LINEAR EXTERNAL SKELETAL FIXATION FOR LONG BONE FRACTURES

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Introduction:

Fractures of the long bones are very common in dogs and are usually the result of traumatic events such as automobile accidents and a fall or jump from a height. The basic surgery in veterinary orthopaedics has been repair of fractures. There are many methods and even more materials that can be employed in the repair of a fracture. They include external coapation techniques, intramedullary pinning, bone plating and external skeletal fixation.

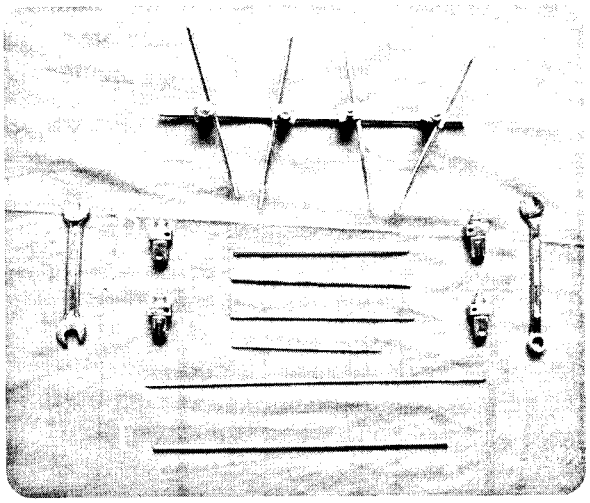
External Skeletal Fixation (ESF) is a means of stabilizing fractures using percutaneous fixation pins that penetrate the bone cortices internally and are connected together externally to form an external frame. Unlike procedures like intramedullary pining and bone plating, ESF provides stable fixation of fractured bone segments with minimal damage to soft tissue and vascularity. It provides joint mobility preventing the chance of ankylosis and also aids in early return to function of the limb.

External skeletal fixators are of two types; linear fixators and ring fixators. Ring fixators otherwise known as Ilizarov fixators consist of small tension wires that penetrate the bone percutaneously and are attached to external rings. They are useful for stabilizing highly comminuted fractures, correcting angular deformities and for lengthening of bones. But the technique is often difficult to learn and master because of the lack of detailed instructions in the veterinary literature. However, recently research works has been carried out on application of ring fixators for managing fractures in dogs (Dwivedi, 2003).

This article is aimed at through light on the application and usage of linear external skeletal fixators in managing fractures in dogs.

Components of linear external fixators (Fig 1)

The external skeletal fixator consists of transfixation pins and an external frame. The external frame consists of connecting bars and clamps. A wrench can be used to tighten the clamps against the connecting bar.



Trasfixation pins:

Transfixation pins are pins that are drilled through the thickness of the bone segments of the fractured bone. They are of different types like, half pins and full pins, threaded pins and non-threaded pins etc. Pins of diameter 20% to 30% of the bone diameter are used as transfixation pins. They can be hand drilled or drilled with bone driller through the bone

External frame

Clamps join transfixation pins drilled through the bone to connecting bar. Clamps of different standard sizes are available to suit the size of transfixation pin used. Connecting bars are special rods or Steinman's

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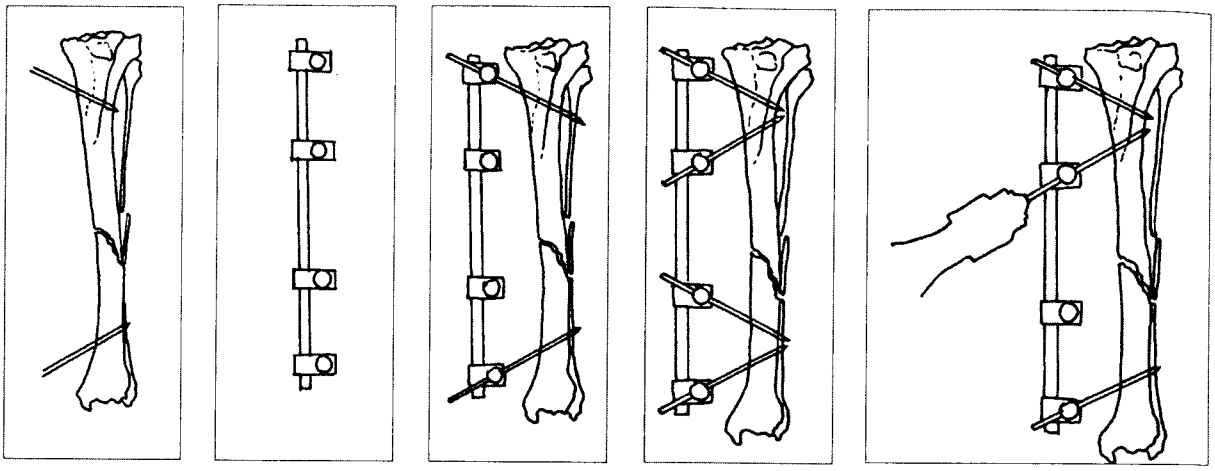
Diagramatic representation of steps in application of stainless steel external frame



