractured bone was radiographed. Images for each bone were captured as well as its corresponding radiogeaphic films using Olympus digital camera . D-340 L, 1.3 megapixel. Finally the skeleton was assembled using silicon and wire.

2.18.4 The caudolateral approach to the proximal antebrachial region.

2.18.5 The caudal approach to the elbow joint.

2.18.6 The craniolateral approach to the hip joint.

2.18.7 The craniolateral approach to the thigh region.

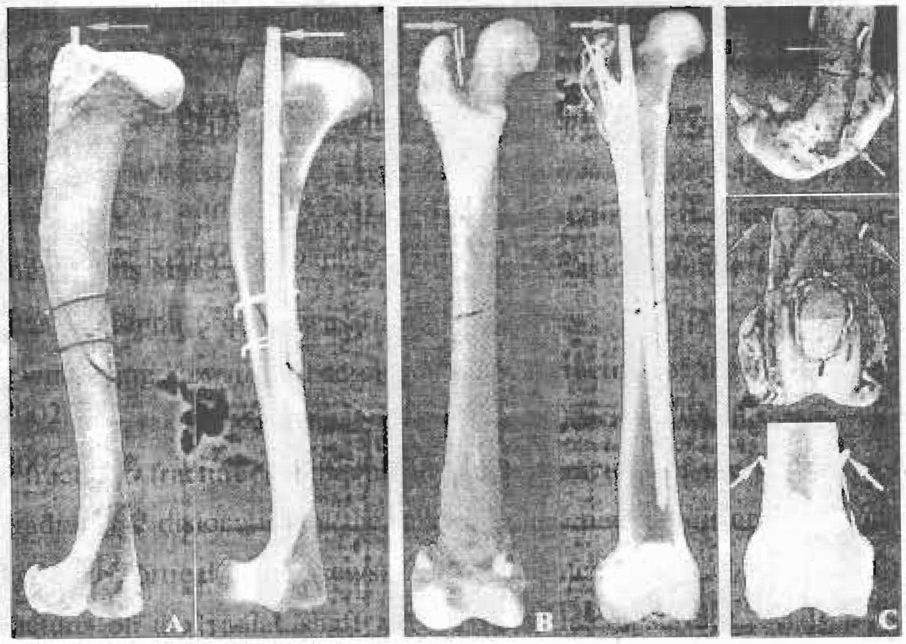
2.18.8 The Medial approach to the leg (crus) region.

2.19 The Computer program:

The reconstructed bones and the radiographic films were shot using the Olympus digital camera D- 340 L, 1.3 megapixel. The desired images were selected, and downloaded onto a windows 98 PC. Images were edited using Adobe Photoshop 6.0. The editing process was focused on the background, sharpening, cropping, and resizing. Macromedia Authorware 5.0 was used to develop the interactive multimedia program. The packaged program was consolidated on a CD-ROM for Windows.

RESULTS

3.1 Methods for stabilizing and fixation of various types of skeletal fractures together with contact radiography for each bone are illustrated in plate 1 through 7.



Plate(1) Intramedullary fixation; (A) Single Steinmann pin in the humeral shaft (B) Multiple Stacked pins in the femoral shaft (C) Crossed pins in the distal extremity of the femur

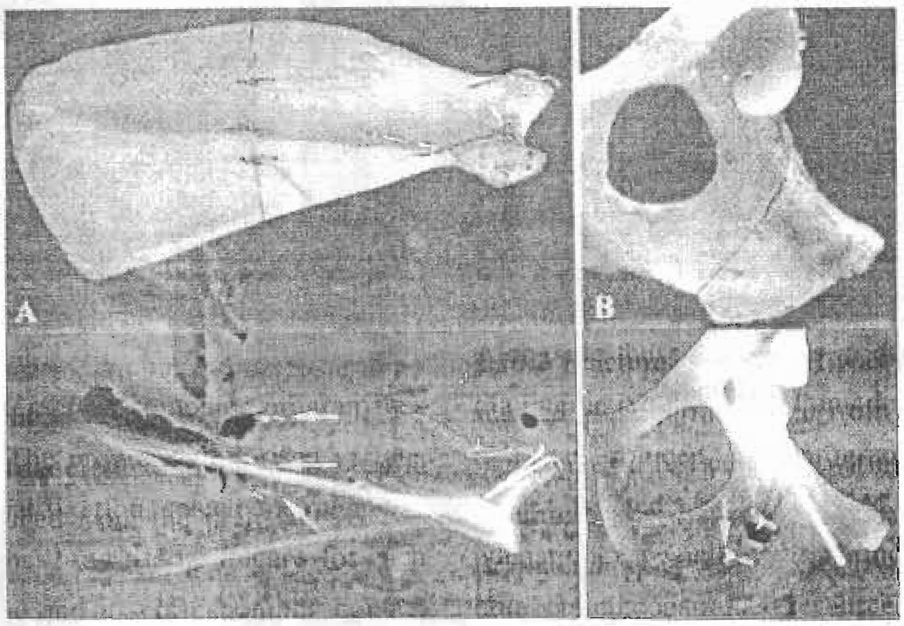


Plate (2): Interfragmentary wiring; (A) in the body of the scapula (B) in the ischiatic table.

