CANADA WEST
VETERINARY SPECIALISTS

Decision-making in long bone fractures

MICHAEL KING BVSc MS Diplomate ACVS

Any significant trauma to the skeleton can result in a fracture. While some specific injuries require particular methods of repair, when assessing long-bone fractures there are often multiple treatment options available. The important thing to recognize with fracture repair is that as a Surgeon you are not actually "fixing" the fracture, but rather the goal is to provide the correct environment for the body to be able to heal the injury. Selecting the appropriate technique of repair depends on understanding how they work to create the optimal healing conditions.

INJURY

Bone is a remarkable structure. Its combination of fibrous and mineralized tissues give it viscoelastic properties meaning that bone is both flexible and brittle, depending on the rate of force applied to it. This is why high energy trauma usually results in a comminuted fracture (multiple intersecting fracture lines), while a lighter injury causes single transverse or oblique fractures.

Though we focus on the fracture itself, it is crucial to consider the surrounding structures and soft tissues that also are damaged. While it can be obvious with visible swelling or lacerations, injuries such as gunshot or dog-bite wounds often cause massive soft tissue injury, with only a small external wound. This becomes especially important when considering how a fracture heals.

HEALING

When a fracture is sustained, hemorrhage occurs at the site due to disruption of the normal intramedullary blood supply. This forms a hematoma and is the first step in forming a callous. As the normal blood supply is damaged, new periosteal vessels arise from the surrounding soft tissues and extend into the hematoma. Over time, the hematoma becomes fibrous tissue, which eventually becomes cartilage, and then finally bone. How rapidly those transitions occur depends on the amount of stability at the fracture site.

Stability is measured by "strain" which is defined as the amount of movement at a fracture site, relative to the size of that fracture gap. A 10mm fracture gap that moves 5mm when force is applied would be quantified as having 50% strain, while 1mm movement at that same site would represent only 10% strain. Fibrous tissue can form in sites with 50% strain, whereas cartilage needs less than 10% strain, and bone less than 2%. The body therefore sets down increasing levels of fibrous tissue to stabilize the fracture enough for cartilage, and then bone to form. Greater instability results in more fibrous tissue, and subsequently a larger callous.

As strain is a percentage, it can also be decreased by changing the size of the fracture gap. That same 5mm movement occurring now at a 20mm fracture gap represents only 25% strain. This is why (as well as laying down additional callous) the body will initially increase the size of the fracture gap by removing mineralized cells on either side. Once sufficient stability is achieved, the healing can then progress.

In fractures with minimal strain (minor greenstick fractures, or where rigid fixation is applied) direct "contact" healing can occur, rather than the "gap" healing described above. Contact healing is achieved by osteoclasts moving directly across the fracture site from one fragment to another, depositing new bone via osteoblasts immediately behind them.

REPAIR

When considering fracture stabilization options the goal is to provide sufficient stability, while minimizing disruption to the biological healing processes already underway. It is important to realize that all stabilization methods will fail given long enough, and so maximizing rate of healing is crucial.

A number of different factors need to be considered, and consist of three main groups;

1. Mechanical - How strong does the repair need to be?

2. Biologic - How rapid will healing occur?

3. Clinical - How compliant are the patient and owner likely to be?

Mechanical factors include how comminuted a fracture is, how large a patient is, and whether there are other orthopedic injuries. A large breed dog with a comminuted femoral fracture, and a hip luxation on the other hindlimb will need a much stronger initial repair than a toy breed dog with a single transverse tibial fracture.

Biologic factors consist of how old and healthy the patient is, the degree of muscling around the fracture site, the health of that soft tissue, and fracture location within a bone (cancellous versus cortical). An older dog with Cushings that sustained a mid-diaphysial radius/ulna fracture will take a significantly longer period of time to heal than a young, otherwise healthy patient with a closed distal metaphysical femoral fracture.

Clinical factors ask how effectively the patient will protect the fracture repair. Will their owner actually follow post-operative instructions? Is the patient calm and stoic, or is it anxious and difficult to control?

From considering all these factors we can estimate a "Fracture Assessment Score", where a low score suggests a high risk patient for repair failure or nonunion, while a high score indicates less risk of complications, and a good chance that a more minor intervention will be successful. The exact number is not important, but rather the exercise to consider these components when deciding on what fixation method will be most appropriate. This process is covered in more detail in the chapter *Fundamentals of Orthopedic Surgery and Fracture Management*, in Fossum's Small Animal Surgery text.

FIXATION

There are a number of different primary fracture fixation techniques to consider;

- External coaptation
- Plate
- Interlocking nail
- External fixator
- Intramedullary pin

These can often be used in combination with other supplementary implants;

- Orthopedic wire
- Fragmentary screws

Of the primary methods of repair, plates, interlocking nails, and type II & III external fixators represent the strongest options. Splints & casts, IM pins, and type I fixators provide the least stability.

Once the patient's fracture score has been assessed, and appropriate fixation options determined, a decision can finally be made on how to achieve stabilization.

FORCES

There are three primary forces that act on a fracture;

- Bending
- Compression
- Rotation

All three need to be counteracted to achieve sufficient stabilization for healing to occur. The orientation and type of fracture can provide some inherent stability against one or two of these forces. For example, a straight, transverse fracture will prevent any axial collapse through compression, as long as the other two forces are counteracted.

Plates, interlocking nails, and external fixators are effective against all three forces. However intramedullary pins only counteract bending (though admittedly very well). In sufficiently oblique mid-shaft fractures cerclage wire can be used in combination to create a construct that does act against rotation and compression as well.

Casts (when used in appropriate patients and applied correctly) are also effective against bending forces. Their action against rotation (and indeed in achieving sufficient overall stability) depends on inclusion of the joint above and the joint below the fracture in the cast. However they do not protect against compression, and therefore are limited to use in transverse fractures where the axial forces are shared by the bone column.

The final choice of fixation method is made based on the need to counteract these forces, and with the factors involved in fracture assessment primarily in mind. The logistics of being able to apply a particular method is the last thing to be considered - for example is there sufficient fragment size for an external fixator, is the fracture oblique enough for an intramedullary pin & cerclage wire combination.

POST-OPERATIVE CARE

The rate of healing of a fracture (and therefore the period of time the patient's activity should be restricted) depends on the biologic factors described previously. Typical fracture healing for a healthy adult dog or cat is around 6 weeks. In puppies or kittens 4 weeks is almost always enough to achieve good stability. Older animals, or patients where there has been a serious injury (comminuted fractures or massive soft tissue injury) take 8 weeks or more to get solid bony healing.