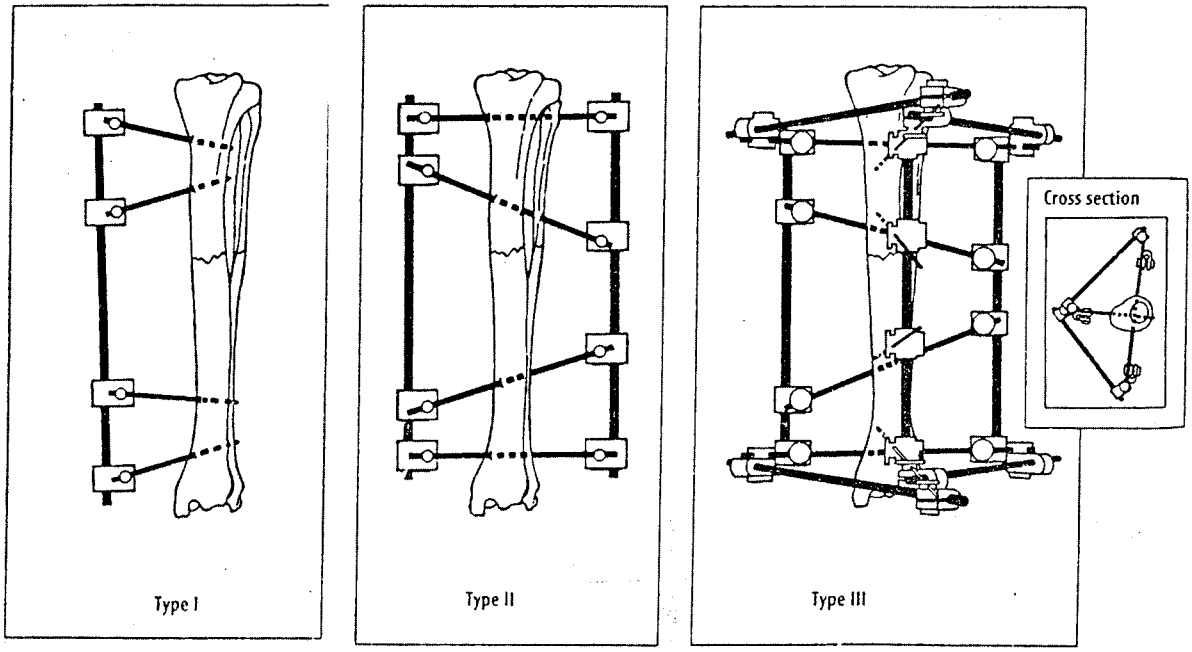
A B C D E

A. The most proximal and distal pins were placed first

B. and C. Connecting bar and the total number of clamps intended for use in the frame design were applied to achieve appropriate reduction and alignment

D. and E. The remaining pins were applied sequentially through the clamps in the connecting bar

TYPES OF ESF



pins used to unite the fixation pins outside the body to provide a rigid external frame.

Types of external skeletal fixators

Linear fixators have mainly three types of frames based on the degrees of stiffness and stability that they provide to the fracture.

Type I: The fixation pins pass through only one skin surface and two cortices of the bone but doesnot penetrate through the opposite skin surface. The connecting rods and clamps can thus be positioned on only one side of the bone (Fig 2a).