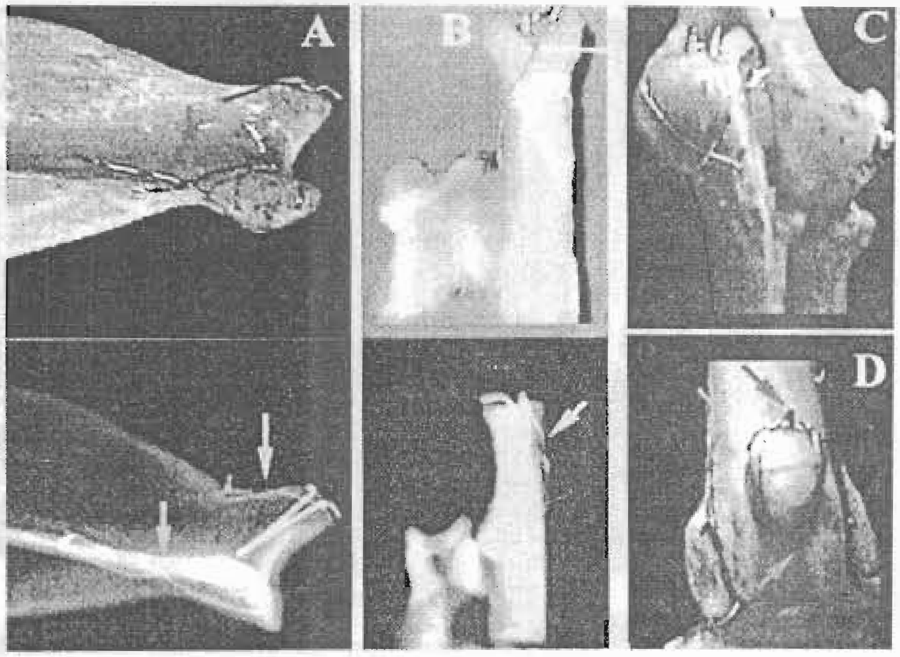
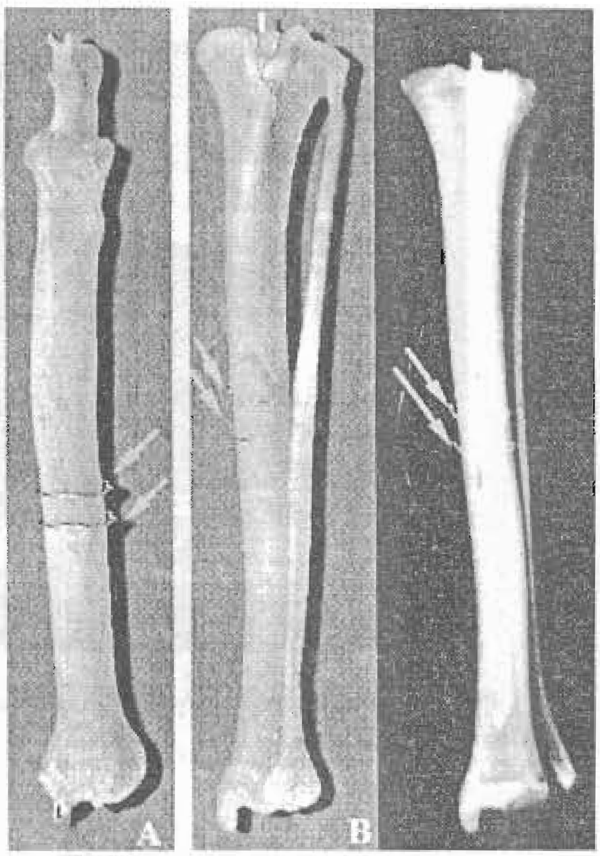


Plate (3): Tension band wiring; (A) in the supraglenoid tubercle and acromion process of the scapula (B) in the calcaneal tuberosity. (C) in the olecranon tuberosity of the ulna and (D) in the patella

Plate (4): Full cerclage wiring; (A) in the shaft of radius (B) in the shaft of tibia.



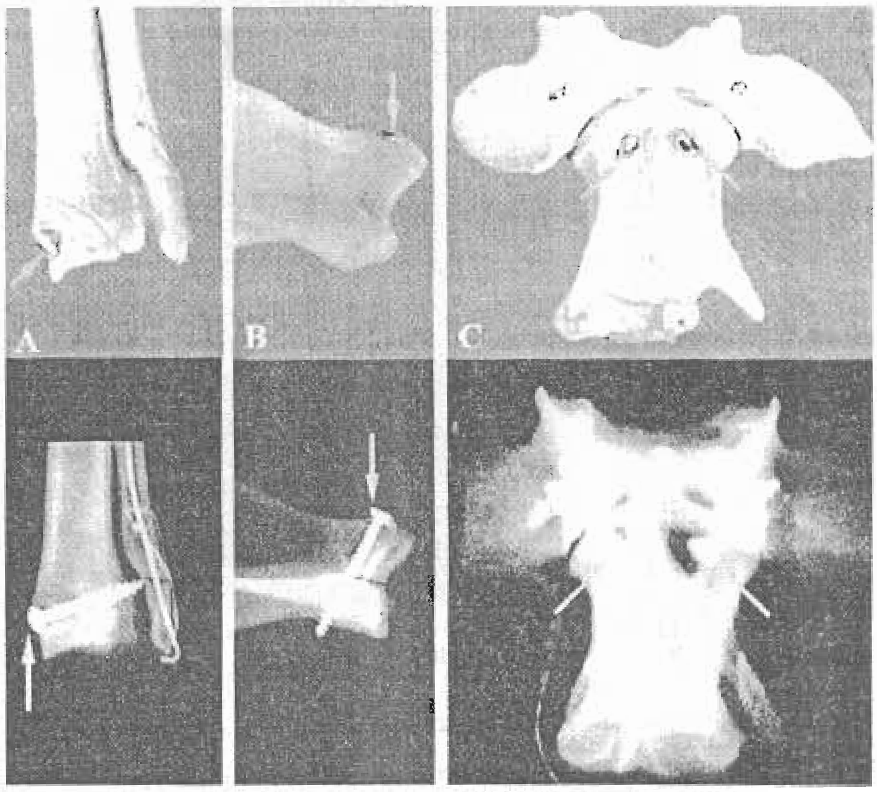


Plate (5): Lag screws; (A) in the radial styloid process (B) in the supraglenoid tubercle of the scapula (C) in the Atlan-

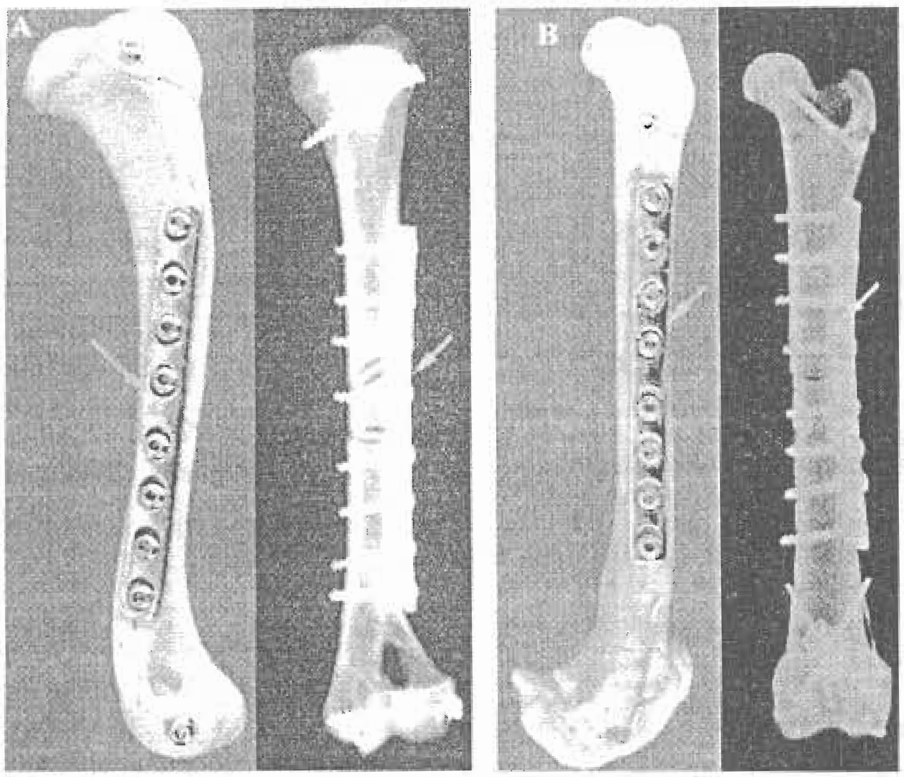


Plate (6): Bone plating (A); on the lateral aspect of the humeral shaft and femoral shaft (B)

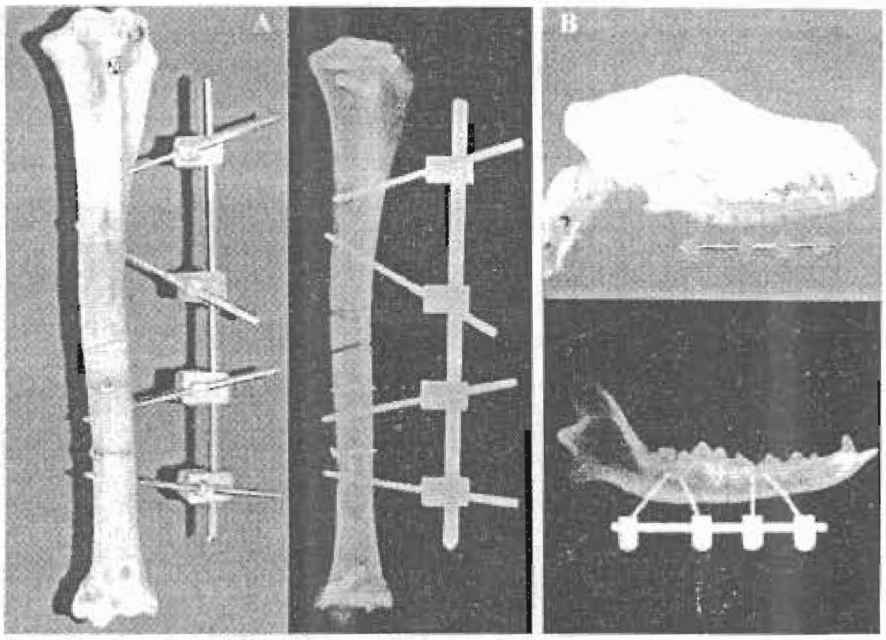
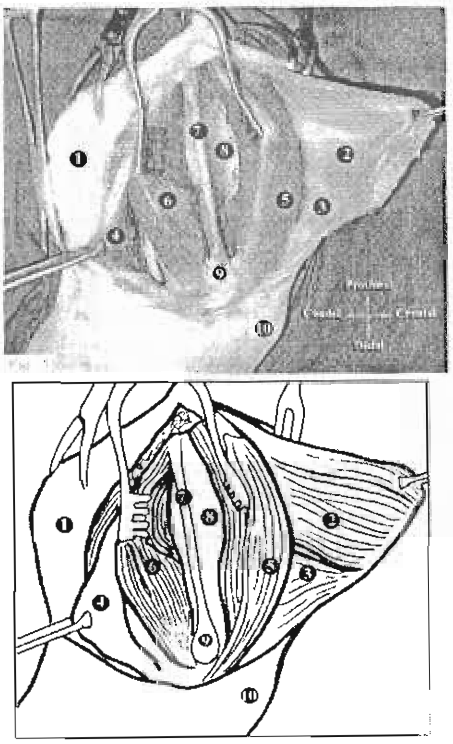


Plate (7): External skeletal fixator (Unilateral single bar type IA); (A) in the shaft of tibia (B) in the body of mandible.

3.2 The techniques adopted for surgical anatomical approaches to some bones of the thoracic and pelvic limbs are described and illustrated.

3.2. 1 The Scapula:

The lateral approach to the shoulder (Fig. 1) permits the repair of the acromion process and scapular body. A direct skin incision along the scapular spine is made, then deepened to free the insertion of the trapezius cervicis muscle and the origin of omotransversarius and scapular part of the deltoideus Muscles.

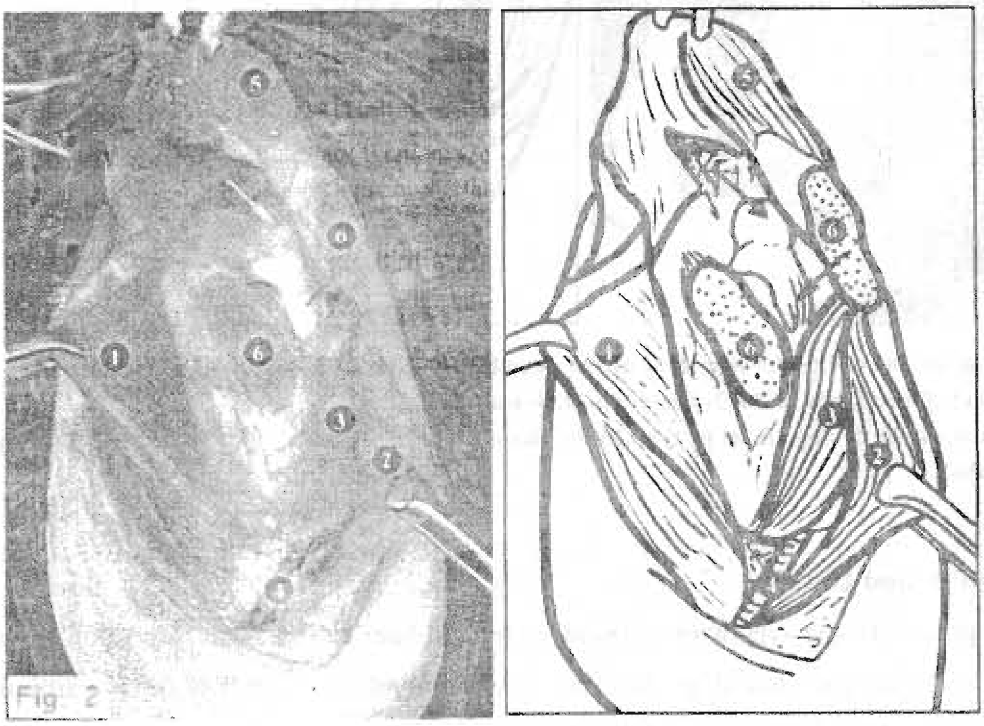


(Fig. 1) :A photograph and its line drawing showing the lateral approach to the shoulder: 1- Skin and Fascia, 2-Trapizeus cervicis M ,3 Omotransversarius M. 4-Deltoideus M. (scapular part) ,5 - Supraspinatus M. 6- Infraspinatus M., 7- Scapular spine, 8- Supraspinous fossa, 9- Acromion process 10- Shoulder joint.