Type II: The fixation pins passing through one skin surfaces, cortices of the bone and then through the opposite skin surface to outside. Thus the connecting rods and clamps are positioned on both sides of the bone (uniplanar) (Fig 2b).

Type III: This is a combination of the Type I and type II fixators. The type I fixator is positioned at 90 degrees

to the type II fixator, giving the external frame a three-dimensional shape (bilateral biplanar) (Fig 2c).

Other types of ESFs like unilateral double clamp configuration, unilateral uniplanar double bar configuration and unilateral biplanar quadrilateral configuration can also be designed using double connecting bars and double clamps depending upon the requirement.

Application of external skeletal fixators

Different authors have explained different methods and tips for the application of ESF based on the type of fracture and its stability (Nunamaker, 1985; VanEe and Geasling, 1992; Harari *et al.,* 1998; Rochat, 2001 and Julie, 2005).

External skeletal fixators can be applied using closed approach or open approach. If the fracture fragments are stable in their normal anatomical position once reduced by external manipulation, then closed approach can be adopted. In this approach there is no need of an extensive surgery. Instead, by external manipulation (traction and counter traction), the fractured segments are brought to normal alignment and apposition and then transfixation pins are drilled through the thickness of the bone percutaneously along a safe corridor. Safe corridors are regions through which when pins are drilled through the bone percutaneously cause least interference of blood vessels, nerves, tendons and muscles. The safe corridors for the insertion of pins through various canine bones are described by Marti and Miller (1994a); Marti and Miller (1994b) and Gorse (1998).

If the fracture fragments are not stably positioned in the normal anatomical position by reduction (unstable fracture), an open approach has to be followed. The fracture site should be surgically exposed and the fracture fragments should be brought to normal alignment and apposition by traction and counter traction or toggling. The fragments can be held in correct position with bone holding forceps and pins are drilled through the bone fragments. The fragments are kept in position with the forceps until application of external fixator is complete.

In both open approach and closed approach, pins in the most proximal and distal positions should be drilled initially. Then the external frame with the clamps fixed to the connecting bar is assembled. Attach the frame to the proximal most and distal most pins drilled through the bone by applying the clamps at either end to the pins. Before tightening the applied clamps with the pins, it should be ensued again that the fractue fragments are in correct alignment and apposition. After tightening the proximal and distal pin clamps, the central pins are inserted into the bone fragments guided through the open clamps attached to the connecting bar (Fig 3).

Certain guidelines have to be followed while drilling the pins through the bones. A minimum of two fixation pins is required for each major segment of the bone to be stabilized, though it is preferable to use three or four pins per segment. The fixation pins should be spread along the entire length of each segment to gain maximum mechanical stability for the fracture fragments. The most proximal and distal pins within a segment should be positioned about 30 degrees from each other to reduce the chance of the pins getting pulled out from the bone. Machine drilling of the pins is preferred over hand drilling and pins should be drilled in small pulses, with 30 seconds or so between pulses.

ESF as adjuncts to other techniques

In some cases, especially femur fracture, external fixator alone may fail to provide adequate stability to the fracture fragments. So it is better to use it in combination with intramedullary pinning (Straw,1984; Harari *et al.;* 1998 and Chandy, G. 2000). This will help to reduce chances of rotation between fracture segments when the pinning technique alone is used for immobilization.

In case of highly unstable oblique fractures, using cerclage wiring along with external fixator will help to increase the stability of fracture fragments.

Postoperative care

Following fracture immobilization with external fixator, the limb, including the external frame, is bandaged. The pin tract entry points are covered properly in order to prevent entry of infectious agents. Bandaging also helps to avoid the frame getting entangled on objects in the environment. The pin tract entry points are cleaned with sterilized cotton mopes and dressing powder applied once in two days for a week and thereafter once in two weeks. How ever, there are reports that the pin entry points need not be cleaned regularly since the scab formed there will act as a barrier for preventing infection (VanEe and Geasling, 1992; McLaughlin and Roush, 1999). Antibiotic therapy, preferably with Cephalosporins should be given for a minimum of five days.