The craniolateral approach to the shoulder (Fig. 2) permits the repair of avulsion fractures involving the supraglenoid tubercle, scapular neck, proximal articular surface and greater tubercle of the humerus.

A curved skin incision begins proximal to the acromion process, crossing the shoulder joint and ends in the proximal third of the humerus.

The belly of the cliedobrachialis muscle is reflected cranially, the cephalic vein should be protected, and the acromial part of the deltoideus muscle is retracted caudally. The lateral tuberosity of the humerus is osteotomized and the insertion of the supraspinatus muscle is reflected proximally for adequate bone exposure.



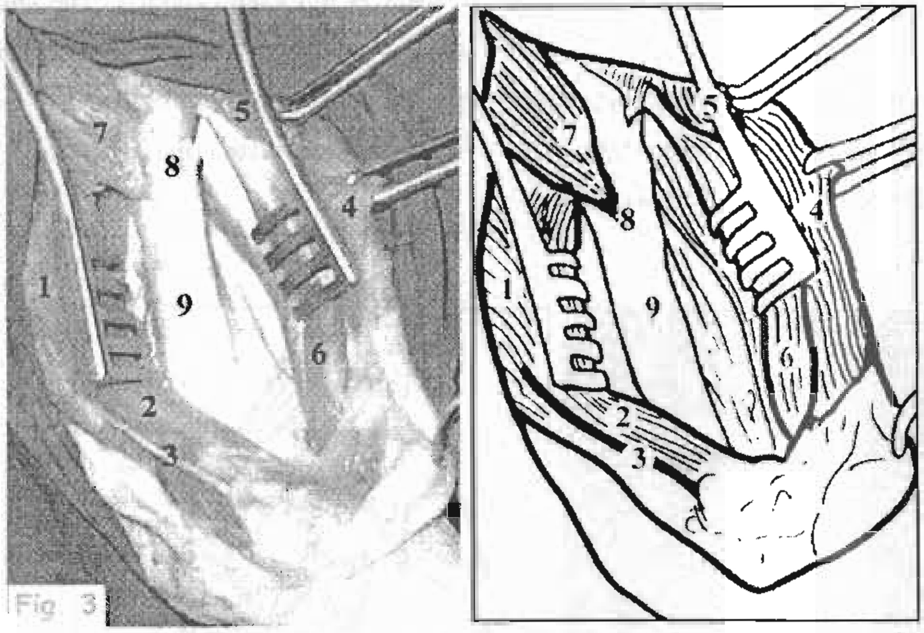
(Fig. 2) :A photograph and its line drawing showing the craniolateral approach to the shoulder: 1- Deltoideus Acromial part 2- Cliedobrachialis M. 3- Superficial pectoral M.4- Cephalic Vein 5- Supraspinatus M. 6- Osteotomized greater tubercle.

- The yellow arrow indicates the supraglenoid tubercl.
- The green arrow indicates the tendon of origin of biceps brachii M.

3.2.2 The Humerus

The craniolateral approach (Fig. 3) permits the repair of humeral shaft fractures.

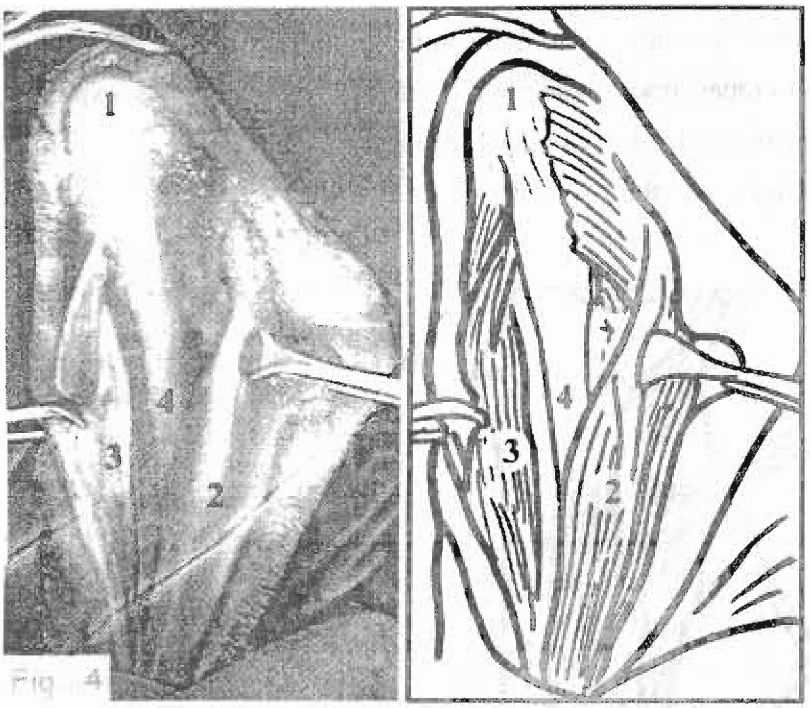
The triceps and brachialis muscles are retracted caudally and the radial nerve must be protected. The cliedobrachialis, superficial pectoral, and biceps brachii muscles are retracted cranially.



(**Fig. 3**) A photograph and its line drawing showing the craniolateral approach to the humeral shaft;
1- Lateral head of triceps brachii M. 2- Brachialis M. 3- Radial N.
4- Cliedobrachialis M. 5- Superficial pectoral M. 6- Bicebrachii M.7- Deltoideus M. 8- Deltoid tuberosity
9- Humeral shaft.

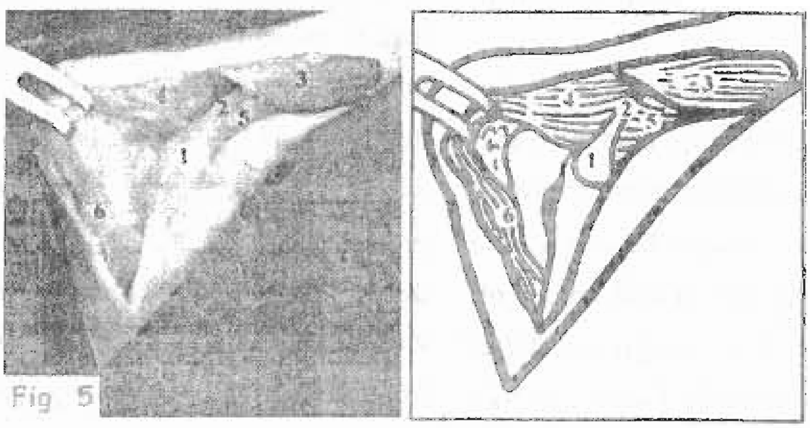
3. 2. 3 The Radius and Ulna:

The caudal approach to the olecranon process and proximal shaft of the ulna (Fig. 4). The skin incision starts at the olecranon and follows the prominent caudal border of the ulna distally. The extensor carpi ulnaris is elevated and retracted laterally by blunt dissection between the muscle and the bone. The flexor carpi ulnaris is elevated to retract it from the bone.



(Fig. 4) :A photograph and its line drawing showing the caudal approach to the olecranon tuberosity and shaft of ulna;
1- Olecranon tuberosity
2- Ulnaris Lateralis
3- Flexor carpi ulnaris
4- shaft of ulna.

The caudolateral approach (Fig. 5) permits the repair of proximal radial and ulnar fractures and in conditions of ununited anconeal process. A crescentic skin incision over the lateral epicondylar crest of the humerus crossing the humeral epicondyle and elbow joint until the proximal end of the radius. Elevation of the lateral head of triceps brachii M. exposed the anconeus muscle, which is incised at its periosteal origin on the lateral epicondylar crest to reveal the caudolateral compartment of the elbow joint and the anconeal process of the olecranon.



(Fig. 5): A photograph and its line drawing showing the caudolateral approach to the elbow joint; 1- lateral epicondyle of the humerus 2- lateral epicondylar crest of of the humerus 3- lateral head of triceps brachii M. 4- Anconeus M. 5- Origin of extensor carpi radialis M. 6- Ulnaris lateralis M

The medial approach to the shaft of the radius (Fig. 6) permits the surgeon to repair fractures of the radial shaft. The incision extended from the medial epicondyle of the humerus to the styloid process of the radius. Retraction of the extensor muscles exposed the shaft of the radius

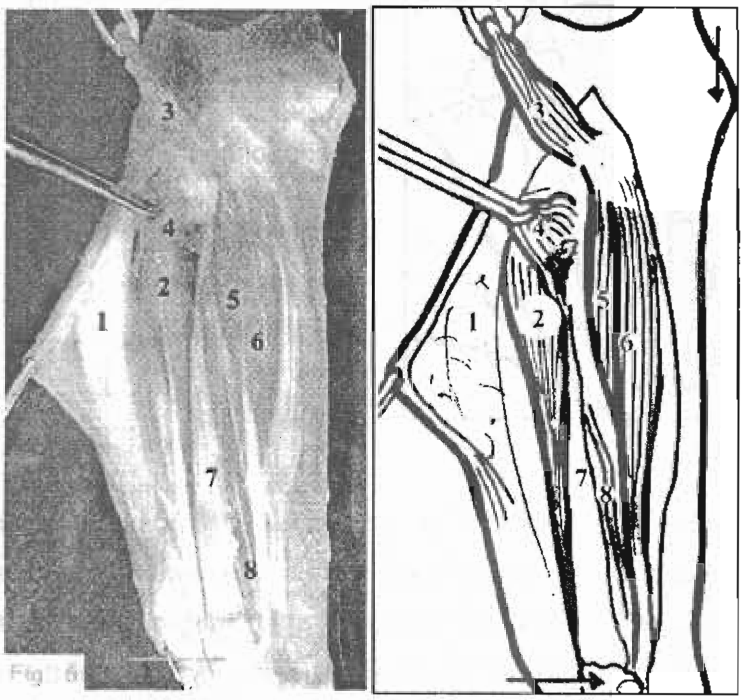
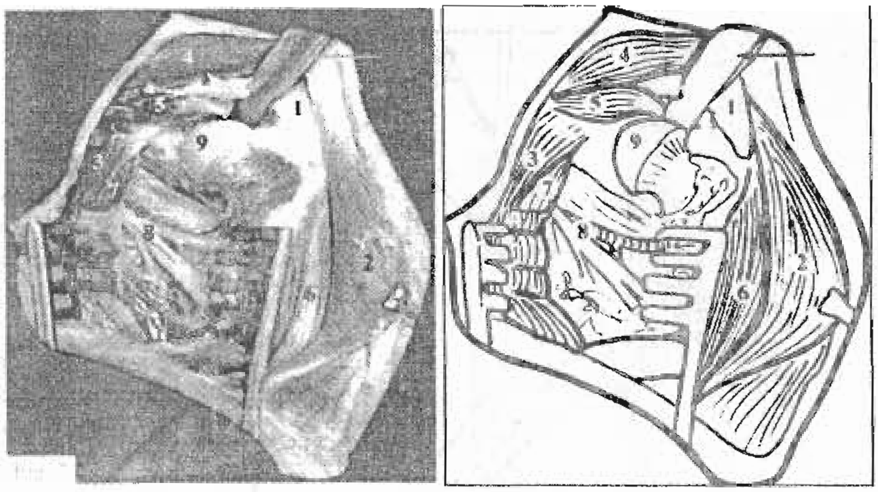


Fig.(6):A photograph and its line drawing showing the medial approach to the shaft of the radius;
1- Skin and antebrachial fascia
2- Extensor carpi radialis M.
3- Pronator teres M.
4- Supinator M.
5- Flexor carpi radialis M.
6- Superficial digital flexor M.
7- Shaft of the Radius 8- median nerve and median vessels.
- The green arrow indicates point of elbow
- The red arrow indicates radial styloid process

3.2.4. The craniolateral approach to Hip joint (Fig. 7):

A curved skin incision started close to the body midline, passing distally, cranial to the greater trochanter to end in the middle third of the thigh. An incision through the tensor fasciae latae muscle along the cranial border of biceps femoris is made.The tensor fasciae latae is retracted cranially and the biceps femoris caudally. A triangle bounded by the middle and deep gluteal muscles dorsally, the vastus lateralis muscle laterally and the rectus femoris muscle medially is visualized by blunt dissiction along the neck of the femur. Fat covering the joint capsule is removed by blunt dissection and the femoral vessels and nerves are protected. The vastus lateralis M. is retracted distally and the joint capsule is incised along the femoral neck. A Hohmann retractor is introduced into the joint to elevate the femoral neck.