According to Burny *et al.* (1980) and VanEe and Geasling (1992), following application of ESF, early ambulation is to be encouraged as weight bearing stimulates fracture healing and minimizes fracture diseases like ankylosis and muscle atrophy. But the patient's activity should be should not result in breakage of transfixation pins.

Radiographic evaluation of the fracture site every two weeks will help to analyse the fracture healing. Any

complications in fracture healing like change in position of the fracture fragments, delayed union, damage to the pins etc. can also be monitored through radiographic evaluation.

In some cases, the animal may mulitate the external frame during the intial healing period. It can be managed with proper bandaging and through administration of antihistaminics and sedatives.

Fracture healing period following external fixation

Following immobilization with external fixator, the functional limb usage returns to normal earlier and this helps to avoid complications such as muscle atrophy and joint stiffness (Julie, 2005). The animal will start bearing weight on the affected limb partially by first week itself. In most cases, they attains near to normal gait within the fourth week itself.

Fracture healing is faster with external skeletal fixation compared to other immobilization techniques. Piermattei and Flo (1997) suggested the time taken for clinical union of fractured bones following external fixation with respect to the age of the animal as;

Less than 3 months age	- 2 to 3 weeks
3 to 6 months age	- 4 to 6 weeks
6 to 12 months age	- 5 to 8 weeks
Over one year age	- 7 to 12 weeks

Removal of the implant

The external fixator can be removed once there is sufficient fracture healing. This can be assessed based on the limb usage, clinical union (assessed by feeling the fracture site) and radiographic evidences of fracture healing (Langley-Hobbs, 2003). The external frame should be removed first by loosening the clamps and removing the connecting bar. Then the pins can pulled out using hand chuck or can be drilled out with an electric drill. The pin sites should be cleaned with antiseptic solutions and sterile dressing should be applied to the limb for one week after removal.

Complications

The common complications observed by various authors with external skeletal fixation are pin loosening, pin tract drainage, pin tract infection, pin breakage, neurovascular injury, osteomyelitis, non-union and delayed union (Gausepohl *et al*,.2000 ; Rochat,2001; Ozsoy and Altunatmaz, 2003 and Julie, 2005).

Pin loosening in mild degree can be neglected. Loosening of pins is caused by soft tissue interference or with instability of the fracture. Once a pin becomes remarkably loose, the only effective treatment is removal. This will not affect the fracture healing if there are atleast two more pins remaining in each fracture fragment.

Pin track drainage is normal with external fixators and that they will not adversely affect the fracture healing usually. How ever, it may predispose pin tract infection and subsequently osteomyelitis. Through proper post-operative these complications can be avoided.

Damage to blood vessels, nerves, tendons and muscles can be avoided if there is sufficient knowledge about the normal anatomy of the limb and about the safe corridors.

Advantages of external skeletal fixators

-- Early return of functional limb usage with no joint stiffness

-- Best choice of immobilization in open or infected fractures, gun shot fractures, and highly comminuted fractures

-- Reusability and economy of components such as pin clamps and connecting bars.

-- Technical ease of application and removal of external fixators.

-- Best method for repairing radial and tibial fractures

-- Can be employed for immobilization of fractures of vertebrae, pelvis and mandibles were most other techniques fail.

2.7.2. Disadvantages

-- Poor choice of fixation when used solely for immobilization of femur or humerus fracture.

-- Complications like osteomyelitis, pin breakage, neurovascular injury and pin loosening

-- Possibility of patient manipulating the fixator and also the fixator getting entangled with surrounding objects.

-- High cost of the clamps even though they can be re-used.

CONCLUSION

External fixators are useful in treating open and closed fractures, simple and comminuted fractures, gun shot fractures, angular deformities, joint luxations, shortened bones and delayed unions. It is compatible with internal fixation devices such as intramedullary pins and cerclage. Fracture stability can be well maintained during the healing period. Reusability and economy of components such as pin clamps and sidebars makes the apparatus economical for veterinary use. Neurovascular supplies to bone and soft tissues will be less affected on immobilization with external fixator and this aids in earlier fracture healing and return of functional limb usage. Technical ease of application and removal of external fixators also makes it a feasible method of fracture immobilization. ❑