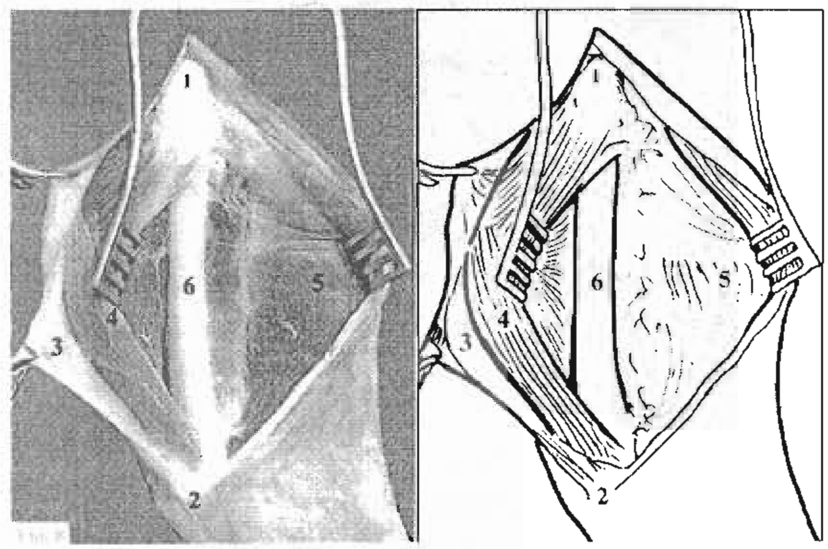
(Fig. 7): A photograph and its line drawing showing the craniolateral approach to the hip joint;

1. Major trochanter
2. Biceps femoris M.
3. Tensor fasci alatae M.
4. Middle gluteal M.
5. Deep gluteal M.
6. Vastus lateralis M.
7. Rectus femoris M.
8. Femoral neurovessels
9. Femoral head

The red arrow demonstrated Hohmann retractor for head elevation.

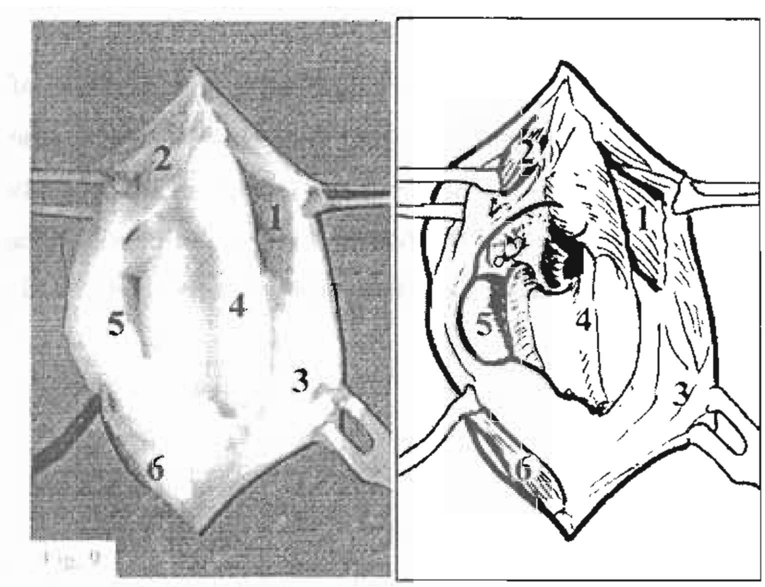
3. 2. 5 The Femur:

The craniolateral approach (Fig. 8), permits the repair of proximal and midshaft femoral fractures. The skin incision is made along the craniolateral border of the bone extending from the level of the trochanter major to the level of the patella. The fasciae latae is incised along the cranial border of the biceps femoris muscle. Caudal retraction of the biceps femoris and cranial retraction of vastus lateralis muscle exposes the femoral shaft.



(**Fig. 8**):A photograph and its line drawing showing the craniolateral approach to the femur:
1- Major trochanter
2- Stifle joint
3- Fascia latae
4- Vastus lateralis M.
5- Biceps femoris M.
6- Shaft of femur

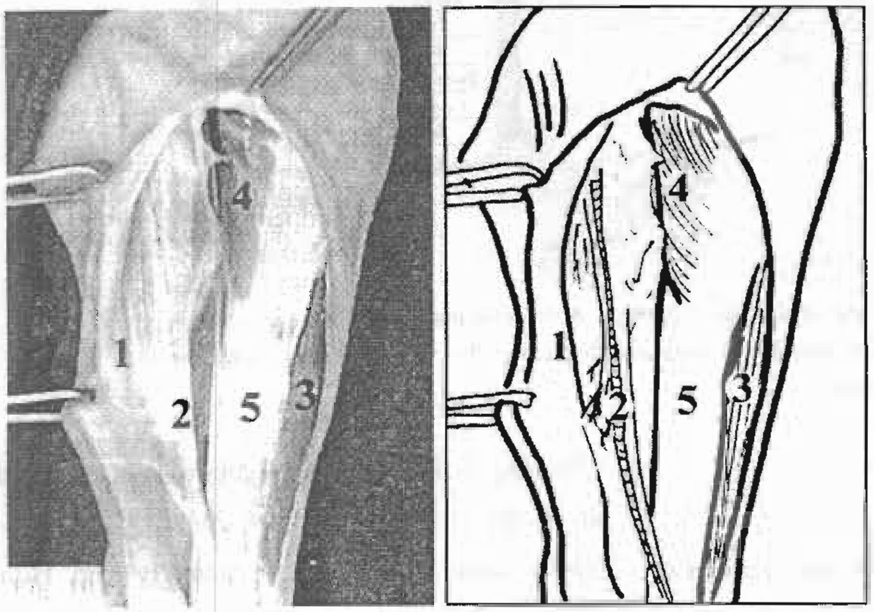
Approach to the distal end of femur (Fig. 9) through a curvilinear parapatellar skin incision extending from the distal fourth of the femur over the lateral trochlear ridge until the tibial tuberosity. Subcutaneous tissues are incised and retracted. Retraction of the biceps femoirs cranially and the vastus laterails with the patellar ligament caudally revealed the stifle joint capsule which then incised to expose the distal extremity of femur.



(**Fig. 9**):A photograph and its line drawing showing the parapatellar approach ; 1- Biceps femoirs M.2- Vastus lateralis M
3. Stifle joint capsule 4 Lateral trochlear ridge- Fascia latae 5- Patella. 6- Patellar ligament

3.2.6. Tibia:

The medial approach permited the repair of midshaft tibial fracture. The skin incision was made over the medial aspect of the bone. The deep crural fascia was incised and the cranial tibial, popliteus and long digital flexor muscles were reflected from the bone by subperosteal elevation. The saphenous vessels should be protected.



(Fig. 10) :A photograph and its line drawing showing the medial approach to the tibial shaft
1. Skin and deep crural fascia
2. Saphenous vessels
3.Cranial tibial M.
4.Popliteus M.
5- Body of tibia

3.3 The interactive computer program has a user-friendly interface. A screenshot of this interface was shown in (Fig. 11). This interface display the various orthopedic techniques used for bone reconstruction in the form of buttons for ease of navigation. The technique to be loaded was selected by clicking on the respective button. A new window will appear showing a text comment about the loaded technique, together with some buttons that can be clicked to display various examples for that technique. Each example presents image of the reconstructed bone with its corresponding contact radiograph. Some video clips explaining the basic steps of surgical anatomical approaches to selected regions of the thoracic and pelvic limbs were included into the program. A quick review on the dog skeletal model was available for right and left sides. A quiz in the form of multiple-choice questions and other formats was included for the user self-evaluation.

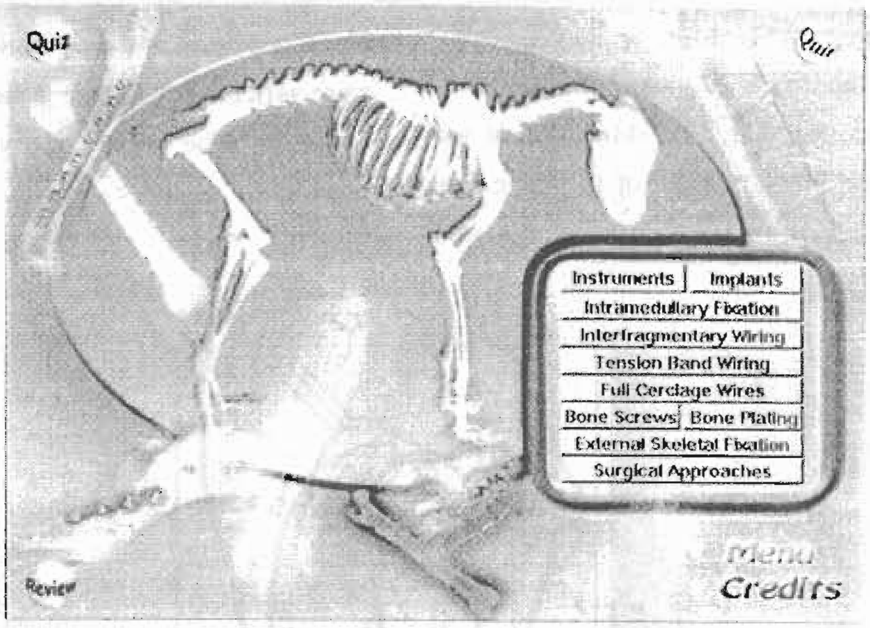


Fig. (11): Overview of the user interface of the veterinary orthopedic guidelines computer interactive program, displaying the various buttons used for navigation.

DISCUSSION

4.1 Surgical Anatomy

Closed reduction and stabilization are one of the methods used for fracture management. However, this method was rarely possible due to the severity of fractures, and the long time for bony union that patients may develop fracture disease. Perfect anatomical reconstruction of the fracture site was performed through open surgical approaches that should be as noninvasive as possible. Advantages of the minimally- invasive techniques were preservation of vascular supply, thus encouraging a quicker healing, less time-consuming, minimal postoperative pain and early return to function. Accurate radiographic assessment of the fracture location is necessary to select the appropriate surgical approach (Brinker, Piermattei and Flo, 1990).

Utilizing different surgical anatomical approaches to the long bones of the thoracic and pelvic limbs were described by (Sanvely and Hohn, 1977; and Piermattei, 1993) approved feasibility for easily procuring the target bone.

The craniolateral approach to the supraglenoid tubercle gave excellent visualized exposure and permitted accurate reduction. On cadaver specimens a lateral approach to the shoulder joint was developed via a longitudinal myotomy of the supraspinatus muscle. This approach was used in the surgical treatment of avulsion fractures of the supraglenoid tubercle of the scapula and excellent results were achieved (Gill, Lippincott and Anderson, 1996). On the other hand, Deneuche and Viguier, (2002) reduced and stabilized fracture of the supraglenoid tubercle under arthroscopic guidance. The authors mentioned that a mildly invasive arthroscopy and video-assisted surgical procedures may allow a faster recovery and may limit complications following the treatment of articular fractures.

The caudolateral approach to the elbow joint guarantees best visual control and minimal tissue damage at the same time (Bohmer, Matis and Waibl, 1987). A lateral approach to the elbow by proximal ulnar diaphyseal osteotomy was developed by (Lenehan and Nunamaker, 1982) as an alternative to a number of currently used surgical approaches to that joint. They reported that this technique provided better visualization of the multiple joint compartments of the elbow than does any other technique, however, repair of the osteotomy was required.

Comparing the results of arthroscopically assisted reduction of displaced intra-articular fractures of the distal aspect of the radius with those of conventional open reduction and internal fixation, there was no consensus that an arthroscopically guided operation can improve the anatomical and functional results of treatment of intra-articular fractures of the distal aspect of the radius. (Doi, Hattori, Otsuka, and Yamamoto, 1999)

The craniolateral approach described in this study allows fast and better visualization of the femoral head. In contrary the ventral approach, described by Kawamata, Niiyama, and Taniyama, (1996), in sabilization of hip joint luxation was time consuming and more complicated.

The main advantages of internal fixation was to achieve optimal anatomical reduction and more rigid and stable fixation (Brinker et al., 1983; Piermattei, and Gretchen, 1997). Three distinct forces act on fracture and it was the main goal of orthopedic surgery to try to neutralize all these forces to achieve such stable and rigid fixation. Failure to stabilize these forces probably the most common error in fracture repair. The axial forces were acting along the long axis of the bone. Axial forces also can be distractive which generally retard bone healing. The bending or shear forces cause displacement perpendicular to the fracture site and the fragment tends to shear away in opposite directions. The tension or rotational forces were very strong forces that cause rotation along the bone axis at the fracture site. Maintaining the alignment and the use of suitable fixation device (s) stabilized all these forces (Perren, 1991; and Gautier, Perren and Gauz, 1992).

Equally important was to discuss the decision making process used to determine the optimal method for managing various fractures of the bone at different sites.

4.2. Intramedullary fixation:

Steinmann pins and K. wires were the most universally accepted form of intramedullary fixation. Ancillary devices (e.g. external skeletal fixation and cerclage wires) may be needed to provide adequate rotational stability (Rudy, 1975; Withrow, 1980; Brinker et al., 1984 and Hulse and Aron, 1994).

4.2. 1 Humerus:

Most pins were retrograded proximally from the fracture site and exit the bone just distal to the greater tuberosity. After the fracture fragments were reduced, the pin was driven across the fracture site into the medial condyle. The pins also can be normograded in a distal direction from the greater tuberosity.

4.2. 3 Radius:

Intramedullary pins were the most and ideal form of radial fixation. If used they should be normograded from the distal end with the point of introduction just proximal to the radiocarpal joint.

4.2. 4 Ulna:

In proximal ulnar fractures, the pins were either retrograded proximally or normograded distally.

4.2.5. Femur:

Generally retrograded proximally from the fracture site to exit at the intertrochanteric fossa. Normograd pins were inserted through the intertrochanteric fossa. Distal femoral physeal fractures were treated by retrograding pins inserted distally from the fracture site through the non articular portion of the stifle joint.

4. 2. 6 Tibia:

Pins always were normograded from the proximal end. If retrograded proximally from the fracture site, the pins entered the stifle joint. Normograde pins from the proximal end was a point half a way between the medial collateral ligament and the tibial crest on the medial aspect of the tibial plateau.

4.2.7 Metacarpal and Metatarsal bones:

The pin was introduced from the distal end of the bone at the dorsal edge of the articular cartilage. A bent hook was made close to the bone surface after the pin was seated in the medullary canal.

Multiple smaller stacked pins provided greater rotational stability through greater endosteal contact (Gibson and Vanee, 1991). Crossed pins were useful for distal femoral and humeral fractures (Franczuski, Chalm and Buttler, 1986; Whitney and Schrader, 1987; Piermattei and Gretchen, 1997; and Gilmore, 1998).

4.3 Full Cerclage Wires:

The wires completely encircle the bone and should be used only on fracture lines that were at least 2 times the diameter of the bone. Using of full cerclage wires across short oblique fracture caused distraction (Withrow and Holemberg, 1977; Withrow, 1978; Rooks, Tarvin and Pijanowski, 1982; Blass and Piermattei, 1986; Pieramttei and Gretchen, 1997).

Heavy monofilament stainless steel wire 18 gauge was appropriate for dogs. The space between the wire loops should be 1-1.5 cm apart. Always 2 wires per fracture side were used. Tension (tightening) must be placed on the loop prior to twist, with even tension the wire was twisted close to the bone. The wire was cut with approximately 5 twists remaining and was not over. The use of eyed wire loops was the preferred method of full cerculage wiring. Tension band wiring was was used in avulsion fractures of major muscle and tendon traction points (greater trochanter, olecranon procedd, tubuer calcaneus, tibial tuberosity and patella) were treated successfully with K. wire and tension band wires of figure-8-. Such tension band counters distractive forces and produces compressive force along the fracture site (Harrison, 1984; Gautier et al. 1992; and Piermattei and Gretchen, 1997).

4. 4 Bone Screws:

Cancellous screws were used to compress the fragments of epiphyseal and metaphyseal bones, sacroiliac separation and atlantoaxial subluxation. Drill pits, taps, depth gauge and screwdriver were needed for application of bone screws (Brinker et al., 1984; Schwarz and Schrader, 1984 and Schatzker, 1991).

4.5 Bone Plating:

Bone plates were generally placed on the tension side of the bone (Laterally in the femur, cranially in the radius, medially in the tibia and medially, laterally or cranially in the humerus)

A minimum of six cortical screws should be inserted proximal and distal to the fracture site. The plate should be modulated to simulate the normal contour of the bone. The plate can serve as compression (DCP), neutralization or Buttress appliance (Bruse and Prieur, 1989; Perren, 1991; Lewis and VanEe, 1993; and Piermattei and Gretchen, 1997).

4. 6 External skeletal fixator (Kirschner- Ehmer pin splintage):

External skeletal fixation or transfixation was a method of immobilization of long bones which involves the transcutaneous transverse passage of pins through soft tissues and bone fragments which were in turn had in rigid immobilization by a connecting bar.

K-E splintage may be half pin or full pin. The conventional K-E apparatus utilizes 4 pins; 2 pins in each fracture fragment and a long connecting bar with clamps. It may be used as a sole method of fracture fixation.

The fixation pins may be either smooth, partially threaded or fully threaded. The percutaneous pins should be inserted through the skin and underlying soft tissue and not through the surgical incision or wounds. The pins were placed at 30 to 40 degree angles to each other in both proximal and distal fracture fragments (Brinker, Piermattei and Flo, 1983; Egger, 1990; Tomlinson and Constantinescu, 1991; Harari, 1992 and Johnson and Decamp, 1999).

K-E splintage may be indicated in the treatment of long bone fracture, arthrodesis, comminuted fractures, infected fractures, delayed union and non union and mandibular fracture (Booth and Tanger, 1983; Aron and Dewey, 1992; Ross and Mattiesen, 1993 and Egger, 1998).

4.7. The past several years have witnessed a dramatic improvement in the way of veterinary educational technology. The traditional approach to teaching veterinary orthopedics had been through lectures, however, teaching effectiveness was greatest when it occurs in small groups interacting with an instructor (Squire, 1989; Goldberg, Fell, Myers and Taylor 1990). Practically, the instructors ,time hardly can go with many small groups. Another obstacle was the expensive price of orthopedic instruments and implants. Computer-assisted learning (CAL) can bridge the gap between the ideal situation and the traditionally passive lecturing situation.

Our developed orthopedic interactive multimedia program at faculty of Vet. Med., Cairo University, run on Window operating systems that most users had. The program augments the electronic and distance learning process as it presents the following benefits; it increased students clinical experience while saving instructor's -time, allows students to work at their own pace, achieves the student interactivity and reinforces their lectures. The quiz portion of the program allows student self-evaluation. Computer-assisted instruction had proven to be a valuable adjunct in teaching at several universities and medical centers (Jacoby, Smith and Albanese, 1984; Tessler, 1989).

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